VISION

To contribute to India and the World through excellence in scientific and technical education and research; to serve as a valuable resource for industry and society; and remain a source of pride for all Indians.

MISSION

To generate new knowledge by engaging in cutting-edge research and to promote academic growth by offering state-of-the-art undergraduate, postgraduate and doctoral programmes.

To identify, based on an informed perception of Indian, regional and global needs, areas of specialization upon which the Institute can concentrate.

To undertake collaborative projects which offer opportunities for long-term interaction with academia and industry.

To develop human potential to its fullest extent so that intellectually capable and imaginatively gifted leaders can emerge in a range of professions.

VALUES

- Academic integrity and accountability.
- Respect and tolerance for the views of every individual.
- Attention to issues of national relevance as well as of global concern.
- Breadth of understanding, including knowledge of the human sciences.
- Appreciation of intellectual excellence and creativity.
- An unfettered spirit of exploration, rationality and enterprise.
COURSES OF STUDY

2017-2018

Undergraduate programmes
Bachelor of Technology
Dual Degree (B.Tech + M.Tech.)

Postgraduate programmes
Diploma of I.I.T. Delhi
Master of Science
Master of Business Administration
Master of Design
Master of Technology
Master of Science (Research)
Doctor of Philosophy

INDIAN INSTITUTE OF TECHNOLOGY DELHI
Hauz Khas, New Delhi 110 016, India.
http://www.iitd.ac.in
COURSES OF STUDY
2017-2018

Undergraduate programmes
Bachelor of Technology
Dual Degree (B.Tech + M.Tech.)

Postgraduate programmes
Diploma of I.I.T. Delhi
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Master of Business Administration
Master of Design
Master of Technology
Master of Science (Research)
Doctor of Philosophy
This book is available at the IIT Delhi website:

http://www.iitd.ac.in
Link: http://www.iitd.ac.in/content/curriculum-info

In case of queries, please visit IIT Delhi website or contact:

Undergraduate Programme
Assistant Registrar
Ph. : +91 11 2659 1718
Fax : +91 11 2659 7114
E-mail : arugs@iitd.ac.in
adcur@admin.iitd.ac.in
deanacad@admin.iitd.ac.in

Postgraduate Programme
Deputy Registrar
Ph. : +91 11 2659 1737
Fax : +91 11 2658 2032
E-mail : drpgsr@iitd.ac.in
adres@admin.iitd.ac.in
deanacad@admin.iitd.ac.in

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July 2017
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1. INTRODUCTION

1.1 Background

I.I.T. Delhi provides science-based engineering education with a view to produce quality engineer-scientists. The curriculum provides broad based knowledge and simultaneously builds a temper for the life long process of learning and exploring. At the undergraduate level, a student needs to do compulsory foundation courses in the areas of basic sciences, humanities, social sciences and engineering sciences apart from departmental requirements in the core engineering discipline. Departmental courses (core and electives) constitute about half of the total curriculum. Further, students do open category electives to develop broad inter-disciplinary knowledge base or to specialize significantly in an area outside the parent discipline. Activities that enhance the quality of learning, but are not part of the foregoing, have been included in the undergraduate curriculum as non-graded core. At the postgraduate level, students are encouraged to look beyond their area of specialization to broaden their horizons through open electives and self-learning.

The medium of instruction in the Institute is English.

The Institute follows a semester system. An academic year runs from July through June next year and is essentially comprised of two semesters. Typically, the 1st semester starts in the last week of July and ends in the 1st week of December; the 2nd semester starts in the 1st week of January and ends in the 2nd week of May. Additionally, the summer semester which starts in the 3rd week of May and ends in the 2nd week of July, is utilized in some exceptional cases. Detailed schedule is given in the Semester Schedule that is made available before the start of each semester.

1.2 Departments, Centres and Schools

Each course is offered by an Academic Unit which could be a Department, a Centre or a School. The names of Departments, Centres and Schools and their two-letter codes are given in Table 1. Some programmes are offered jointly by multiple academic units and are classified as interdisciplinary programmes; their codes are given in Table 2.

Table 1. Academic Departments, Centres and Schools

<table>
<thead>
<tr>
<th>Name of Academic Unit (alphabetical order)</th>
<th>Code of Academic Unit</th>
<th>Course Prefix</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied Mechanics, Department of</td>
<td>AM</td>
<td>AP</td>
</tr>
<tr>
<td>Applied Research in Electronics, Centre for</td>
<td>CR</td>
<td>CR</td>
</tr>
<tr>
<td>Atmospheric Sciences, Centre for</td>
<td>AS</td>
<td>AS</td>
</tr>
<tr>
<td>Biochemical Engineering and Biotechnology, Department of</td>
<td>BE</td>
<td>BB</td>
</tr>
<tr>
<td>Biological Sciences, Kusuma School of</td>
<td>BL</td>
<td>SB</td>
</tr>
<tr>
<td>Biomedical Engineering, Centre for</td>
<td>BM</td>
<td>BM</td>
</tr>
<tr>
<td>Chemical Engineering, Department of</td>
<td>CH</td>
<td>CL</td>
</tr>
<tr>
<td>Chemistry, Department of</td>
<td>CY</td>
<td>CM</td>
</tr>
<tr>
<td>Civil Engineering, Department of</td>
<td>CE</td>
<td>CV</td>
</tr>
<tr>
<td>Computer Science and Engineering, Department of</td>
<td>CS</td>
<td>CO</td>
</tr>
<tr>
<td>Electrical Engineering, Department of</td>
<td>EE</td>
<td>EL</td>
</tr>
<tr>
<td>Energy Studies, Centre for</td>
<td>ES</td>
<td>ES</td>
</tr>
<tr>
<td>Humanities and Social Sciences, Department of</td>
<td>HU</td>
<td>HU</td>
</tr>
<tr>
<td>Industrial Tribology, Machine Dynamics and Maintenance Engineering Centre</td>
<td>IT</td>
<td>IT</td>
</tr>
<tr>
<td>Information Technology, Amar Nath and Shashi Khosla School of</td>
<td>AN/SI</td>
<td>SI</td>
</tr>
<tr>
<td>Instrument Design and Development Centre</td>
<td>ID</td>
<td>DS</td>
</tr>
<tr>
<td>Management Studies, Department of</td>
<td>SM</td>
<td>MS</td>
</tr>
<tr>
<td>Mathematics, Department of</td>
<td>MA</td>
<td>MT</td>
</tr>
<tr>
<td>Mechanical Engineering, Department of</td>
<td>ME</td>
<td>MC</td>
</tr>
<tr>
<td>Physics, Department of</td>
<td>PH</td>
<td>PY</td>
</tr>
<tr>
<td>Polymer Science and Technology, Centre for</td>
<td>PT</td>
<td>PT</td>
</tr>
<tr>
<td>Rural Development and Technology, Centre for</td>
<td>RD</td>
<td>RD</td>
</tr>
<tr>
<td>Telecommunication Technology and Management, Bharti School of</td>
<td>BS</td>
<td>BS</td>
</tr>
<tr>
<td>Textile Technology, Department of</td>
<td>TT</td>
<td>TX</td>
</tr>
<tr>
<td>Value Education in Engineering, National Resource Centre for</td>
<td>VE</td>
<td>VE</td>
</tr>
</tbody>
</table>
1.3 Programmes Offered

IIT Delhi offers a variety of academic programmes for students with a wide range of backgrounds. Admission to many of these programmes are based on performance in national level tests/entrance examinations. Details are given in the Prospectus.

The programmes offered by IIT Delhi are presently classified as undergraduate (UG) and postgraduate (PG) programmes. This classification is based primarily on entry/admission qualification of students rather than the level of degree offered. For all undergraduate programmes, students are admitted after 10+2 years of schooling while for all postgraduate programmes, students are admitted after they have obtained at least a college level Bachelor’s degree. Various programmes offered and their specializations are listed below.

A. Bachelor of Technology: (B.Tech.)

<table>
<thead>
<tr>
<th>Department</th>
<th>Programme</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biochemical Engg. and Biotechnology</td>
<td>B.Tech. in Biochemical Engineering and Biotechnology</td>
<td>BB1</td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>B.Tech. in Chemical Engineering</td>
<td>CH1</td>
</tr>
<tr>
<td>Computer Science and Engineering</td>
<td>B.Tech. in Computer Science and Engineering</td>
<td>CS1</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>B.Tech. in Civil Engineering</td>
<td>CE1</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>B.Tech. in Electrical Engineering</td>
<td>EE1</td>
</tr>
<tr>
<td>Mathematics</td>
<td>B. Tech. in Mathematics &amp; Computing</td>
<td>MT1</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>B.Tech. in Mechanical Engineering</td>
<td>ME1</td>
</tr>
<tr>
<td></td>
<td>B.Tech. in Production and Industrial Engineering</td>
<td>ME2</td>
</tr>
<tr>
<td>Physics</td>
<td>B.Tech. in Engineering Physics</td>
<td>PH1</td>
</tr>
<tr>
<td>Textile Technology</td>
<td>B.Tech. in Textile Engineering</td>
<td>TT1</td>
</tr>
</tbody>
</table>

B. Dual-Degree : (B.Tech. and M.Tech.)

<table>
<thead>
<tr>
<th>Department</th>
<th>Programme</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biochemical Engg. &amp; Biotechnology</td>
<td>B.Tech. and M.Tech. in Biochemical Engineering and Biotechnology</td>
<td>BB5</td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>B.Tech. and M.Tech. in Chemical Engineering</td>
<td>CH7</td>
</tr>
<tr>
<td>Computer Science and Engineering</td>
<td>B.Tech. and M.Tech. in Computer Science and Engineering</td>
<td>CS5</td>
</tr>
<tr>
<td>Mathematics</td>
<td>B.Tech. and M.Tech. in Mathematics &amp; Computing</td>
<td>MT6</td>
</tr>
</tbody>
</table>

C. Master of Technology: (M.Tech.)

<table>
<thead>
<tr>
<th>Department/Centre</th>
<th>Programme</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied Mechanics</td>
<td>M.Tech. in Engineering Analysis and Design</td>
<td>AMA</td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>M.Tech. in Chemical Engineering</td>
<td>CHE</td>
</tr>
<tr>
<td>Chemistry</td>
<td>M.Tech. in Molecular Engineering : Chemical Synthesis &amp; Analysis</td>
<td>CYM</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>M.Tech. in Geotechnical and Geoenviromental Engineering</td>
<td>CEG</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Rock Engineering and Underground Structures</td>
<td>CEU</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Structure Engineering</td>
<td>CES</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Water Resources Engineering</td>
<td>CEW</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Construction Engineering and Management</td>
<td>CET</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Construction Technology and Management (*)</td>
<td>CEC</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Environmental Engineering and Management</td>
<td>CEV</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Transportation Engineering</td>
<td>CEP</td>
</tr>
<tr>
<td>Computer Science &amp; Engineering</td>
<td>M.Tech. in Computer Science and Engineering</td>
<td>MCS</td>
</tr>
<tr>
<td>Courses of Study 2017-2018</td>
<td></td>
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<tr>
<td>---------------------------</td>
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</tr>
<tr>
<td><strong>Electrical Engineering</strong></td>
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</tr>
<tr>
<td>M.Tech. in Communications Engineering</td>
<td>EEE</td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Computer Technology</td>
<td>EET</td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Control and Automation</td>
<td>EEA</td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Integrated Electronics and Circuits</td>
<td>EEN</td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Power Electronics, Electrical Machines and Drives</td>
<td>EEP</td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Power Systems</td>
<td>EES</td>
<td></td>
</tr>
<tr>
<td><strong>Mechanical Engineering</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Mechanical Design</td>
<td>MEM</td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Industrial Engineering</td>
<td>MEE</td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Production Engineering</td>
<td>MEP</td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Thermal Engineering</td>
<td>MET</td>
<td></td>
</tr>
<tr>
<td><strong>Physics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Applied Optics</td>
<td>PHA</td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Solid State Materials</td>
<td>PHM</td>
<td></td>
</tr>
<tr>
<td><strong>Textile Technology</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Fibre Science &amp; Technology</td>
<td>TTF</td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Textile Engineering</td>
<td>TTE</td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Textile Chemical Processing</td>
<td>TTC</td>
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</tr>
<tr>
<td><strong>Applied Research in Electronics</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Radio Frequency Design and Technology</td>
<td>CRF</td>
<td></td>
</tr>
<tr>
<td><strong>Atmospheric Sciences</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Atmospheric-Oceanic Science and Technology</td>
<td>AST</td>
<td></td>
</tr>
<tr>
<td><strong>Biomedical Engineering</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Biomedical Engineering</td>
<td>BMT</td>
<td></td>
</tr>
<tr>
<td><strong>Interdisciplinary Programme</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Energy Studies</td>
<td>JES</td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Industrial Tribology and Maintenance Engineering</td>
<td>JIT</td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Instrument Technology</td>
<td>JID</td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Optoelectronics and Optical Communication</td>
<td>JOP</td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Polymer Science and Technology</td>
<td>JPT</td>
<td></td>
</tr>
<tr>
<td>M.Tech. in Telecommunication Technology Management</td>
<td>JTM</td>
<td></td>
</tr>
<tr>
<td>M.Tech. in VLSI Design Tools and Technology (*)</td>
<td>JVL</td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** (*) These are sponsored programmes.

**D. Master of Science (Research): M.S.(R)**

<table>
<thead>
<tr>
<th>Department/Schools</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied Mechanics</td>
<td>AMY</td>
</tr>
<tr>
<td>Bharti School of Telecommunication Technology and Management</td>
<td>BSY</td>
</tr>
<tr>
<td>Biochemical Engineering and Biotechnology</td>
<td>BEY</td>
</tr>
<tr>
<td>Chemical Engineering</td>
<td>CHY</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>CEY</td>
</tr>
<tr>
<td>Computer Science and Engineering</td>
<td>CSY</td>
</tr>
<tr>
<td>Electrical Engineering</td>
<td>EEY</td>
</tr>
<tr>
<td>Mechanical Engineering</td>
<td>MEY</td>
</tr>
<tr>
<td>Amar Nath and Shashi Khosla School of Information Technology</td>
<td>SIY</td>
</tr>
<tr>
<td>Kusuma School of Biological Sciences</td>
<td>BLY</td>
</tr>
</tbody>
</table>
E. Master of Design: (M.Des.)

| Department           | Programme                                      | Code |
|----------------------|------------------------------------------------|
| Interdisciplinary    | Master of Design in Industrial Design          | JDS  |

F. Master of Business Administration: (M.B.A.)

| Department             | Programme                                                      | Code |
|------------------------|----------------------------------------------------------------|
| Management Studies     | M.B.A.                                                          | SMG  |
|                        | M.B.A. (with focus on Telecommunication Systems Management)   | SMT  |
|                        | M.B.A. (with focus on Technology Management) (part-time and evening programme) | SMN  |

G. Master of Science: (M.Sc.)

<table>
<thead>
<tr>
<th>Department</th>
<th>Programme</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemistry</td>
<td>M.Sc. in Chemistry</td>
<td>CYS</td>
</tr>
<tr>
<td>Mathematics</td>
<td>M.Sc. in Mathematics</td>
<td>MAS</td>
</tr>
<tr>
<td>Physics</td>
<td>M.Sc. in Physics</td>
<td>PHS</td>
</tr>
</tbody>
</table>

H. Postgraduate Diploma

| Department            | Programme                                             | Code |
|-----------------------|-------------------------------------------------------|
| Applied Mechanics     | D.I.I.T (Naval Construction) (for candidates sponsored by the Indian Navy) | AMX  |

The DIIT is also awarded under special circumstances in every Master of Technology programme listed in item C above. It is awarded only to those students who have not been able to complete the requirements of the corresponding M.Tech. degree. For details please see Section 5.6.

I. Doctor of Philosophy: (Ph.D.)

All departments, centres and schools listed in Section 1.2 offer the Ph.D. programme. The two letter code of the academic unit followed by Z corresponds to the Ph.D. code of the respective academic unit. (e.g. MAZ is the Ph.D. code of the Mathematics Department).

1.4 Entry Number

The entry number of a student consists of eleven alpha-numerals, as described below:
In case of a programme change of a student, the programme code in his/her entry number (fields 5, 6 and 7) will be changed. However, his/her unique identification number will remain unchanged. Such students will have two entry numbers, one prior to programme change and one after the change. At any time, though, only one entry number, that corresponds to the student’s present status will be valid and active.

1.5 Honour Code

The Honour Code of IIT Delhi is given at the end of this document. Every student signs this Honour Code at the time of admission and is expected to adhere to the Honour Code throughout the period of his/her studies at the Institute.

2. COURSE STRUCTURE AND CREDIT SYSTEM

2.1 Course Numbering Scheme

Normally every course at IIT Delhi runs for the full length of the semester. Only exception is for V-type courses which may run for part of the semester. A student registers in advance for courses that he/she wants to study and at the end of the semester a grade is awarded. On obtaining a pass grade, the student earns all the credits associated with the course while a fail grade does not get any credit. Partial credits are not awarded.

Each course is denoted by a unique code consisting of three alphabets followed by three numerals:
(a) Codes for the nature of the course

Table 2: Codes for the nature of courses.

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>Project based courses (e.g. Major, Minor, Mini Projects)</td>
</tr>
<tr>
<td>L</td>
<td>Lecture courses (other than lecture hours, these courses can have Tutorial and Practical hours, e.g. L-T-P structures 3-0-0, 3-1-2, 3-0-2, 2-0-0, etc.)</td>
</tr>
<tr>
<td>N</td>
<td>Non-graded core component</td>
</tr>
<tr>
<td>P</td>
<td>Practical/Practice based courses (where performance is evaluated primarily on the basis of practice, practical or laboratory work with LTP structures such as 0-0-3, 0-0-4, 1-0-3, 0-1-3, etc.)</td>
</tr>
<tr>
<td>Q</td>
<td>Seminar Courses</td>
</tr>
<tr>
<td>R</td>
<td>Professional Practices</td>
</tr>
<tr>
<td>S</td>
<td>Independent Study</td>
</tr>
<tr>
<td>T</td>
<td>Practical Training</td>
</tr>
<tr>
<td>V</td>
<td>Lecture Courses on Special Topics (1 or 2 credits)</td>
</tr>
</tbody>
</table>

(b) Level of the course

The first digit of the numeric part of the course code indicates level of the course as determined by pre-requisite course(s) and/or by the maturity required for registering for the course. The latter requirement is enforced through a requirement of minimum number of earned credits. In general,

- 100 – 400 level courses: Core and elective courses for UG programmes. These courses are not open to any PG student.
- 500 level courses: Courses for M.Sc. programmes. These courses are not open to other students.
- 600 level courses: Preparatory/introductory courses for M.Tech. and advanced courses for M.Sc. programmes. 500 and 600 level courses are normally not open to UG students.
- 700 - 800 level courses: Core and elective courses for M.Tech., M.Des., M.B.A., M.S.(Research) and Ph.D. programmes. Usually 800 level courses are advanced courses for PG students.

2.2 Credit System

Education at the Institute is organized around the semester-based credit system of study. A student is allowed to attend classes in a course and earn credit for it, only if he/she has registered for that course. Prominent features of the credit system are a process of continuous evaluation of a student's performance/progress and flexibility to allow a student to progress at an optimum pace suited to his/her ability or convenience, subject to fulfilling minimum requirements for continuation and within the maximum allowable period for completion of a degree.

A student's performance/progress is measured by the number of credits that he/she has earned, i.e. completed satisfactorily. Based on the course credits and grades obtained by the student, grade point average is calculated. A minimum grade point average is required to be maintained for satisfactory progress and continuation in the programme. Also, a minimum number of earned credits and a minimum grade point average should be acquired in order to qualify for the degree. All programmes are defined by the total credit requirement and a pattern of credit distribution over courses of different categories as defined in sections 4 and 5 for UG and PG programmes respectively.

2.3 Assignment of Credits to Courses

Each course has a certain number of credit(s) or non-graded unit(s) assigned to it depending upon its lecture, tutorial and laboratory/practical contact hours in a week. This weightage is also indicative of the academic expectation that includes in-class contact and self-study outside class hours.
Lectures and Tutorials: One lecture or tutorial hour per week over the period of one 14 week semester is assigned one credit.

Practical/Practice: One laboratory/practice hour per week over the period of one 14 week semester is assigned half credit.

A few courses are without credit and are counted under non-graded (NG) courses.

Example: Course ELL100 Fundamentals of Electrical Engineering; 4 credits (3-0-2)

The credits indicated for this course are computed as follows:

- 3 hours/week lectures = 3 credits
- 0 hours/week tutorial = 0 credit
- 2 hours/week practicals = $2 \times 0.5 = 1$ credit

Total = $3 + 0 + 1 = 4$ credits

Total contact hours for the course = $(3 \text{ h Lectures} + 0 \text{ h Tutorial} + 2 \text{ h Practical})$ per week = 5 contact hours per week for 14 weeks.

For each lecture or tutorial credit, the self study component is 1-2 hours/week (for 100-600 level courses) and 3 hours/week (for 700-800 level courses). The self study component for practicals is 1 hour for every two hours of practicals per week. In the above example, the student is expected to devote a minimum of $3 + 1 = 4$ hours per week on self study in addition to class contact of 5 hours per week.

2.4 Earning Credits

At the end of every semester, a letter grade is awarded in each course for which a student had registered. On obtaining a pass grade, the student accumulates the course credits as earned credits. An undergraduate student has the option of auditing some courses within the credit requirements for graduation. Grades obtained in audit courses are not counted for computation of grade point average. However, a pass grade is essential for earning credits from an audit course. Section 2.9 defines the letter grades awarded at IIT Delhi and specifies the minimum grade for passing a course.

2.5 Description of Course Content

Course content description consists of following components: (i) Course Number, (ii) Title of the Course, (iii) Credit and L-T-P, (iv) Pre-requisites and overlapping courses, if any and (v) List of broad topics covered in the course. Content descriptions for all courses are given in section 10 of this document. An example course content description of a 100 level course is as follows:

**MTL100 Calculus**

4 Credits (3-1-0)

Review of Limit, Continuity and Differentiability, uniform continuity, Mean Value Theorems and applications, Taylor’s Theorem, maxima and minima, Sequences and series, limsup, liminf, convergence of sequences and series of real numbers, absolute and conditional convergence.

Riemann Integral, fundamental theorem of integral calculus, applications of definite integrals, improper integrals, beta and gamma functions.

Functions of several variables, limit and continuity, partial derivatives and differentiability, gradient, directional derivatives, chain rule, Taylor’s theorem, maxima and minima and method of Lagrange Multipliers.

Double and triple integration, Jacobian and change of variables formula. Parametrization of curves and surfaces, vector fields, divergence and curl, Line integrals, Green’s theorem, surface integral, Gauss and Stokes theorems with applications.
2.6 Pre-requisites

Each course, other than 100 level courses, may have specified pre-requisite(s) which may be other course(s) or a minimum number of earned credits or both. A student who has not obtained a pass grade in the pre-requisite(s) specified or has not earned requisite number of credits will not be eligible to register for that course. Example:

**TXL372 Speciality Yarns and Fabrics**

2 credits (2-0-0)

*Pre-requisites: TXL221/TXL222 and TXL231/TXL232 and EC50*

A student who has obtained a pass grade in TXL221 or TXL222, and in TXL231 or TXL232 and has also earned 50 credits will be eligible to register for this course.

For UG students the pre-requisites for some courses of special nature are given below.

- Independent Study: 65 earned credits
- Mini Project: 65 earned credits
- Minor Project (Dual Degree): 100 earned credits
- B.Tech. Project Part - I: 100 earned credits
- B.Tech. Project Part - II: B Grade in B.Tech. Project Part - I
- M.Tech. Major Project Part-I (Dual Degree): 135 earned credits

In addition to any pre-requisite specified for 700 and 800 level courses, a UG student needs to earn 75 and 100 credits to register for 700 and 800 level courses, respectively.

2.7 Overlapping/Equivalent Courses

Wherever applicable, overlapping and equivalent courses have been identified for each course. A student is not permitted to earn credits by registering for more than one course in a set of overlapping/equivalent courses. Departments/Centres/Schools may use these overlapping/equivalent courses for meeting degree/pre-requisite requirements in special circumstances. For example:

**CLL113 Numerical Methods in Chemical Engineering**

4 credits (3-0-2)

*Overlaps with: MTL107, MTP290, MTL445, CVL734, COL726*

A student who has earned a pass grade in CLL113 will not be eligible to register for MTL107, MTP290, MTL445, CVL734 or COL726. An overlapping course cannot serve as a substitute for a core course of his/her programme. In the above example, if MTL107 is a core course for a student, he/she is not allowed to register for CLL113 as a substitute for this core course.

2.8 Course Coordinator

Every course is usually coordinated by a member of the teaching staff of a Department/Centre/School in a given semester. This faculty member is designated as the Course Coordinator. He/she has the full responsibility for conducting the course, coordinating the work of other members of the faculty and teaching assistants involved in that course, administering assignments, conducting the tests as well as moderating and awarding the grades. For any difficulty related to a course, the student is expected to approach the respective course coordinator for advice and clarification. The distribution of the weightage for tests, quizzes, assignments, laboratory work, workshop and drawing assignment, term paper, etc. that will be the basis for award of grade in a course will be decided by the course coordinator of that course, in consultation with other teachers involved, and announced at the beginning of the semester.

2.9 Grading System

The grade obtained in a course reflects a student's performance in the course. While relative standing of the student is indicated by his/her grades, the process of awarding grades is not necessarily based upon fitting the marks scored by the students to some statistical distribution. The course coordinator and associated faculty for a course formulate appropriate procedure to award grades that are reflective of the student's performance vis-à-vis the expected learning outcomes of the course.
2.9.1 Grade points

The grades and their equivalent numerical points (referred to as Grade Points) are listed in Table 3.

Table 3: Grades and their description.

<table>
<thead>
<tr>
<th>Grade</th>
<th>Grade points</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>10</td>
<td>Outstanding</td>
</tr>
<tr>
<td>A (-)</td>
<td>9</td>
<td>Excellent</td>
</tr>
<tr>
<td>B</td>
<td>8</td>
<td>Very good</td>
</tr>
<tr>
<td>B (-)</td>
<td>7</td>
<td>Good</td>
</tr>
<tr>
<td>C</td>
<td>6</td>
<td>Average</td>
</tr>
<tr>
<td>C (-)</td>
<td>5</td>
<td>Below average</td>
</tr>
<tr>
<td>D</td>
<td>4</td>
<td>Marginal</td>
</tr>
<tr>
<td>E</td>
<td>2</td>
<td>Poor</td>
</tr>
<tr>
<td>F</td>
<td>0</td>
<td>Very poor</td>
</tr>
<tr>
<td>I</td>
<td>-</td>
<td>Incomplete</td>
</tr>
<tr>
<td>NP</td>
<td>-</td>
<td>Audit pass</td>
</tr>
<tr>
<td>NF</td>
<td>-</td>
<td>Audit fail</td>
</tr>
<tr>
<td>W</td>
<td>-</td>
<td>Withdrawal</td>
</tr>
<tr>
<td>X</td>
<td>-</td>
<td>Project/Ph.D. Continuation</td>
</tr>
<tr>
<td>S</td>
<td>-</td>
<td>Satisfactory completion</td>
</tr>
<tr>
<td>Z</td>
<td>-</td>
<td>Course continuation</td>
</tr>
<tr>
<td>U</td>
<td>-</td>
<td>Unsatisfactory progress in Ph.D.</td>
</tr>
</tbody>
</table>

2.9.2 Description of grades

A grade

An ‘A’ grade stands for outstanding achievement. The minimum marks for award of an ‘A’ grade is 80%. However, individual course coordinators may set a higher marks requirement for awarding an ‘A’ grade.

C grade

The ‘C’ grade stands for average performance. This is the minimum grade required to pass in the Major Project Part 1 and Part 2 of Dual degree and 2 year M.Tech. and M.S.(R) Programmes.

D grade

The ‘D’ grade stands for marginal performance; i.e. it is the minimum passing grade in any course excluding the M.Tech. Major Project. The minimum marks for award of ‘D’ grade is 30%. However, individual course coordinators may set a higher marks requirement.

E and F grades

A student who has scored at least 20% aggregate marks in a subject can be awarded an ‘E’ Grade. The Course Coordinators are, however, free to enhance this limit but should keep the percentage about 10% less than the cut-off marks for ‘D’ Grade. The Course Coordinators can also specify any additional requirements (to be specified at the beginning of the Semester) for awarding ‘E’ Grade. Students who obtain an ‘E’ Grade will be eligible to appear in a repeat major test (re-major test), an examination with weightage same as that of Major test, for only lecture courses (‘L’ Category Courses described in section 2.1). If they perform satisfactorily, they become eligible for getting the grade converted to a ‘D’ Grade, otherwise they will continue to have ‘E’ Grade. The student will have only one chance to appear for re-major for an ‘E’ Grade. The re-major test will be conducted within the first week of the next semester. The date of re-major test of Institute core courses for undergraduate students will be
centrally notified, while for all other courses, the date would be announced by the respective course coordinators. A student can appear for a maximum of three such re-major tests in a given semester. If a student cannot appear for the re-major test due to any reason(s), he/she will not get any additional chance.

If a student with E grade in a course does not pass the course through a re-major test, or obtains an ‘F’ grade in the course, he/she has to repeat the course if it is a core course. In case the course is an elective, the student may take the same course again or any other course from the same category. ‘E’ and ‘F’ Grades are not counted in the calculation of the CGPA; however, these are taken into account in the calculation of the SGPA. (see 2.10 for definitions)

I grade
An ‘I’ grade is temporarily awarded to a student on his/her request to denote incomplete performance in L (lecture), P (practical), V (special module) category courses. Requests for ‘I’ grade should be made at the earliest but not later than the last day of major tests. An ‘I’ grade is awarded in case of absence on medical grounds or other special circumstances, before or during the major examination period, provided the student has met the attendance criterion of the course. Attendance in the course for which ‘I’ grade is being sought will be certified by the course coordinator of the course. The course coordinators can instruct all students awarded ‘I’ grade as well as ‘E’ grade to appear for a common re-major test. All evaluation requirements for such students in the corresponding course(s) should be completed before the end of the first week of the next semester. Upon completion of all course requirements, the ‘I’ grade is converted to a regular grade (A to F, NP or NF).

NP and NF grades
These grades are awarded in a course that the student opts to audit. Only elective courses can be audited. Auditing a course is allowed until a date stipulated in the semester schedule. The audit pass (NP) grade is awarded if the student’s attendance is above 75% in the class and he/she has obtained at least a ‘D’ grade. The course coordinator can specify a higher criterion, at the beginning of the semester, for audit pass. If the stipulated requirements are not fulfilled, the audit fail (NF) grade is awarded. The grades obtained in an audit course are not considered in the calculation of SGPA, CGPA or DGPA. However, for undergraduate students, the credits will be counted in total earned credits in the respective category, subject to the maximum allowable limit for audit.

W grade
A ‘W’ grade is awarded in a course from which the student has opted to withdraw. Withdrawal from a course is permitted until the date specified in the Semester Schedule. Withdrawal from PG major project part 2 is allowed only if he/she is given semester withdrawal. The W grade is mentioned on the grade card.

X grade
The ‘X’ grade is awarded for incomplete work in Independent Study, Mini Project, Minor Project, or Major Project Part 1 and Part 2, based on the request of the student. On completion of the work, ‘X’ grade can be converted to a regular grade within the first week of the next semester. Otherwise, the student will be awarded ‘X’ grade on a permanent basis and it will appear in his/her grade card. Further, the student will be required to register for the course in the next semester. The credits of the course will be counted towards his/her total load for the semester. In case of Major Project Part 1, the student will not be permitted to register for Major Project Part 2 simultaneously as Major Project Part 1 is a pre-requisite for Major Project Part 2. A regular full-time student can be awarded ‘X’ grade only once in a course, other than the summer semester. A part-time M.Tech. student is permitted a maximum of two X-grades in the major project part-2.

S and Z grades
The ‘S’ grade denotes satisfactory performance and completion of a course. The ‘Z’ grade is awarded for non-completion of the course requirements, and if it is a core course, the student will have to register for the course until he/she obtains the ‘S’ grade. The specific courses in which ‘S’ or ‘Z’ grades are awarded for undergraduate students are:

(i) Introduction to Engineering and Programme
(ii) Language and writing skills
(iii) NCC/NSO/NSS
(iv) Professional Ethics and Social Responsibility
(v) Communication Skills/Seminar
(vi) Design/Practical Experience

Besides, summer/winter internships in some PG programmes are also awarded S/Z.
2.10 Evaluation of Performance

The performance of a student will be evaluated in terms of three indices, viz., the Semester Grade Point Average (SGPA) which is the Grade Point Average for a semester, Cumulative Grade Point Average (CGPA) which is the Grade Point Average for all the completed semesters at any point in time, and Degree Grade Point Average (DGPA). Degree Grade Point Average (DGPA) is calculated on the basis of the best valid credits in each category, after graduation requirements in all categories are met.

The Earned Credits (E.C.) are defined as the sum of credits for courses in which a student has been awarded pass grades. Points secured in a semester = Σ (Course credits × Grade point for all courses in which pass grade has been obtained). The SGPA is calculated on the basis of grades obtained in all courses the student registered for, in the particular semester, except audit courses.

\[
SGPA = \frac{\text{Points secured in the semester}}{\text{Credits registered in the semester, excluding audit and S/Z grade courses}}
\]

The CGPA is calculated on the basis of pass grades obtained in all completed semesters, except audit courses and courses in which S/Z grade is awarded.

\[
CGPA = \frac{\text{Cumulative points secured in courses with pass grades}}{\text{Cumulative earned credits, excluding audit and S/Z grade courses}}
\]

Examples of these calculations are given in Tables 4(a) and 4(b).

Table 4: (a) Typical academic performance calculations - I semester

<table>
<thead>
<tr>
<th>Course no.</th>
<th>Course credits</th>
<th>Grade awarded</th>
<th>Earned credits</th>
<th>Grade points</th>
<th>Points secured</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(column 1)</td>
<td>(column 3)</td>
<td>(column 4)</td>
<td>(column 5)</td>
<td>(column 6)</td>
</tr>
<tr>
<td>MTLXXX</td>
<td>5</td>
<td>C</td>
<td>5</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>COLXXX</td>
<td>4</td>
<td>C (-)</td>
<td>4</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>PYLXXX</td>
<td>4</td>
<td>A</td>
<td>4</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>PYPXXX</td>
<td>2</td>
<td>B</td>
<td>2</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>MCLXXX</td>
<td>4</td>
<td>E</td>
<td>0</td>
<td>2</td>
<td>08</td>
</tr>
<tr>
<td>TXNXXX</td>
<td>2</td>
<td>S</td>
<td>2</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Credits registered in the semester (total of column 2) = 21
Credits registered in the semester excluding audit and S/Z grade courses = 19
Earned credits in the semester (total of column 4) = 17
Earned credits in the semester excluding audit and S/Z grade courses = 15
Points secured in the semester (total of column 6) = 114
Points secured in the semester in all passed courses (total of column 6 and pass grade) = 106

\[
SGPA = \frac{\text{Points secured in the semester}}{\text{Credits registered in the semester, excluding audit and S/Z grade courses}} = \frac{114}{19} = 6.000
\]

\[
CGPA = \frac{\text{Cumulative points secured in courses with pass grades}}{\text{Cumulative earned credits, excluding audit and S/Z grade courses}} = \frac{106}{15} = 7.067
\]

Semester performance: Earned credits (E.C.) = 17  SGPA = 6.000
Cumulative performance: Earned credits (E.C.) = 17  CGPA = 7.067
Table 4: (b) Typical academic performance calculations - II semester

<table>
<thead>
<tr>
<th>Course no.</th>
<th>Course credits</th>
<th>Grade awarded</th>
<th>Earned credits</th>
<th>Grade points</th>
<th>Points secured</th>
</tr>
</thead>
<tbody>
<tr>
<td>(column 1)</td>
<td>(column 2)</td>
<td>(column 3)</td>
<td>(column 4)</td>
<td>(column 5)</td>
<td>(column 6)</td>
</tr>
<tr>
<td>MTLXXX</td>
<td>5</td>
<td>B</td>
<td>5</td>
<td>8</td>
<td>40</td>
</tr>
<tr>
<td>ELLXXX</td>
<td>4</td>
<td>A (-)</td>
<td>4</td>
<td>9</td>
<td>36</td>
</tr>
<tr>
<td>CMLXXX</td>
<td>4</td>
<td>W</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>CMPXXX</td>
<td>2</td>
<td>B (-)</td>
<td>2</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>MCLXXX</td>
<td>4</td>
<td>C</td>
<td>4</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>APLXXX</td>
<td>4</td>
<td>A</td>
<td>4</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>NLNXX</td>
<td>1</td>
<td>S</td>
<td>1</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

Credits registered in the semester (total of column 2) = 24
Credits registered in the semester excluding audit and S/Z grade courses = 23
Earned credits in the semester (total of column 4) = 20
Earned credits in the semester excluding audit & S/Z grade courses = 19
Points secured in this semester (total of column 6) = 154
Points secured in this semester in all passed courses (total of column 6 & A-D grade) = 154
Cumulative points secured = 106 (I semester) + 154 (this sem.) = 260
Cumulative earned credits = 17 (I semester) + 20 (this sem.) = 37

\[
SGPA = \frac{Points \text{ secured in the semester}}{Credits \text{ registered in the semester, excluding audit and S/Z grade courses}} = \frac{154}{19} = 8.105
\]

\[
CGPA = \frac{Cumulative \text{ points secured in courses with pass grades}}{Cumulative \text{ earned credits, excluding audit and S/Z grade courses}} = \frac{106 + 154}{15 + 19} = 7.647
\]

Semester performance: Earned credits (E.C.) = 20 \hspace{1cm} SGPA = 8.105
Cumulative performance: Earned credits (E.C.) = 37 \hspace{1cm} CGPA = 7.647

On completing all the degree requirements, the degree grade point average, DGPA, will be calculated and this value will be indicated on the degree/diploma. The DGPA will be calculated on the basis of category-wise best valid credits required for graduation.

A student who has earned the requisite credits but does not meet the graduation DGPA requirement may do additional courses in any elective category to meet the DGPA requirement within the maximum permissible time limit.

3. REGISTRATION AND ATTENDANCE

3.1 Registration

Registration is a very important procedural part of the academic system. The registration procedure ensures that the student's name is on the roll list of each course that he/she wants to study. No credit is given if the student attends a course for which he/she has not registered. Registration for courses to be taken in a particular semester will be done according to a specified schedule before the end of the previous semester. Each student is required to complete the registration process on the web based system. The student must also take steps to pay his/her dues before the beginning of the semester. Students who do not make payments by a stipulated date can be de-registered for the particular semester.
In-absentia registration or registration after the specified date will be allowed only in rare cases at the discretion of Dean, Academics. In case of illness or absence during registration, the student should intimate the same to his/her Programme coordinator and Dean, Academics.

Brief description of registration related activities is given in the following paragraphs. The relevant dates are included in the Semester Schedule that is made available before the start of the semester. There may be changes in the schedule and/or procedure of registration from time to time. The students are intimated through e-mail about any such change to the e-mail address allocated to each student by the Institute at the time of admission. This e-mail address is the only channel through which the Institute would communicate with the student. For cyber security reasons, e-mail accounts/kerberos logins that are not used for a certain length of time are disabled and such accounts locked/deleted by the Institute. Students must therefore login into their e-mail accounts/kerberos logins regularly.

3.2 Registration and Student Status

Failure to register before the last date for late registration will imply that the student has discontinued studies and his/her name will be struck-off the rolls.

All registered students, except part-time postgraduate students and casual students, are considered as full-time students at the Institute. They are expected to be present at the Institute and devote full time to academics and co-curricular and extra curricular activities in the campus.

3.3 Advice on Courses

At the time of registration, each student must finalize the academic programme, keeping in view factors such as, minimum/maximum numbers of total and lecture credits, past performance, backlog of courses, SGPA/CGPA, pre-requisite(s), work load and student’s interests, amongst others. Special provisions exist for advising academically weak students. Details are given in section 4.7.

3.4 Validation of Registration

Before the commencement of classes of each semester, on a date specified in the Semester Schedule, every student including part-time students, is required to be present on campus and validate his/her registration by logging into the website. Students who do not do registration validation will not be permitted to add/drop courses.

3.5 Minimum Student Registration in a Course

Undergraduate courses (of 100, 200, 300, or 400 level) and M.Sc. courses (500 or 600 level) will run if a minimum of 12 students register for the course. Under special circumstances, a departmental elective course may be allowed to run with minimum registration of 8 students, with prior permission of Chairman, Senate. A 700 or 800 level course can run with a minimum of 4 students. This requirement will be verified on the last date for Add/Drop. Courses without the minimum enrolment will be dropped. The students who had registered for these courses will be de-registered, and they will be given one more day for adding a course in lieu of the dropped course.

3.6 Late Registration

For reasons beyond his/her control, if a student is not able to register or send an authorized representative with a medical certificate, he/she may apply to the Dean, Academics for late registration. Dean, Academics will consider and may approve late registration in genuine cases on payment of an extra fee called late registration fee. Late registration is permitted until a date specified in the Semester Schedule, typically one week after the beginning of the semester.

3.7 Add / Drop, Audit and Withdrawal of Courses

a) **Add/Drop**: A student has the option to add courses that he/she has not registered for, or drop courses for which he/she has already registered for. This facility is restricted to a period stipulated in the Semester Schedule, during the first week of the semester, subject to vacancy status of the courses concerned.
b) **Audit**: A student may apply for changing a credit course to an audit course before a deadline specified in the Semester Schedule.

c) **Withdrawal**: A student who wants to withdraw from a course should apply before a deadline specified in the Semester Schedule. A withdrawal grade (W) will be awarded in such cases.

Appropriate web-based applications are to be used for availing of the above-mentioned options.

### 3.8 Semester Withdrawal

Semester withdrawal and absence for a semester under different conditions, viz. (i) medical and personal grounds (ii) industrial internship (iii) exchange/deputation to another academic institution in India or abroad, and (iv) disciplinary condition can be granted on application. The condition as per the following should be clearly specified in the application.

(a) Semester Withdrawal (SW) reflects the condition, in which a student is forced to withdraw from all courses in the semester for medical conditions, or for a part-time student when he/she is sent for an outstation assignment by his/her employer. A student can apply for semester withdrawal if he/she has missed 20 or more teaching days on these grounds. Under no circumstances will an application for semester withdrawal be accepted after the commencement of major tests. A student is not permitted to request for semester withdrawal with retrospective effect.

(b) Semester Leave (SL) indicates the situation in which a student is permitted to take one or more semesters off for industrial internship or any other assignment with prior approval and planning. The application is to be routed through his/her advisor/programme coordinator and Head of the concerned Department/Centre/School. Dean, Academics is the final approving authority for such requests. All such applications must be processed before the beginning of the semester in which the leave will be taken. At present, JEE-entry B.Tech. and dual degree students are allowed one extra semester for completion of the programme for every semester leave for industrial internship. Such students are permitted a maximum of two semesters of leave. The full-time 2 year M.Tech./M.S.(R) students would be permitted a maximum of one semester leave for industrial internship or other assignment as approved by the Dean. These semesters will not be counted towards the maximum permitted time period for completion of the degree similar to the provision for JEE entry students.

(c) When a student registers at another academic institution in India or abroad with the expectation of credit transfer or research work through a pre-approved arrangement including an MoU, the student should be considered as being on a Semester Exchange (SE). The SE period will be counted towards the total period permitted for the degree.

(d) When a student is suspended for one or more semesters on disciplinary grounds, the student status should be called Disciplinary Withdrawal period (DW).

### 3.9 Registration in Special Module Courses

Special module courses, i.e. ‘V’-category courses, are 1 or 2 credit courses that can be offered at the beginning of the semester and the regular registration procedure will be followed. A ‘V’-category course may also be offered during the semester. In such a case, students will be allowed to add this course before classes for the course begin. These courses will usually cover specialized topics that are not generally available in the regular courses. Eligible students can register for these courses. The course coordinator will evaluate the students’ performance and award a letter grade. The credits so earned will count towards the appropriate category for degree completion purposes.

### 3.10 Registration for Non-Graded Units

Details pertaining to registration and other modalities of earning non-graded units are given in section 8 of this booklet.

### 3.11 Pre-requisite Requirement(s) for Registration

A student can register for a course only if he/she fulfills the pre-requisite requirement(s). Request for relaxation of pre-requisite requirement(s) may be raised by students under special circumstances. Such a request needs approval of the Departmental Faculty Advisor and Chairman Grades and Registration.

### 3.12 Overlapping/Equivalent Courses

A student is not allowed to earn credits from two overlapping/equivalent courses. Overlapping/equivalent courses, wherever applicable, are specified in the Description of Course Contents.
3.13 Limits on Registration

An undergraduate student (B.Tech. or Dual Degree) should register for a minimum of 12 credits in a semester. The maximum number of credits permitted for a UG student in a semester is 26, with a provision to register for up to 28 credits in a maximum of two semesters during the entire period of their study. This number would be reduced to a maximum of 1.25 times the average credits earned by the student in the past two registered semesters, in case the student is placed on probation on the basis of academic performance.

3.14 Registration and Fee Payment

Every registered student must pay the stipulated fees in full before the specified deadlines. In the event that a student does not make these payments, he/she can be de-registered from all courses and his/her name can be struck off from the rolls.

3.15 Continuous Absence and Registration Status

If a student is absent from the Institute for more than four weeks without notifying the Head of Department/Centre/ School or Dean, Academics his/her registration will be terminated and name will be removed from the Institute rolls.

3.16 Attendance Rule

It is mandatory for the students to attend all classes. Attendance Records of all students for each course will be maintained.

The Course Coordinator will announce the class policy on attendance with respect to grading etc., at the beginning of the semester. This shall be done keeping in mind the importance of classroom learning in the teaching-learning process. Once the class attendance policy has been made clear to all the students registered for the course, the Course Coordinator will implement the same in totality.

For the purpose of attendance calculation, every scheduled practical class will count as one unit irrespective of the number of contact hours.

Attendance record will be maintained based upon roll calls (or any equivalent operation) in every scheduled lecture, tutorial and practical class. Students are required to strictly adhere to and comply with any method or device employed by the Course Coordinator/Instructor for purpose of Attendance Recording. Failure to do so may call for disciplinary action. The course coordinator will maintain and consolidate attendance record for the course (lectures, tutorials and practicals together, as applicable).

A Course Coordinator may choose any one or more of the following as attendance policy.

(a) The Course Coordinator can assign 10% of the total marks to surprise quiz(zes). If attendance of the student is greater than 90%, result of the best three quizzes will be considered, else average of all quizzes will be considered.

(b) The Course Coordinator can allocate specific marks for participation in discussions in the class on a regular basis.

(c) If a student’s attendance is less than 75%, the student will be awarded one grade less than the actual grade that he/she has earned. For example, a student who has got A grade but has attendance less than 75% will be awarded A (-) grade.

(d) A student cannot get NP for an audit course if his/her attendance is less than 75%.

The Course Coordinator can implement any other attendance policy provided the policy is approved by the Dean, Academics.

Attendance statistics will also be used in the following way:

(a) If a student’s attendance is less than 75% in more than two courses without any valid reason in a semester, he/she will be issued warning and put under probation. If this is repeated, he/she will not be allotted a hostel seat in the next semester.
(b) If a student’s attendance is less than 75% in any course or CGPA is less than 7.0, then he/she will not be eligible to hold any position of responsibility in the hostel/institute in the next semester.

4. UNDERGRADUATE DEGREE REQUIREMENTS, REGULATIONS AND PROCEDURES

4.1 Overall Requirements

4.1.1 B.Tech.

The total credit requirement for the B.Tech. (4-year programme) is 145-155 credits (exact requirement is discipline specific). The minimum and maximum number of registered semesters for graduation requirements are listed in Table 7. For B. Tech. programmes, the total credits are distributed over following categories:

(a) Institute Core (IC):
- Basic Sciences (BS): Mathematics, Physics, Chemistry and Biology courses
- Engineering Arts and Science (EAS): Fundamental engineering courses
- Humanities and Social Sciences (HUSS): At least two courses to be taken in the 200 level and at least one course to be taken in the 300 level. Management Courses (MSL 3XX) are not counted under this category.

(b) Departmental Core (DC): courses of relevant discipline.

(c) Departmental Electives (DE): electives related to the parent discipline.

(d) Programme linked basic sciences/EAS (PL): additional BS/EAS courses that are specified by the department.

(e) Open Category (OC): electives can be taken outside or within the discipline; these credits can be used towards departmental specialization or minor area also (see Sec 4.6).

(f) Non-graded Core (NG) units: These are core requirements and can be earned through formal academic activity and informal co-curricular or extra-curricular activities.

4.1.2 Dual degree programmes:

The total credit requirements for a dual degree programme would depend upon the credit requirements of the B.Tech. and M.Tech. programmes that constitute the Dual Degree. The minimum credit requirement for the award of Dual Degree would typically be 10 less than the total credits of the constituent B.Tech. and M.Tech. programmes. The B.Tech. requirements for a dual degree are same as that given in Section 4.1.1. The M.Tech. part is divided into two categories – Programme Core (PC) and Programme Elective (PE). The minimum and maximum number of registered semesters for graduation requirements are listed in Table 7.

4.2 Breakup of Degree Requirements

4.2.1 Earned Credit Requirements

The minimum earned credit/unit requirements for B.Tech. degree are given in Table 5.

<table>
<thead>
<tr>
<th>Category</th>
<th>Symbol</th>
<th>B. Tech. Requirements</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Institute Core</td>
<td>IC</td>
<td>55 Credits</td>
<td>Common to all disciplines</td>
</tr>
<tr>
<td>2 Programme Linked EAS/BS</td>
<td>PL</td>
<td>0-15 Credits</td>
<td>Discipline specific as decided by the Department</td>
</tr>
<tr>
<td>3 Departmental core</td>
<td>DC</td>
<td>65-80 with min 10 as DE</td>
<td>Discipline specific</td>
</tr>
<tr>
<td>4 Departmental Elective</td>
<td>DE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 Open Category</td>
<td>OC</td>
<td>10 Credits</td>
<td>Open to student’s choice</td>
</tr>
<tr>
<td>6 Non-graded Core</td>
<td>NG</td>
<td>15 units</td>
<td>See Sec. 4.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>145-155 Credits +15 nongraded units</td>
<td></td>
</tr>
</tbody>
</table>
4.2.2 Degree Grade Point Average (DGPA) Requirement

A student must obtain a minimum DGPA of 5.0 to be eligible for award of the B.Tech. degree. The minimum DGPA requirement for M.Tech. part of dual degree programme is 6.0. All exceptions to the above conditions will be dealt with as per following regulations:

(a) If a student completes required credits for B.Tech. with DGPA less than 5.0, then the student will be permitted to do additional elective courses under appropriate category to improve the DGPA within the maximum time limit for completion of B.Tech. degree. In case a DGPA of 5.0 or more is achieved within the stipulated period, a B.Tech. degree will be awarded and in case the same is not achieved no degree will be awarded and the student may apply for a diploma.

(b) If a student completes requisite credits for Dual Degree Programme:

(i) with B. Tech. DGPA less than 5.0 but M. Tech. DGPA more than 6.0
The student will be permitted to do additional elective courses (under appropriate category) to improve the DGPA for completion of B.Tech. part within the maximum time limit. In case a DGPA of 5.0 or more is achieved for B.Tech., the student will become eligible for award of the Dual Degree (B.Tech. & M. Tech.) and in case the same is not achieved no degree will be awarded and the student may apply for a diploma.

(ii) with B. Tech. DGPA more than 5.0 but M. Tech. DGPA less than 6.0
The student may opt to do additional elective courses (PE category only) to improve the DGPA within the maximum time limit. If no programme elective (PE) courses are available, other relevant 700 and 800 level courses as approved by the department can be done for the purpose of improving the DGPA. In case DGPA of 6.0 or more is achieved for the M.Tech. part, the student will be eligible for award of the Dual Degree (B.Tech. & M.Tech.). However, in case the same is not achieved at the end of the stipulated period, the student will be eligible for the award of only B.Tech. degree, provided a written request for the same is made to the Dean, Academics.

(iii) with B. Tech. DGPA less than 5.0 and M. Tech. DGPA less than 6.0
The student will be permitted to do additional elective courses under appropriate categories to improve the DGPA for completion of B.Tech. and courses under PE category for completion of M.Tech. degree within the maximum time limit. If no programme elective courses are available, relevant 700 and 800 level courses as approved by the department can be done for the purpose of improving the DGPA. In case a DGPA of 5.0 or more for B.Tech. and 6.0 or more for M.Tech. are achieved, the student will be eligible for award of the Dual Degree (B.Tech. & M.Tech.). However, in case a DGPA 5.0 or more for B.Tech. is achieved but the DGPA of 6.0 or more for M.Tech. is not achieved at the end of stipulated period, the student will be eligible for award of only B.Tech. degree provided a written request for the same is made to the Dean, Academics.

(c) A student may be permitted to do additional elective courses under appropriate elective categories for improving DGPA, even if he/she satisfies all graduation requirements. The student may be permitted to register for courses in the additional semesters, up to the maximum limit in terms of registered semesters for improving his/her DGPA provided a request for the same is made to the Dean, Academics within 15 days of the notification of grades in the final semester. During this period when the student is registered for improving DGPA, no hostel facilities or assistantship will be provided to the student.

(d) A student is eligible to apply for a Diploma provided he/she has earned 100 credits and has exhausted the maximum number of permitted registered semesters for completion of his/her degree. If the student has completed 50 credits (out of 100 credits) from his/her DC+DE+PC+PE categories then the student will be awarded ‘Undergraduate Diploma in the respective discipline’ on completion. If the student has not completed 50 credits from these categories but has completed 100 credits then he/she will be awarded ‘Undergraduate Diploma in Engineering’. The Diploma is not equivalent to an undergraduate degree.

(e) No self-study course will be permitted for the purpose of improvement of DGPA.

4.2.3 Audit Courses

Audit facility is open to all undergraduate students who have 85 Earned Credits. A student will be permitted to do any number of audit courses over and above the graduation requirements. The audit limits for graduation are:

(a) B.Tech. (4-year) programme: A maximum of 8 credits from the elective courses in any category out of the total credits required for B.Tech. degree may be completed on audit basis.
(b) Dual-degree programme: A maximum of 8 credits from the elective courses in any category may be completed on audit basis from the UG part of the programme.

(c) A student earns either an NP (audit pass) or an NF (audit fail) grade for an audit course. The audit pass (NP) grade may be awarded if the student satisfies the attendance criteria specified for the course and he/she has obtained at least a 'D' grade. The course coordinator can specify a higher criterion for audit pass at the beginning of the semester. If either of these requirements is not fulfilled, the audit fail (NF) grade is awarded.

(d) Grades obtained in an audit course are not considered in the calculation of SGPA or CGPA.

4.3 Non-graded Core Requirement

As part of the curriculum, non-graded units have been prescribed as core requirements for the undergraduate degree. These units can be earned through a combination of formal academic activity and informal co-curricular or extra-curricular activities. The components of non-graded core requirement are listed in Table 6.

Table 6: Components of Non-Graded Core Requirement

<table>
<thead>
<tr>
<th>Components</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Introduction to the Engineering and Programme</td>
<td>02</td>
</tr>
<tr>
<td>2 Language and Writing Skills</td>
<td>02</td>
</tr>
<tr>
<td>3 NCC/NSO/NSS</td>
<td>02</td>
</tr>
<tr>
<td>4 Professional Ethics and Social Responsibility</td>
<td>02</td>
</tr>
<tr>
<td>5 Communication Skills/Seminar</td>
<td>02</td>
</tr>
<tr>
<td>6 Design/Practical Experience</td>
<td>05</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>15</strong></td>
</tr>
</tbody>
</table>

The 15 units listed in Table 6 will be core requirement for all undergraduate programmes. A student must earn these 15 units over the complete duration of the programme with special considerations and requirements for each component. A student must get S grades to earn these units. Incomplete performance in these components will be indicated by a Z grade. A brief description of the six components is given below.

(a) Introduction to Engineering (NIN100) (1 unit)

All students will be required to undergo exercises in the first semester, for earning 1 unit. These may involve listening to lectures, developing project reports based upon self-study, visit to laboratories (in and outside the Institute) and industry, executing simple scientific or engineering projects.

Introduction to Programme (XXN101) (1 unit)

This would be discipline specific introduction to programme. This would be offered in the third semester. In the Course no, ‘XX’ is the Course code prefix as shown in Table 1. An exception to this are the ME2 and EE3 Programmes, for which the course number would be MCN111 and ELN111 respectively.

(b) Language and Writing Skills (NLN100–101) (2 units)

All students will be required to undergo exercises in the first year, spanning over two semesters. These exercises will be designed to impart language skills – enhancing their ability of listening comprehension, reading and writing in English. Further, students will be exposed to principles of English Grammar and nuances of technical writing. These exercises will be tailored according to the background of the students. The background of the students will be assessed through a test to be conducted at the beginning of the first semester. These exercises can be organized either during normal academic hours or outside. A student can be prescribed self learning exercises or additional practice sessions during vacations as requirement for securing an S grade.

(c) NCC/NSO/NSS (NCN100/NSN100/NPN100) (2 units)

NCC/NSO/NSS will form part of core requirement of the degree. Students will be required to earn 2 units from these activities. The faculty coordinator will devise a scheme for awarding these units.
(d) **Professional Ethics and Social Responsibility (2 units)**

There is increasing consensus worldwide that professional ethics need to be incorporated into the engineering curriculum to provide students exposure to the kind of professional ethical dilemmas they might face on an individual basis as well as the larger ethical aspects of technology development. Workshops, discussions/debates will be organized to sensitize students about Professional Ethics and Social Responsibility. This course will be also associated with 2 units implying total involvement of about 100 hours. Involvement of students in these activities will be monitored by the coordinator for awarding the S grade.

**Part 1 : Regular Classroom Contact (NEN100-101) (1 unit)**

The first part of PESR involves regular sessions of 1.5-2 hours with a faculty mentor. Activities in the sessions would be decided by the faculty mentor, with a total of 14-15 hours in regular sessions in each of the first two semesters. NEN100 and NEN101 are compulsory for all students, and a student will earn one unit by getting S grade in both these courses.

**Part 2 : Case Studies and Practical/Field Activity (NEN300 and NEN201/NEN202/NEN203)**

The Second unit under PESR has two components. The first component, Professional Ethics Case Studies, is compulsory, and is offered under the course number NEN300. For the second component, the student can choose to participate in any one out of a large variety of activities relevant to the core themes of PESR. These activities have been divided into three broad categories, viz. (a) PESR internships (b) PESR workshops and (c) PESR projects with separate course numbers NEN201, NEN202 and NEN203 respectively. All requirements of PESR non-graded component should be completed before the beginning of 7th semester.

(e) **Communication Skills (2 units)**

Communication skills are an essential requirement for a modern engineer. As a part of the degree requirements, undergraduate students will have to earn 2 units in communication skills.

(i) Students need to register for at least one topic-specific seminar course in his/her parent department for earning one unit. These courses will be elective, offered in each semester. These seminar sessions will be held for two hours per week. Multiple such courses can run in parallel. These seminars will be open to all students and faculty of IIT Delhi. These seminars can be scheduled outside office hours as well.

(ii) Further, students can earn the remaining one unit through any one of the following means:

- By successfully undergoing a Communication Skills course/workshop as an activity approved by Dean, Academics.
- By documentary evidence of excellence in debating and/or writing as certified by faculty in-charge of these activities.
- By participating in course seminars of regular courses the student is attending; for example regular L courses can have optional seminar component.
- Registering and completing a seminar course offered by any Department/Centre/School.

A student will be required to earn these units during his/her 5th to 8th registered semester.

(f) **Design and Practical Experience (5 units)**

The objective of this non-graded core requirement component is to give opportunities to students to acquire substantial design and practical experience both as a part of formal courses as well as in an informal setting. Second and even more important objective of this course is to inculcate design thinking among students and facilitate gaining some design immersion experience. Design and Practical Experience (DPE) component is introduced to promote learning by doing which does two important things: it allows students to immerse themselves in the environment in which work is to be done, so that they can understand the values and expectations of the target beneficiaries. Secondly, it enables a fresh look at problems, not only at the ways of defining them, but also at the ways to solve those including skill-sets that are required to address them. A shift from problem based learning (acquisition of knowledge) to project based learning (application of knowledge), where the projects are grounded in problems outside the classrooms and
labs in everyday scenarios, will involve students in reality, and reality in education. Design and Practical Experience bridges division between the curricular and the co-curricular, and encourages curiosity and involvement that arise out of total absorption in a subject of interest. Non-graded units in Design and Practical Experience can be earned through one or more the following:

- Specialized Elective Courses related to Design and Practical Experience (Maximum 2 Units)
- Regular Courses with optional Design and Practical Experience Component (Maximum 2 Units)
- Summer/winter/semester/SURA/DISA projects with Institute faculty, not evaluated for earning credits (Maximum 2 units)
- Co-curricular projects such as Robocon, SAE-mini-baja, etc. (Maximum 2 Units)
- Summer Internships with Industry (Maximum 2 Units)
- One Semester Internship (Maximum 5 Units)
- Workshop Module on Design and Practical Experience offered by Faculty/Visitors (1 Unit each)

4.4 Minimum and Maximum durations for completing degree requirements

(a) The minimum and maximum permitted duration of each academic programme will be determined in terms of number of registered regular semesters, hereinafter called registered semesters. Any semester in which a student has registered for a course will be called a registered semester subject to the following:

(i) Only the First and Second semesters of an academic year can be registered semesters. The summer semester will not be counted as a registered semester.

(ii) A semester when a student has been granted semester withdrawal or granted semester leave will not be considered as a registered semester.

(iii) The semester when a student is suspended from the Institute on disciplinary grounds will not be counted towards the number of registered semesters.

(iv) A semester in which a student is allowed by the Institute to undergo semester-long internship will be counted as a registered semester.

The summer semesters shall normally be available for earning credits. However, after the student has registered for the maximum permissible number of registered semesters, the subsequent summer semesters will not be available for earning credits.

(b) The minimum and maximum permissible number of registered semesters for completing all degree requirements are defined in Table 7.

<table>
<thead>
<tr>
<th>Programme Name</th>
<th>Minimum Number of Registered Semesters</th>
<th>Maximum Number of Registered Semesters Permitted for Completing Degree Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.Tech.</td>
<td>8</td>
<td>12*</td>
</tr>
<tr>
<td>Dual Degree</td>
<td>12</td>
<td>14*</td>
</tr>
</tbody>
</table>

*If a student opts for the slow-paced programme, then the maximum permissible number of registered semesters shall be increased by two semesters.

4.5 Absence During the Semester

(a) A student must inform the Dean, Academics immediately of any instance of continuous absence from classes.

(b) A student who is absent due to illness or any other emergency, up to a maximum of two weeks, should approach the course coordinator for make-up quizzes, assignments and laboratory work.

(c) A student who has been absent from a minor test due to illness should approach the course coordinator for a make-up test immediately on return to class. The request should be supported with a medical certificate from Institute’s medical officer. A certificate from a registered medical practitioner will also be acceptable.
for a student normally residing off-campus provided registration number of the medical practitioner appears explicitly on the certificate.

(d) In case a student misses a minor test on the same day on which he/she has appeared in another test, a medical certificate from the institute’s medical officer will only be acceptable.

(e) In case of absence on medical grounds or other special circumstances, before or during the major examination period, the student can apply for 'I' grade. At least 75% attendance in a course is necessary for being eligible for request of 'I' grade in that course. An application requesting 'I' grade should be made at the earliest but not later than the last day of major tests. An online application should be made by the student. On submission of a medical certificate/Dean’s permission, the UG section verifies the certificate and forwards the request to the concerned course coordinator. The course coordinator verifies the attendance requirement and forwards the application to the Head of the Department/Center/School of the student’s programme. Head’s approval is contingent upon the satisfaction of attendance requirement. On approval, an 'I' grade is awarded to the student. All evaluation requirements for students with 'I' grade should be completed before the end of the first week of the next semester. Upon completion of all course requirements, the 'I' grade is converted to a regular grade (A to F, NP or NF).

(f) In case the period of absence on medical grounds is more than 20 working days during the semester, a student may apply for withdrawal from the semester, i.e. withdrawal from all courses registered that semester. Such application must be made as early as possible and latest before the start of the major tests. No applications for semester withdrawal will be considered after the major tests have commenced. Dean, Academics, depending on the merit of the case, will approve such applications. Partial withdrawal from courses registered in a semester is not allowed.

(g) If a student is continuously absent from the institute for more than four weeks without notifying the Dean Academics, his/her name will be removed from institute rolls.

4.6 Conditions for Continuation of Registration, Termination / Re-start, Probation and Warning

During the first two registered semesters of an undergraduate programme, a student is registered for a total of 34 credits, besides non-graded units. By the end of the first two registered semesters, not including summer, a student is expected to earn a minimum number of credits (excluding non-graded units) as specified in Table 8, in order to continue registration. If a student does not meet this criterion, his/her performance is classified as “Poor Performance”, and he/she may opt to start the programme afresh, or else his/her registration will be terminated. This option to re-start the programme is available to a student only once.

Table 8 : Criteria for continuation at the end of second registered semester

<table>
<thead>
<tr>
<th>Description</th>
<th>Earned Credits (excluding non-graded units)</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GE/OBC</td>
<td>SC/ST/PD</td>
</tr>
<tr>
<td>Minimum for Continuation</td>
<td>23</td>
<td>19</td>
</tr>
<tr>
<td>Poor Performance</td>
<td>≤ 22</td>
<td>≤ 18</td>
</tr>
</tbody>
</table>

(a) If a student chooses to restart after the first two registered semesters, then his/her credits earned and semesters registered will not be carried over. The re-start will be indicated on the transcript. The re-start will be permitted only once. If at the end of two registered semesters after re-start, the earned credits are less than or equal to 22 for GE/OBC or less than or equal to 18 for SC/ST/PD students, then the registration will be terminated.

(b) Each student is expected to earn at least 12 credits in each registered semester with an SGPA greater than or equal to 5.0. If the performance of a student at the end of any registered semester is below this minimum acceptable level, then he/she will be placed on probation, a warning shall be given to him/her and intimation sent to the parents.
(c) A student placed on probation shall be monitored, including mandatory attendance in classes, special tutorials and mentoring. Mentoring would comprise structured guidance under a senior/postgraduate student.

(d) If the performance of a student on probation does not meet the criterion in item (b) in the following registered semester, then the student would face termination, and will be permitted to register by the Dean, Academics only if the department makes a favourable recommendation. The Head of the Department’s recommendation shall be prepared after consultation with the student, and should include (i) feasibility of completing the programme requirements, and (ii) identification of remedial measures for the problems leading to poor performance.

(e) The registration of any student will be limited to 1.25 times the average earned credits of the previous two registered semesters, subject to a minimum of 12 credits and a maximum of 26 credits.

**Slow-paced programme**

(a) If a student has earned the minimum credits specified in Table 8 for continuation but has less than 28 Earned Credits at the end of the first two registered semesters, he/she will be eligible to opt for the slow-paced programme. A student opting for such a programme shall be permitted two additional registered semesters for completing degree requirements as indicated in Table 7.

(b) In the slow paced programme, the upper limit for credits registered in a semester will be 18. A student in this programme is expected to earn at least 9 credits with minimum SGPA of 5.0 in any semester, falling which he/she will be issued a warning and placed on probation.

A student placed on probation would be monitored, including mandatory attendance in special tutorials and mentoring.

If the performance of a student on probation does not meet the above criterion in the following registered semester, then the student would face termination and will be permitted to register by the Dean Academics only if the department makes a favourable recommendation. The Head of the Department’s recommendation shall be prepared after consultation with the student, and should include (i) feasibility of completing the programme, and (ii) identification of remedial measures for the problems leading to poor performance.

(c) The semester-wise schedule of the slow-paced programme shall be defined by the respective department for each student.

### 4.7 Scheme for Academic Advising of Undergraduate Students

**Advising Scheme for Regular Students**

(a) There is a class committee for each entry year of all programmes. The class committee is responsible for providing consistent and uniform academic advice to the entire batch of students.

(b) Class committee shall consist of a Chairman, at least two faculty members of the department (one of them will function as convenor of the class committee) and elected student representatives (as per CAIC constitution) including a student coordinator. All student coordinators of courses intended for the batch in a given semester and special advisors of academically weak students will be permanent invitees to the class committee. The faculty members in the class committee would be referred to as Faculty Mentors for the batch.

(c) A Chairperson appointed for each entry year of students by the Head of the Department shall be associated with the batch till it graduates and will provide basic guidance for formulating course plan and electives for the students of the batch.

(d) The Convenor of a class committee will be appointed in a year-specific fashion - for example, the convenor of the second year class committee would continue in the same position for 3 years, serving consecutive batches.

(e) Students can approach any class committee member for academic advice before registration. In other words, all the three members of the class committee will have the functional role of mentor and local guardian for all the students. In case of need for any exception and relaxation in rules or regulations pertaining to registration of courses, the class committee convenor will recommend and forward the request.

(f) The faculty members of the committee in consultation with the elected representatives of the students will provide academic advice applicable to all the students in general. The class committee is also expected to discharge following responsibilities:
(i) Considering mid-semester feed-back about courses running in the current semester

(ii) Identifying electives for the subsequent semester

(iii) Addressing issues related to scheduling and categorisation of courses

(iv) Organising STIC events for the batch.

(g) The class committee convenor with the support of student coordinator will organise at least one Student-Teacher Interaction Committee (STIC) event in each semester for interaction between class committee members and all the students of the batch.

(h) The Chairman, Convenor and the other faculty members of first year class committee would be identified by the department prior to the orientation of new students. During orientation, students and their parents will be introduced to these class committee members.

Advising Scheme for Academically Weak Students

(a) The students on probation in each batch will be put under a special advisor, identified by the department, who is expected to monitor the students on probation in a personalised manner. Normally, not more than 5-8 students would be assigned to a special advisor. Heads of Departments will appoint special advisors at the beginning of an academic session.

(b) A meeting of the special advisors with Dean, Academics would be held at the beginning of each semester for coordination of the advising process.

(c) A student on probation is expected to be in close contact with the advisor by meeting him/her at least once every 3 weeks for the entire period during which the student continues to remain in probation. Special advisors will be invitees to the class committee meetings.

(d) Special advisor in consultation with the parents and student counsellor, if required, will make a student-specific academic plan. The special advisor is expected to:
   • Closely interact with the weak student and his/her parents
   • Formulate individualised academic plan
   • Manage and track counselling process of the student, if any, in coordination with the Associate Dean, Student Welfare.
   • Approve their registration
   • Manage the recommendation/appeal for termination/continuation process in consultation with Head of the Department and Dean, Academics.

(e) At the time of registration for a semester, the student meets his/her advisor if possible with parents, to:
   • Identify specific problems and ways to mitigate the same
   • Formulate academic plan and target(s) for the semester
   • Help Head of the Department in the processing of the student’s appeal against termination, if applicable
   • Approve the registration of the student online.

(f) The student being placed under probation for the first time may also meet the counsellor during this period, if needed. The counsellor can provide professional help in identifying to resolving problems. Counsellors’ input will be available to the special advisor. During the add-drop period, the student, preferably along with his/her parents, should come and meet the Counsellor.

(g) While considering any appeal from an academically weak student for continuation of his registration, the Dean, Academics would consider the following:
   (i) whether he/she has met his/her Advisor and Counsellor at the scheduled times on a regular basis and
   (ii) whether he/she is regular in help sessions.

   Registration of a student under probation will not be approved for the next semester if he/she does not comply with the process of meeting the advisor and counsellor. He/ she will then be required to withdraw
from the semester.

(h) A student on probation will not be permitted to contest for any position of responsibility. However, he/she will be permitted to participate in extra-curricular activities in a restricted fashion only on specific recommendation of his/her advisor.

An institute level committee known as the Welfare Committee would monitor the entire operation of academic advising for weak students. Functions of the Welfare committee include monitoring the performance of weak students and making the final recommendations regarding termination/continuation, restarting first year and slow-paced programme requests. This committee would also evaluate the weak students based on the feedback regarding

(i) regularity in meeting the advisor and/or counsellor
(ii) student's attendance in help sessions and
(iii) academic performance.

A summary of the weak student's performance would be made available to the class committee members, Head of the student's Department as well as Course Coordinators of the courses in which the student is currently registered.

Student Mentors

(a) Each student will be assigned a student mentor from the same hostel and preferably from the same discipline to mentor students on academic and extra-curricular activities and provide feedback to the advisor and counselor in case of weak students.

(b) There are individual incentives for good student mentors. Also, hostels performing well on mentoring benefit in terms of points towards BSW trophy.

4.8 Capability Linked Opportunities for Undergraduate Students

A student who clears all the first year credit requirements with CGPA 7.0 and above will be permitted to register for additional credits from third semester onwards. A student will be permitted to register for up to 26 credits per semester provided

(a) The student has cleared all courses for which the student has registered till then and

(b) his/her CGPA is 7 or above

In case a student does not meet this requirement but has cleared 20×N credits, where N is the total number of semesters spent, then he/she can register up to a maximum of 24 credits.

A student registering for 26 credits in each semester after the end of first year can complete a maximum of 190 credits at the end of 4 years. Similarly, a student registering for 24 credits in each semester after first year can complete a maximum of 178 credits. Since the graduation requirement for 4-year B.Tech programmes varies between 145-155 Earned Credits, it will be feasible for capable students to add value to their degrees by registering for additional courses of their choice.

Students can make use of these additional credits in two blocks of 20 credits to opt for:

(a) Minor/Interdisciplinary Area Specialization

(b) Departmental Specialization

A student based on his/her performance and interest can choose either one on both. Successful completion of minor area credits and/or departmental Specialization will be indicated on the degree.

When a student opts for a departmental specialization and/or a minor area, he/she can use 10 open category credits (mandatory degree requirement) towards departmental specialization and/or minor area requirements. For example, a student registered for B.Tech (Chemical engg.) and opting for minor area in Computer Science and Engg., can opt for courses prescribed for minor area in Computer Science and Engg., as part of mandatory 10 credits requirements under OC. He/she will need to do additional 10 credits in the minor area to be eligible for Minor area specialization in the degree.

A student may not opt for either of the two but can do additional credits through open choice of courses. In case a student cannot meet requirements of a minor area or departmental Specialization, additional credits earned by the student over and above his/her degree requirement will be used for DGPA calculation and will be indicated on his/her transcript.

A set of pre-defined courses of total 20 credits in a focus area comprises a Departmental Specialization if the courses belong to the parent Department of an undergraduate programme, or a Minor/Interdisciplinary Area
Specialization if the courses belong to a different Department/Centre/School. Additional conditions and details of individual specializations are given in Section 7.

If any course of a Minor/Interdisciplinary area overlaps with any core course (DC or PC category courses) or elective course (DE or PE category courses) of the student’s programme, then credits from this course will not count towards the minor area credit requirements, though this course may contribute towards satisfying the requirement of the Minor/Interdisciplinary area. In such a case, the requirement of 20 credits must be completed by taking other courses of the specialization.

### 4.9 Change of Programme at the End of the First Year

(a) An undergraduate student is eligible to apply for change of branch at the end of the first year only, provided he/she satisfies the following criteria:

(i) CGPA for General and OBC category students : >8.00

(ii) CGPA for SC/ST and Person with Disability category students : >7.00

(iii) Earned credits/non-graded units at the end of the second semester of the first year:

   All credits of core and non-graded units of the first year

(iv) Optionally, one first year course would be identified by each programme, in which the grade of the applicant is equal to or above B. A list of such courses identified for various programmes is given in Table 9.

(b) The student should have no disciplinary action against him/her.

(c) Change of the branch will be permitted strictly in the order of merit, in each category, as determined by CGPA at the end of first year, subject to the limitation that the actual number of students in the third semester in the branch to which transfer is to be made should not exceed its sanctioned strength by more than 15% and the strength of the branch from which transfer is being sought does not fall below 85% of its sanctioned strength.

(d) In case more than one student applying for programme change have the same CGPA, the tie shall be resolved on the basis of JEE ranks of such applicants.

(e) The conditions mentioned in item (a) above will not be insisted upon for change to a branch in which a vacancy exists with reference to the sanctioned strengths, and the concerned student was eligible as per JEE Rank for admission to that branch at the time of entry to IIT Delhi. However, these conditions will continue to apply in case of students seeking change to a branch to which the concerned student was not eligible for admission at the time of entry to IIT Delhi.

#### Table 9: Qualifying criterion as per a(iv) for change of branch

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Programme Code and Name of the Programme to which Change is sought</th>
<th>Specified Course in which a minimum of B grade is required</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BB1 B.Tech. in Biochemical Engineering and Biotechnology</td>
<td>CML100: Introduction to Chemistry</td>
</tr>
<tr>
<td>2</td>
<td>BB5 B.Tech. and M.Tech in Biochemical Engineering and Biotechnology</td>
<td>CML100: Introduction to Chemistry</td>
</tr>
<tr>
<td>3</td>
<td>CH1 B.Tech in Chemical Engineering</td>
<td>MTL101: Linear Algebra and Differential Equations</td>
</tr>
<tr>
<td>4</td>
<td>CH7 B.Tech. and M.Tech in Chemical Engineering</td>
<td>MTL101: Linear Algebra and Differential Equations</td>
</tr>
<tr>
<td>5</td>
<td>CE1 B.Tech in Civil Engineering</td>
<td>APL100: Engineering Mechanics</td>
</tr>
<tr>
<td>6</td>
<td>CS1 B.Tech. in Computer Science and Engineering</td>
<td>COL100: Introduction to Computer Science</td>
</tr>
<tr>
<td>Course ID</td>
<td>Program</td>
<td>Course Title</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------------------</td>
<td>---------------------------------------------------</td>
</tr>
<tr>
<td>7</td>
<td>CS5</td>
<td>B.Tech. and M.Tech in Computer Science and Engineering</td>
</tr>
<tr>
<td>8</td>
<td>EE1</td>
<td>B.Tech. in Electrical Engineering</td>
</tr>
<tr>
<td>9</td>
<td>EE3</td>
<td>B.Tech. in Electrical Engineering (Power and Automation)</td>
</tr>
<tr>
<td>10</td>
<td>MT1</td>
<td>B.Tech. in Mathematics and Computing</td>
</tr>
<tr>
<td>11</td>
<td>MT6</td>
<td>B.Tech. and M.Tech. in Mathematics and Computing</td>
</tr>
<tr>
<td>12</td>
<td>ME1</td>
<td>B.Tech. in Mechanical Engineering</td>
</tr>
<tr>
<td>13</td>
<td>ME2</td>
<td>B.Tech. in Production and Industrial Engineering</td>
</tr>
<tr>
<td>14</td>
<td>PH1</td>
<td>B.Tech. in Engineering Physics</td>
</tr>
<tr>
<td>15</td>
<td>TT1</td>
<td>B.Tech. in Textile Technology</td>
</tr>
</tbody>
</table>

### 4.10 Self-study Course

A self-study course will be from the regular UG courses listed in this document (Section 10). The main features of a self-study course are as follows:

(a) A student may be given a self-study course not exceeding 5 credits in the final semester if he/she is short by a maximum of 5 earned credits required for graduation provided that the course is not running in that semester as a regular course. Students in the Dual-degree programmes are allowed to avail of this provision during their last semester. However, they would be permitted to take only a UG course as a possible self-study course. A student can make use of this provision only once during the programme.

(b) A student may also be permitted to do a U.G. core course not exceeding 5 credits in self-study mode at most once during the program, provided he/she has failed in it earlier and the course is not being offered as a regular course during that semester.

(c) Students should apply for a self-study course with appropriate recommendation of a Course Coordinator and the Head of the Department of the student's programme. The final sanction of a self-study course to a student is made by the Dean, Academics.

(d) Normally, no formal lectures will be held for a self-study course but laboratory, design and computation exercises will be conducted if they form an integral part of the course.

(e) The Course Coordinator will hold minor and major tests besides other tests/quizzes for giving his/her assessment at the end of the semester. In summer semester, there will be at least one mid semester test and a major test.

(f) The self-study course will run during the total duration of the semester (including summer semester).

### 4.11 Assistantship for Dual-degree Programmes

The students of dual-degree programmes will be considered for award of institute research/ teaching assistantship if they have earned 135 credits. Only those students who have either qualified GATE or have a CGPA more than 8.0 will be eligible for this assistantship. The assistantship will be provided for a maximum period of 14 months beginning from the summer semester following eighth semester, provided the student is registered for M.Tech Major Project in that semester. A student availing assistantship will be required to provide 8 hours of assistance per week besides his/ her normal academic work. For continuation of assistantship a student will need to secure SGPA of 7.0. A student will be eligible to receive assistantship from sources other than institute fund or MHRD if he/she has a CGPA of 7.0 and has earned 135 credits.

A student receiving assistantship will be eligible for total of 30 days leave during the 14-month period. He/she will not be entitled to mid-semester breaks, winter and summer vacations.
5. **POSTGRADUATE DEGREE REQUIREMENTS, REGULATIONS AND PROCEDURES**

5.1 **Degree requirements**
The detailed degree requirements for M.Sc., M.B.A., M.Des, M.Tech., M.S. (Research) and Ph.D. degrees and D.I.I.T. are listed in Table 10.

5.2 **Continuation Requirements**
The detailed requirements for continuation as a student in the respective programme for M.Sc., D.I.I.T., M.B.A., M.Des, M.Tech., M.S. (Research) and Ph.D. degrees and D.I.I.T. are listed in Table 10. Failure to maintain the specified academic standing will result in termination of registration and the student's name will be struck-off the rolls. The maximum permitted duration of each programme will be determined in terms of number of registered semesters. Any semester in which a student has registered for a course will be called a registered semester subject to the following:

(a) Only the 1st and 2nd semesters of an academic year can be registered semesters. The summer semester will not be considered as a registered semester.

(b) A semester when a student has been granted semester withdrawal or granted leave will not be considered as a registered semester.

(c) The semester when a student is suspended from the Institute on disciplinary grounds will not be counted towards the number of registered semesters.

The summer semesters falling in between the permitted registered semesters shall be available for earning credits. After the student has registered for the maximum permissible number of registered semesters, the subsequent summer semesters will not be available for earning credits.

5.3 **Minimum Student Registration for a Programme**
A M.Sc., M.B.A., M.Des. or M.Tech. programme will not be run unless the number of students registered for that programme is six or more. If the number of students left in a programme at the end of the 2nd semester is less than four, the same programme may be looked into for temporary suspension by the Board of Educational Research and Planning.

5.4 **Lower and Upper Limits for Credits Registered**
For students pursuing M.Sc., M.B.A., M.Tech. and M.S.(Research), the minimum registration requirement in a semester are specified in Table 10. These minimum credit requirements are not applicable for graduating students who require lower than the proposed minimum to graduate.

5.5 **Audit Courses for PG Students**
(a) M.Tech./M.S.(R)/M.Sc./Ph.D. students are eligible for auditing a course at any time before completion of the programme.

(b) A student can request for an audit grade in any course provided he/she is eligible to earn audit credits, he/she is already registered for that course and it is not a core requirement of the student's programme. The request for auditing a course should be made on or before the last date for audit requests as defined in the semester schedule.

(c) A student earns either an NP (audit pass) or an NF (audit fail) grade for an audit course. The audit pass (NP) grade may be awarded if the student satisfies the attendance criteria specified for the course and he/she has obtained at least a 'D' grade. The course coordinator can specify a higher criterion for audit pass at the beginning of the semester. If either of these requirements is not fulfilled, the audit fail (NF) grade is awarded.

(d) Grades obtained in an audit course are not considered in the calculation of SGPA or CGPA.

(e) M.Tech., M.Sc., M.S.(R) and Ph.D. students can audit a course over and above their credit requirements, as specified by the supervisor and SRC. Audited credits do not count for graduation requirements of PG students.
(f) Non-credit core courses or core courses not considered for calculation of SGPA or CGPA for PG programmes like Ph.D., MBA, M.Tech., M.S. (R) should not be referred to as audit courses. These courses should be treated like similar core requirements for UG programmes such as Introduction to Programme. A student can earn either a S or Z grade in such courses. The grade S indicates successful completion. A student has to earn a S grade in such a course to meet the core requirements of a programme.

5.6 Award of D.I.I.T. to M.Tech./MBA Students

If a student after completing the maximum period available for the M.Tech. programme is not able to get the required minimum DGPA of 6.0 with the minimum required credits for the respective programme, then he/she can apply for a D.I.I.T. irrespective of whether the department/centre runs a Diploma programme or not. For the award of D.I.I.T., the student must have earned a minimum of 36 valid credits with a minimum CGPA of 5.5. The request for the award of DIIT must be made within 5 years of the date of joining the programme.

In case of M.B.A., DIIT shall be considered if at least 36 credits (9 courses from core and 3 courses from focus module) +4 compulsory audit courses, have been completed satisfactorily with a minimum CGPA of 5.5.

5.7 Regulations for Part-time Students

Normally, part-time M.Tech. and M.S. (Research) students are expected to complete the degree requirements in six semesters. In case of special circumstances, including extension of project work, the student can be allowed to continue beyond six semesters but in any case he/she cannot extend registration beyond ten semesters excluding summer semesters. In case of full-time students converting to part-time registration, the limit of six semesters will continue to apply.

5.8 Leave rules for D.I.I.T., M.Des., M.Tech. and M.S. (Research)

A full-time D.I.I.T., M.Des., M.Tech. or M.S. (Research) student during his/her stay at the Institute will be entitled to leave for 30 days (including leave on medical grounds), per academic year. Even during mid-semester breaks, and summer and winter vacations, he/she will have to explicitly apply for leave. He/she, however, may be permitted to avail of leave only up to 15 days during winter vacation at the end of the first semester.

The leave will be subject to approval of the Head of Department/Centre/Programme/School Coordinator concerned and a proper leave account of each student shall be maintained by the Department/Centre/Programme/School Coordinator concerned.

5.9 Assistantship requirements

A D.I.I.T., M.Des., M.Tech. or M.S. (Research) student irrespective of the source of assistantship, must attend at least 75 % of classes in each course in which he/she is registered. In case his/her attendance falls below 75 % in any course during a month, he/she will not be paid assistantship for that month. Further, if his/her attendance again falls short of 75 % in any course in any subsequent month in that semester, his/her studentship and assistantship will be terminated. For the above purpose, if 75 % works out to be a number which is not a whole number, the immediate lower whole number will be treated as the required 75 % attendance.

The students are expected to put in 8 hours per week towards the work assigned by the Institute. Continuation of assistantship in a subsequent semester would be conditional to satisfactory performance of the assigned work and a SGPA of 7.0 or more (relaxed to 6.75 for SC/ST and PH students registered in M.Des., M.Tech. and M.S. (Research) programmes).

5.10 Summer registration

Summer semester registration for PG students is admissible. M.Tech./M.S. (R)/M.Des. students will be allowed to register for maximum of one course (upto 4 Credits) and M.B.A./M.Sc. students upto 2 courses in the summer. Summer semester registration for PG students is permitted only when a student would graduate on completion of the courses registered in summer, and it is recommended by DRC/CRC. For projects, in case X grade is awarded in the second semester, the student would be expected to register during summer for completion of the project. Normally regular courses would not be offered during summer semester. Courses can, however, be offered by departments/centres/Schools for taking care of special situations subject to the availability and consent of faculty.
5.11 Master of Science (Research) Regulations

The M.S. (Research) programme will comprise of 15 credits of the course work and 36 credits of the research work. The 15 credits of course work should not include any component of minor project. In the first semester the student has to register for a minimum of 09 and a maximum of 15 credits. In the first semester, the part-time students can only register for course work with minimum and maximum limits of 3 and 12 credits, respectively. The course work must be completed by the end of third semester; otherwise the registration of the student will stand cancelled.

The larger project component gives the student an opportunity to conduct in-depth investigation on a topic of his/her interest. The project will be monitored by the Student Research Committee (SRC) and the students will have to register for thesis (project course no. xxD895, ‘xx’ is department/school code) for 36 credits. An ‘X’ grade is awarded at the end of each semester until the project work gets completed and the thesis is written. Nominally the M.S.(R) programme is expected to take 4 semesters (excluding summer). Upon completion of project work, a thesis is written that is evaluated by one internal and one external examiner. Upon satisfactory recommendations from the examiners, the thesis defence can be conducted before a committee. Conversion to Ph.D. is also possible. For further details, see the “Rules and Regulations for Master of Science (Research) Programme” booklet.

5.12 Migration from one PG programme to another PG Programme of the Institute

Provision exists for the PG students of the Institute to move from (i) M.Tech. / M.S.(R) to Ph.D., (ii) M.Tech. to M.S.(R), and (iii) M.S.(R) to M.Tech. as per details given in the table below:

<table>
<thead>
<tr>
<th>M.Tech./M.S.(R) to Ph.D.</th>
<th>M.Tech. to M.S.(R)</th>
<th>M.S.(R) to M.Tech.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eligibility</td>
<td>≥ 8.0 SGPA/CGPA &amp; ≥ 12 credits</td>
<td>≥ 12 credits</td>
</tr>
<tr>
<td>Admission</td>
<td>DRC/CRC (Evaluation)</td>
<td>DRC/CRC (Evaluation)</td>
</tr>
<tr>
<td>Credits</td>
<td>Credits transfer as recommended by DRC/CRC</td>
<td>Credits transfer as recommended by DRC/CRC</td>
</tr>
<tr>
<td>Duration</td>
<td>Max. 7 years from date of joining M.Tech. / M.S.(R)</td>
<td>Max. 5 years from date of joining M.Tech.</td>
</tr>
</tbody>
</table>

Full-time M.Tech. and M.S.(R) students of IIT Delhi interested in joining the Ph.D. programme within two years of completion of their M.Tech./M.S.(R) will be granted waiver of residency period. The course work requirements be made up by either additional credits (6 credits as per present norms) taken during their M.Tech./M.S.(R) period (over and above their minimum Degree requirements) or in the summer semester (first or second) by identifying courses. In all cases, the request for such credit transfer be recommended by the concerned DRC/CRC/SRC as relevant to their respective Ph.D. programmes.

5.13 Doctor of Philosophy (Ph.D.) Regulations

The award of Ph.D. degree is in recognition of high achievements, independent research and application of scientific knowledge to the solution of technical and scientific problems. Creative and productive enquiry is the basic concept underlying the research work. In order to overcome any deficiency in the breadth of fundamental training or proper foundation for advanced work, special preliminary or pre-Ph.D. courses are given by each Department/centre/School. These courses are given either by faculty members or by guest-speakers and specialists in the field of research.

5.13.1 Course requirements

Candidates admitted to non-engineering departments and having a B.Tech./M.Sc./M.A. or equivalent degree are required to complete a minimum of 12 credits. Relaxation up to 6 credits in the course work can be considered for those with M.Phil. degree. The requirement of pre-Ph.D. Course Credits/work for Ph.D. student admitted to engineering department and having a B.Tech. and M.Sc. Degree is 20 credits. Individual Academic Unit may recommend minimum course work requirements beyond the minimum requirements specified by the Institute, with details as described below.
### Table 10. Continuation of Registration and Graduation Requirements for Postgraduate Programmes

<table>
<thead>
<tr>
<th>Degree</th>
<th>Registration limits (Per semester)</th>
<th>Criteria for continuation of registration</th>
<th>Graduation requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>D.I.T. (Naval Construction)</td>
<td>Minimum 12 credits Maximum 20 credits</td>
<td>CGPA &gt; 5.0 at the end of each semester.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Valid Credits ($)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Minimum DGPA</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Max. Period of stay</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.Sc., Chemistry</td>
<td>Minimum 12 credits Maximum 26 credits</td>
<td>(i) The minimum acceptable performance level in any registered semester is SGPA of 5.0. However, at the end of the 1st registered semester, a student with SGPA of 4.0 or more will be permitted to continue. If the SGPA is less than 4.0 then registration will be terminated.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(ii) If at the end of any registered semester, the SGPA is less than 5.0 then the student will be issued a warning letter and placed on probation; a copy of the warning letter will be sent to the parents. The Chairperson DRC/CRC shall assess the feasibility of completing degree requirements and identify remedial measures for problems leading to poor performance.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iii) If a student is on probation and his/her academic performance is below the minimum acceptable level in the following registered semester then his/her registration will be terminated.</td>
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<td></td>
<td></td>
<td>(iv) The registration of any student will be limited to 1.25 times the average earned credits of the previous two registered semesters, subject to a minimum of 15 credits and a maximum of 26 credits.</td>
<td></td>
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<tr>
<td></td>
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<tr>
<td>M.Sc., Mathematics</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>M.Sc., Physics</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.Tech., Full Time</td>
<td>Minimum 09 credits Maximum 15 credits</td>
<td>(i) The minimum acceptable performance level in any registered semester is SGPA of 6.0. However, at the end of the 1st registered semester, a student with SGPA of 5.0 or more will be permitted to continue. If the SGPA is less than 5.0 then registration will be terminated.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>(ii) If at the end of any registered semester the SGPA is less than 6.0, then the student will be issued a warning letter and placed on probation; a copy of the warning letter will be sent to Chairperson DRC/CRC. The Chairperson DRC/CRC shall assess the feasibility of completing degree requirements and identify remedial measures for problems leading to poor performance.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iii) If a student is on probation and his/her academic performance is below the minimum acceptable level in the following registered semester then his/her registration will be terminated.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iv) The registration of any student shall be limited to 1.25 times the average earned credits of the previous two registered semesters, subject to a minimum of 09 credits and a maximum of 15 credits for full time students.</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>M.Tech., Part Time</td>
<td>Minimum 3 credits Maximum 15 credits</td>
<td></td>
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<tr>
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<tr>
<td>M. Des.</td>
<td>Minimum 09 credits Maximum 15 credits</td>
<td>(iii) If a student is on probation and his/her academic performance is below the minimum acceptable level in the following registered semester then his/her registration will be terminated.</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>(iv) The registration of any student shall be limited to 1.25 times the average earned credits of the previous two registered semesters, subject to a minimum of 09 credits and a maximum of 15 credits for full time students.</td>
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<tr>
<td></td>
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<tr>
<td>M.B.A., Full Time</td>
<td>Same as M.Tech. full time</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>M.B.A., Part Time</td>
<td>Same as M.Tech. part time</td>
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<table>
<thead>
<tr>
<th>Valid Credits ($)</th>
<th>Minimum DGPA</th>
<th>Max. Period of stay</th>
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<tr>
<td>49</td>
<td>6.0</td>
<td>6 sem.</td>
</tr>
<tr>
<td>75-81</td>
<td>5.0</td>
<td>6 sem.</td>
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<td>48-54 credits</td>
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<td>6 sem.</td>
</tr>
<tr>
<td>54</td>
<td>6.0</td>
<td>6 sem.</td>
</tr>
<tr>
<td>72 (+ 6 compulsory audit courses)</td>
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<td>6 sem.</td>
</tr>
<tr>
<td>Same as M.Tech. full time</td>
<td>6.0</td>
<td>10 sem.</td>
</tr>
<tr>
<td>Same as M.Tech. part time</td>
<td>6.0</td>
<td>10 sem.</td>
</tr>
<tr>
<td>Courses of Study 2017-2018</td>
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<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td>---------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>M.S. (Res.) Full Time</strong></td>
<td>See note +</td>
<td></td>
</tr>
<tr>
<td>(i) The minimum acceptable performance level in any registered semester is SGPA of 7.0 or more. However, at the end of the 1st registered semester, a student with SGPA of 6.0 or more will be permitted to continue. If the SGPA is less than 6.0 then registration will be terminated.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(ii) If at the end of any registered semester, the SGPA is less than 7.0, then the student should be issued a warning letter and placed on probation; a copy of the warning letter should be sent to the Chairperson DRC/CRC. The Chairperson DRC/CRC shall assess the feasibility of completing degree requirements and identify remedial measures for problems leading to poor performance.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(iii) If a student is on probation and his/her academic performance is below the minimum acceptable level in the following registered semester then his/her registration will be terminated.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(iv) During the research work period, each unsatisfactory performance grade would entail a warning and two consecutive warnings would result in termination of registration.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>M.S. (Res.) Part Time</strong></td>
<td>See note ++</td>
<td></td>
</tr>
<tr>
<td><strong>Ph.D.</strong></td>
<td>For details please refer to Ph.D. Ordinances and Regulations</td>
<td></td>
</tr>
<tr>
<td>(i) A student will be evaluated on completion of pre-Ph.D. course work in terms of Degree Grade Point Average (DGPA) which is calculated on the basis of the best valid credits as prescribed by the Department/Centre/School. The requirement for completion of pre-Ph.D. course work is DGPA of 7.5 or more. within the maximum permissible period i.e 18 and 24 months respectively for full-time and part-time students.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(ii) Registration of a Ph.D. student will be terminated at the end of 1st Semester on account of performance in the course work if the SGPA is less than 6.0. In case the SGPA is equal to or more than 6.0, the student will be allowed to continue the course work even if the credit requirements as recommended by the SRC have been completed in the first semester itself.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(iii) In the subsequent semesters, the student must maintain a CGPA of more than 7.0 to continue registration.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>NOTE:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$ Detailed break-up of core, elective and open category courses are given in the latter pages of this document.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>£ If a student at the end of the M.Tech. programme fails to complete required valid credits with a CGPA of 6.00 or above, he/she still can get a DIIT even though the Department/Interdisciplinary Programme does not have a regular Diploma programme provided: (i) he/she has a minimum of 45 valid credits; and (ii) he/she has secured a minimum CGPA of 5.50. The request for the award of D.I.I.T. must be made within 5 years of the date of joining the programme.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+ In the first semester the student has to register for a minimum of 9 and a maximum of 15 credits of course work only. In the subsequent 3-semesters the student shall complete the research work and the course work remaining, if any.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>++ In the first two semesters the part-time student shall register only for the course work with the minimum and maximum limits of 3-15 credits. The research work and the remaining course work, if any, shall be completed in the remaining 4 semesters. However, the course work must be completed within the first 4-semesters of registration.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+++ The 10 Semester rule for part-time M.S. (Research) students will be applicable only to those who have joined initially as part-time students. For students converting from full-time to part-time the maximum stay limit of 6 semesters will be applicable, subject to recommendations of DRC/CRC/SRC and approval by Dean, Academics.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>@ The 10 Semester rule for part-time M.Tech. students will be applicable only to those who have joined initially as part-time students. For students converting from full-time to part-time, the maximum stay limit of 6 semester will be applicable.</td>
<td></td>
<td></td>
</tr>
<tr>
<td># The summer semester will not be considered as a registered semester.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
M.Tech. or equivalent degree holders admitted to Ph.D. are required to complete a minimum of 6 credits. The Departments / Centres / Schools may stipulate a larger number of credits in general or in specific cases. The course requirement will be determined by the Department / Centre / School Research Committee (DRC / CRC / SRC) on the recommendations of the supervisor after due consideration of the background of the student in relation to the proposed topic of research. These courses can be prescribed from existing M.Tech. courses and/or from special pre-Ph.D. courses including laboratory, seminar, foreign language, etc. Normally, no independent study course will be allowed for Ph.D. students.

Further, in case a Ph.D. student having completed 20 credits is unable to complete the research at the Ph.D. level for any reason whatsoever, he/she may be allowed to complete M.S. (Research) degree requirement as per Institute rules.

A student shall be formally registered/admitted to the candidacy of Ph.D. degree only after he/she has cleared the comprehensive examination. Students would be permitted to take the comprehensive examination only after they have submitted a research plan and have completed the course work (including compulsory audit course - HUL 810: Communication Skills). Full-time and part-time students must clear the comprehensive examination within a period of 18 months and 24 months, respectively, from the date of joining. A maximum of two chances will be given to any student to clear the comprehensive examination. Every student, after having completed the comprehensive examination must formally register for the candidacy on a form obtainable from the PG Section.

5.13.2 Time limit

In addition to the information in Table 10, the time limits shown in Table 11 apply for Ph.D. work.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Candidate’s qualification</th>
<th>M.Tech. or equivalent</th>
<th>B.Tech./M.Sc. or equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Limits for Registration</td>
<td>2 years</td>
<td>3 years (can be reduced to 2 years with the approval of Senate)</td>
</tr>
<tr>
<td>1.2</td>
<td>Normal maximum period of registration</td>
<td>10 Semesters</td>
<td>10 Semesters</td>
</tr>
<tr>
<td>1.3</td>
<td>Extended maximum period of registration</td>
<td>14 Semesters</td>
<td>14 Semesters</td>
</tr>
<tr>
<td>2</td>
<td>Conversion from Full-time to Part-time Registration</td>
<td>Comprehensive examination with the approval of dean academics</td>
<td></td>
</tr>
</tbody>
</table>

5.13.3 Leave regulations

(a) Leave during course work

A full-time Ph.D. student, during his/her stay at the Institute will be entitled to leave for 30 days, including leave on medical grounds, per academic year. Even during mid-semester breaks, and summer and winter vacations, he/she will have to explicitly apply for leave. He/she, however, may be permitted to avail of leave only up to 15 days during winter vacation at the end of the first semester.

Leave beyond 30 days in an academic year may be granted to a research scholar in exceptional cases subject to the following conditions:

(i) the leave beyond 30 days will be without Assistantship/Scholarship, and

(ii) such an extension of up to additional 30 days will be granted only once during the programme of the scholar.

In addition, a Ph.D. student who has completed his/her course work may be granted leave on medical grounds up to 10 days per academic year.

Women research scholars will be eligible for Maternity Leave with assistantship for a period not exceeding 135 days once during the tenure of their Ph.D. programme.

The leave may be subject to the approval of the Head of Department / Centre / School / Programme Coordinator concerned on the recommendation of the Supervisor; and a proper leave account of each research scholar shall be maintained by the Department / Centre / School / Programme Coordinator concerned.
5.13.4 Attendance requirements for assistantship

A Ph.D. student irrespective of the source of research assistantship while pursuing course work, must attend at least 75% of classes in each course in which he/she is registered. In case his/her attendance falls below 75% in any course during a month, he/she will not be paid Assistantship for that month. Further, if his/her attendance again falls short of 75% in any course in any subsequent month in that semester, his/her studentship and Assistantship will be terminated. A research scholar after having completed the course work must attend to his/her research work on all the working days and mark attendance except when he/she is on duly sanctioned leave. The requirement of 75% attendance will apply as above, on daily attendance except in the cases where longer leave has been duly sanctioned within the leave entitlement of the student. For the above purpose, if 75% works out to be a number which is not a whole number, the immediate lower whole number will be treated as the required 75% attendance.

All scholars who are offered assistantship are expected to put in 8 hours per week towards the work assigned by the Institute. Continuation of assistantship in the subsequent semester would be conditional, subject to satisfactory performance in the work assigned.

5.13.5 Further regulations governing Ph.D. students

The Ph.D. degree of the Institute may be conferred on a candidate who fulfills all the requirements detailed in the Ordinances and other rules, approved by the Senate. Some of the important regulations are given below:

(i) Applications for Ph.D. registration, i.e., for entry to a course of study and research leading to Ph.D. degree must be made to the Board of Academic Programmes (BAP) on the approved form. The date of registration is normally the date of joining the programme. However, in exceptional cases the date of registration may be preponed by a maximum of 6 months by the BAP if it is convinced that the candidate has spent adequate amount of time on research earlier.

(ii) The academic programme of all the Ph.D. candidates in a Department/Centre/School will be coordinated by the DRC/CRC/SRC appointed by the BAP.

(iii) The supervisor shall be a full-time member of the academic staff of the Institute. The supervisor(s) shall be appointed within three months of joining the programme. For this, Ph.D. candidates must fill up the required portion of the prescribed form, following which supervisor(s) must fill up the required portion, and the Student Research Committee (SRC) must be finalized by the respective DRC/CRC/SRC, of the Academic Unit. This process must be completed within three months of the Ph.D. candidates date of first registration. If necessary, the Board of Academic Programme on the recommendations of the Supervisor through the DRC/CRC/SRC, may appoint Joint Supervisor(s) not exceeding two from inside or outside the Institute. Normally, there should not be more than two supervisors for a candidate from within the Institute. Appointment of any Joint Supervisor would not be permitted after a lapse of eighteen months from the date of registration of the candidate, except in case when none of the supervisors is in the Institute for a year or more at a stretch.

(iv) The DRC/CRC/SRC shall meet from time to time and review the progress of each candidate in the course work, as well as research, by any means, including oral examination of the candidate, if necessary, and recommend, after due consultation with the supervisor(s), such steps to the candidate as are necessary to improve his/her performance.

(v) The progress of each candidate will be monitored by the DRC/CRC/SRC. For this purpose the following procedures will be followed:

(a) Ph.D. research work will be compulsorily given a course number, DTD 899 (Doctoral Thesis) for all candidates across the Institute.

(b) The DRC/CRC/SRC Secretary/Ph.D. Coordinator will be Coordinating collection of progress reports written and signed by the scholars and forwarded by the supervisors every semester.

(c) The supervisor(s)/SRC/DRC/CRC will evaluate the progress of the student every semester.

(d) 'X' grade will be awarded if the progress is ‘satisfactory’ in that semester.

(e) If the progress is ‘unsatisfactory’, ‘U’ grades will be awarded. For the first appearance of ‘U’ grade, a warning would be issued to the candidate by Dean, Academics. If his/her performance does not improve after warning, the assistantship may be withheld.

(f) If there are two consecutive ‘U’ grade (in consecutive semesters), the registration will stand terminated.
(g) Submission of progress report should continue till submission of thesis.

(h) Like all other courses, the grades for DTD 899 will be discussed in the Department/Centre/School as per the semester schedule.

The above process will continue till the thesis is submitted.

(vi) The candidate may submit the thesis at any time provided that:

(a) He/she has completed the minimum period of registration including any extension prescribed by the Board of Academic Programmes (BAP).

(b) He/she has completed the course work requirement as prescribed by the DRC/CRC/SRC with DGPA not below 7.50 and has also cleared the comprehensive examination.

(c) He/she has submitted at least two months in advance, the title and a synopsis of the thesis. The Synopsis along with the list of examiners suggested by the supervisor needs to be approved by the DRC/CRC/SRC and then forwarded to Dean, Academics.

(vii) The thesis shall normally be written in English in the specific format and shall contain a critical account of the candidate's research. It should be characterized by discovery of facts, of fresh approach towards interpretation of facts and theories or significant contribution to knowledge of design or development, or a combination of them. It should bear evidence of the candidate's capacity for analysis and judgement and also his/her ability to carry out independent investigation, design or development. A thesis should normally be supplemented by published work. No part of the thesis or supplementary published work, shall have been submitted for the award of any other Degree/Diploma. Normally, three copies of thesis in soft cover have to be submitted in the format prescribed by the Institute. In case of joint supervision, four copies of the thesis are required to be submitted.

(viii) On receipt of the title and synopsis of a thesis, the Dean, Academics will appoint a Board of Examiners for each candidate. The Board will consist of one (or two) internal examiner(s), normally the supervisor(s), and two external examiners, one from within India and one from abroad who shall be expert in the subject of thesis. These external examiners shall be chosen from a list of eight, to be recommended by the supervisor(s) through the DRC/CRC/SRC while forwarding the title and synopsis of the thesis. The candidate will be required to submit a fresh synopsis if more than 9 months elapse from the synopsis submission date to the thesis submission date.

(ix) Each Examiner will submit a detailed assessment report recommending to the BAP, one of the following courses of action:

(a) that the thesis be deemed satisfactory and that the candidate may defend his/her thesis orally before a committee constituted for the purpose and any members of the faculty and research students who wish to be present.

(b) that the candidate may submit a revised thesis before the expiry of a specific period. In the normal circumstances, he/she may submit the revised thesis within a period of one year from the date of communication in this regard from the Dean, Academics. However, in exceptional circumstances, this period may be extended by the BAP by another one year : the total revision time irrespective of the number of revisions allowed will not exceed a period of two years.

(c) that the thesis be rejected outright.

In the event of disagreement between the external examiners, the BAP may, as a special case, appoint another external examiner, if the merit of the case so demands. The examiner will report independently to the BAP.

(x) The oral defence of the thesis shall be conducted by a committee consisting of the internal examiner(s) and one external examiner. If none of the external examiners, is available for the conduct of the oral defence, an alternative external examiner shall be appointed by the BAP for this purpose only.

(xi) On the completion of all stages of the examination, the Oral Defence Committee shall recommend to the BAP one of the following courses of action:

(a) that the degree be awarded.

(b) that the candidate should be examined on a further occasion in a manner they shall prescribe.
(c) that the degree shall not be awarded.

In the case of (a) above, the Oral Defence Committee shall also provide to the candidate a list of all corrections and modifications, if any, suggested by the examiners.

(xii) The degree shall be awarded by the Senate, provided that:

(a) the Oral Defence Committee, through the BAP so recommends.

(b) the candidate produces a 'no dues certificate' from all concerned in the prescribed form and gets it forwarded along with the report of the Oral Defence Committee; and

(c) the candidate has submitted two hard cover copies of the thesis, after incorporating all necessary corrections and modifications including appropriate IPR notice. The hard bound copies of the Ph.D. thesis, submitted after the viva-voce examination, must contain the appropriate copyright certificate in the beginning of the thesis, on a separate page on the left side. One of these copies is for the Department/Centre/School Library and the other is for the Central Library. A softcopy of the thesis has been submitted to the Central Library.

(d) A Hindi translation of the thesis abstract is to be submitted as part of final submission (after examiner reports are received). The students can seek assistance from Hindi Cell in this regard.

(xiii) The relevant IPR notice to be incorporated in the soft/hard bound thesis, reports etc. shall be chosen from the following:

(a) the thesis/report etc. for which formal copyright application has NOT been filed should carry the copyright notice as:

© Indian Institute of Technology Delhi (IITD), New Delhi, 200 ... [the year of submission of the thesis/report].

(b) and for which formal copyright application has been filed with the copyright office. Should carry the copyright notice as:

© Indian Institute of Technology Delhi (IITD), New Delhi, 200 ...[the year of submission of the thesis/report]. All right reserved. Copyright Registration Pending.

(c) and for which, in-addition to a formal copyright application with the Copyright Office, patent/design application has also been filed with the patent office, should carry the “IPR Notice” as:

Intellectual Property Rights (IPR) notice

Part of this thesis may be protected by one or more of Indian Copyright Registrations (Pending) and/or Indian Patent/Design (Pending) by Dean, Industrial Research & Development (IRD) Unit Indian Institute of Technology Delhi (IITD) New Delhi-110016, India. IITD restricts the use, in any form, of the information, in part or full, contained in this thesis only on written permission of the Competent Authority: Dean, IRD, IIT Delhi or MD, FITT, IIT Delhi.

The notices at ‘b’ and ‘c’ should only be inserted after the formal application(s) has (have) been filed with the appropriate office(s) as the case may be and the same has been confirmed by FITT office.

(xiv) If a member of the academic staff, who is registered for the degree, leaves the Institute before the minimum period of registration is completed, he/she will be permitted to submit his thesis in due course, provided that:

(a) a substantial part of the research has been completed at the Institute; and

(b) any additional work required can be adequately supervised.

(xv) A member of the academic staff who has commenced his research before joining the Institute may, at the discretion of the BAP and on the recommendation of the Supervisor through the DRC/CRC/SRC concerned, be permitted to include in his period of registration, part or all of the time spent on research before joining the Institute, up to a maximum of one year.

(xvi) A member of the non-academic staff of the Institute who satisfies eligibility qualifications may be considered for admission to the degree as a part-time candidate provided his/her application is duly approved by the Director of the Institute.
6. UNDERGRADUATE PROGRAMME STRUCTURES
## The overall Credit Structure

<table>
<thead>
<tr>
<th>Course Category</th>
<th>Credits</th>
</tr>
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<tbody>
<tr>
<td><strong>Institute Core Courses</strong></td>
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</tr>
<tr>
<td>Basic Sciences (BS)</td>
<td>22</td>
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<tr>
<td>Engineering Arts and Science (EAS)</td>
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<tr>
<td>Humanities and Social Sciences (HuSS)</td>
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<td><strong>Programme-linked Courses</strong></td>
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<tr>
<td><strong>Departmental Courses</strong></td>
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<td>Departmental Core</td>
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<td>Departmental Electives</td>
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<tr>
<td><strong>Open Category Courses</strong></td>
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<tr>
<td><strong>Non Graded Units</strong></td>
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### Institute Core: Basic Sciences

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<th>Course Code</th>
<th>Course Title</th>
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<td>CML100</td>
<td>General Chemistry</td>
<td>3 0 0 3</td>
</tr>
<tr>
<td>CMP100</td>
<td>Chemistry Laboratory</td>
<td>0 0 4 2</td>
</tr>
<tr>
<td>MTL100</td>
<td>Calculus</td>
<td>3 1 0 4</td>
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<td>MTL101</td>
<td>Linear Algebra and Differential Equations</td>
<td>3 1 0 4</td>
</tr>
<tr>
<td>PYL100</td>
<td>Electromagnetic Waves and Quantum Mechanics</td>
<td>3 0 0 3</td>
</tr>
<tr>
<td>PYP100</td>
<td>Physics Laboratory</td>
<td>0 0 4 2</td>
</tr>
<tr>
<td>SBL100</td>
<td>Introductory Biology for Engineers</td>
<td>3 0 2 4</td>
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**Total Credits**: 22

### Institute Core: Engineering Arts and Sciences

<table>
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<td>Engineering Mechanics</td>
<td>3 1 0 4</td>
</tr>
<tr>
<td>COL100</td>
<td>Introduction to Computer Science</td>
<td>3 0 2 4</td>
</tr>
<tr>
<td>CVL100</td>
<td>Environmental Science</td>
<td>2 0 0 2</td>
</tr>
<tr>
<td>ELL100</td>
<td>Introduction to Electrical Engineering</td>
<td>3 0 2 4</td>
</tr>
<tr>
<td>MCP100</td>
<td>Engineering Visualization</td>
<td>0 0 4 2</td>
</tr>
</tbody>
</table>

**Total Credits**: 18

### Programme-Linked Basic/Engineering Arts/Sciences Core

<table>
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<th>Course Title</th>
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</tr>
</thead>
<tbody>
<tr>
<td>APL102</td>
<td>Introduction to Materials Science and Engineering</td>
<td>3 0 2 4</td>
</tr>
<tr>
<td>CLL110</td>
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**Total Credits**: 11

### Humanities and Social Sciences

Courses from Humanities, Social Sciences and Management offered under this category: 15

### Departmental Core

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**Total Credits**: 69

### Departmental Electives

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## B.Tech. in Biochemical Engineering and Biotechnology

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<th>Course-7</th>
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<td>PYP100</td>
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<td><strong>Note:</strong> Courses 1-6 above are attended in the given order by half of all first year students. The other half of first year students attend the Courses 1-6 of II semester first.</td>
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**TOTAL=155.0**
**Dual Degree Programme: Bachelor of Technology and Master of Technology in Biochemical Engineering and Biotechnology**

**Programme Code: BB5**

### The overall Credit Structure

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<td>Engineering Arts and Science (EAS)</td>
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<td>Humanities and Social Sciences (HuSS)</td>
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<td><strong>Programme-linked Courses</strong></td>
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*Those students who join the dual degree program from JEE or those who choose to pursue a M.Tech degree along with their B.Tech program, will not be required to do the 3-credit B.Tech Project as part of the Departmental core requirement.

### Institute Core: Basic Sciences

<table>
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<td>MTL100</td>
<td>Calculus</td>
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<td>MTL101</td>
<td>Linear Algebra and Differential Equations</td>
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<tr>
<td>PYL100</td>
<td>Electromagnetic Waves and Quantum Mechanics</td>
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<td>PYP100</td>
<td>Physics Laboratory</td>
<td>0 0 4 2</td>
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<tr>
<td>SBL100</td>
<td>Introductory Biology for Engineers</td>
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<tr>
<td>ELL100</td>
<td>Introduction to Electrical Engineering</td>
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<td>MCP100</td>
<td>Engineering Visualization</td>
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### Programme-Linked Basic/Engineering Arts/Sciences Core

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<td>Transport Phenomena</td>
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<tr>
<td>MTL102</td>
<td>Differential Equations</td>
<td>3 0 0 3</td>
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### Humanities and Social Sciences

Courses from Humanities, Social Sciences and Management offered under this category 15

### Departmental Core

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<td>Mass and Energy Balances in Biochemical Engineering</td>
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<td>BBL231</td>
<td>Molecular Biology and Genetics</td>
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<td>BBL431</td>
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### Departmental Electives

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<td>Physical and Chemical Engineering and Biotechnology</td>
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<td>Carbohydrates and Lipids in Biotechnology</td>
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<td>Special Module in Biochemical Engineering and Biotechnology</td>
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<td>BBD351</td>
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<td>Food Science and Engineering</td>
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<td>Modeling and Simulation of Bioprocesses</td>
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<td>Advanced Bioprocess Control</td>
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<td>Membrane Applications in Bioprocessing</td>
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*BBBD851 and BBBD852 together are alternatives to BBBD853 and BBBD854*

### Program Electives

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<td>Combinatorial Biotechnology</td>
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<td>BBL746</td>
<td>Current Topics in Biochemical Engineering and Biotechnology</td>
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<td>Bionanotechnology</td>
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Total=190.0
### Bachelor of Technology in Chemical Engineering

#### Department of Chemical Engineering

#### The overall Credit Structure

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**Institute Core: Basic Sciences**

- CML100 General Chemistry: 3 0 0 3
- CMP100 Chemistry Laboratory: 0 0 4 2
- MTL100 Calculus: 3 1 0 4
- MTL101 Linear Algebra and Differential Equations: 3 1 0 4
- PYL100 Electromagnetic Waves and Quantum Mechanics: 3 0 0 3
- PYP100 Physics Laboratory: 0 0 4 2
- SBL100 Introductory Biology for Engineers: 3 0 2 4

**Total Credits**: 22

**Institute Core: Engineering Arts and Sciences**

- APL100 Engineering Mechanics: 3 1 0 4
- COL100 Introduction to Computer Science: 3 0 2 4
- CVL100 Environmental Science: 2 0 2 4
- ELL100 Introduction to Electrical Engineering: 3 0 2 4
- MCP100 Engineering Visualization: 0 0 4 2
- MCP101 Product Realization through Manufacturing: 0 0 4 2

**Total Credits**: 18

**Programme-Linked Basic/Engineering Arts/Sciences Core**

- APL102 Introduction to Materials Science and Engineering: 3 0 2 4
- CML103 Applied Chemistry - Chemistry at Interfaces: 3 0 0 3

**Total Credits**: 7

**Humanities and Social Sciences**

Courses from Humanities, Social Sciences and Management offered under this category

**Total Credits**: 15

**Departmental Core**

- CLL110 Transport Phenomena: 3 1 0 4
- CLL111 Material and Energy Balances: 2 2 0 4
- CLL113 Numerical Methods in Chemical Engineering: 3 0 2 4
- CLL121 Chemical Engineering Thermodynamics: 3 1 0 4
- CLL122 Chemical Reaction Engineering-I: 3 1 0 4
- CLL141 Intro. to Materials for Chemical Engineers: 3 0 0 3
- CLL222 Chemical Reaction Engineering-II: 3 0 0 3
- CLL231 Fluid Mechanics for Chemical Engineers: 3 1 0 4
- CLL251 Heat Transfer for Chemical Engineers: 3 1 0 4
- CLL252 Mass Transfer-I: 3 0 0 3
- CLL261 Process Dynamics and Control: 3 1 0 4
- CLL271 Introduction to Industrial Biotechnology: 3 0 0 3
- CLP301 Chemical Engineering Laboratory-I: 0 0 3 1.5
- CLP302 Chemical Engineering Laboratory-II: 0 0 3 1.5
- CLP303 Chemical Engineering Laboratory-III: 0 0 3 1.5
- CLL331 Fluid-Particle Mechanics: 3 1 0 4
- CLL352 Mass Transfer-II: 3 1 0 4
- CLL361 Instrumentation and Automation: 1 0 3 2.5
- CLL371 Chemical Process Technology and Economics: 3 1 0 4
- CLD411 B. Tech. project: 0 0 8 4

**Total Credits**: 67

**Departmental Electives**

- CLL133 Powder Processing and Technology: 3 0 0 3
- CLL296 Nano-engineering of Soft Materials: 3 0 0 3
- CLL350 Process Utilities and Pipeline Design: 3 0 0 3
- CLL402 Process Plant Design: 3 0 0 3
- CLD412 Major Project in Energy and Environment: 0 0 10 5
- CLD413 Major Project in Complex Fluids: 0 0 10 5
- CLD414 Major Project in Process Engineering, Modeling and Optimization: 0 0 10 5
- CLD415 Major Project in Biopharmaceuticals and Fine Chemicals: 0 0 10 5
- CLL475 Safety and Hazards in Process Industries: 3 0 0 3

**Programme Code**: CH1

**Institute Core Courses**

- CLL710 Petroleum Reservoir Engineering: 3 0 0 3
- CLL706 Petroleum Production Engineering: 3 0 0 3
- CLL707 Population Balance Modeling: 3 0 0 3
- CLL720 Principles of Electrochemical Engineering: 3 0 0 3
- CLL721 Electrochemical Methods: 3 0 0 3
- CLL722 Electrochemical Conversion and Storage Devices: 3 0 0 3
- CLL723 Hydrogen Energy and Fuel Cell Technology: 3 0 0 3
- CLL724 Environmental Engineering and Waste Mgmt: 3 0 0 3
- CLL725 Air Pollution Control Engineering: 3 0 0 3
- CLL726 Molecular Modeling of Catalytic Reactions: 3 0 0 3
- CLL727 Heterogeneous Catalysis and Catalytic Reactors: 3 0 0 3
- CLL728 Biomass Conversion and Utilization: 3 0 0 3
- CLL730 Structure, Transport and Reactions in BioNanoo Systems: 3 0 0 3
- CLL731 Advanced Transport Phenomena: 3 0 0 3
- CLL732 Advanced Chemical Engineering: 3 0 0 3
- CLL733 Industrial Multiphasic Reactors: 3 0 0 3
- CLL734 Process Intensification and Novel Reactors: 3 0 0 3
- CLL735 Design of Multicomponent Separation Processes: 3 0 0 3
- CLL736 Experimental Characterization of Multiphase Reactors: 3 0 0 3
- CLL742 Experimental Characterization of BioMacromolecules: 3 0 0 3
- CLL743 Petrochemicals Technology: 3 0 0 3
- CLL761 Chemical Engineering Mathematics: 3 0 0 3
- CLL762 Advanced Computational Techniques in Chemical Engineering: 2 0 2 3
- CLL766 Interfacial Engineering: 3 0 0 3
- CLL767 Structures and Properties of Polymers: 3 0 0 3
- CLL768 Fundamentals of Computational Fluid Dynamics: 2 0 2 3
- CLL769 Applications of Computational Fluid Dynamics: 2 0 2 3
- CLL771 Introduction to Complex Fluids: 3 0 0 3
- CLL772 Transport Phenomena in Complex Fluids: 3 0 0 3
- CLL773 Thermodynamics of Complex Fluids: 3 0 0 3
- CLL774 Simulation Techniques for Complex Fluids: 3 0 0 3
- CLL775 Polymerization Process Modeling: 3 0 0 3
- CLL776 Granular Materials: 3 0 0 3
- CLL777 Complex Fluids Technology: 3 0 0 3
- CLL778 Interfacial Behaviour and Transport of Biomolecules: 3 0 0 3
- CLL779 Molecular Biotechnology and in-vitro Diagnostics: 3 0 0 3
- CLL780 Bioprocessing and Bioseparations: 3 0 0 3
- CLL781 Process Operations Scheduling: 3 0 0 3
- CLL782 Process Optimization: 3 0 0 3
- CLL783 Advanced Process Control: 3 0 0 3
- CLL784 Process Modeling and Simulation: 3 0 0 3
- CLL785 Evolutionary Optimization: 3 0 0 3
- CLL786 Fine Chemicals Technology: 3 0 0 3
- CLL791 Chemical Product and Process Integration: 3 0 0 3
- CLL792 Chemical Product Development and Commercialization: 3 0 0 3
- CLL793 Membrane Science and Engineering: 3 0 0 3
- CLL794 Petroleum Refinery Engineering: 3 0 0 3
- CVL796 Current Topics in Chemical Engineering: 1 0 0 1
- CVL797 Recent Advances in Chemical Engineering: 2 0 2 2
- CLL798 Selected Topics in Chemical Engineering-I: 3 0 0 3
- CLL799 Selected Topics in Chemical Engineering-II: 3 0 0 3
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Note: Courses 1-6 above are attended in the given order by half of all first year students. The other half of First year students attend the Courses 1-6 of II semester first.

TOTAL = 151.0
# Chemical Engineering

## Dual Degree Programme: Bachelor of Technology and Master of Technology in Chemical Engineering

### Department of Chemical Engineering

The overall Credit Structure

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### Institute Core: Basic Sciences

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## Dual Degree Programme: B.Tech. and M.Tech. in Chemical Engineering

| Semester | Course-1                  | Course-2                  | Course-3                  | Course-4                  | Course-5                  | Course-6                  | Course-7                  | Course-8                  | Course-9                  | L  | T  | P  | Credits | Non-Grad | Contact Hours |
|----------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|---------------------------|----------------|----------------|----------------|----------------|----------------|
| I        | ELL100                    | MCP100                    | PYL100                    | MTL100                    | PYP100                    | MCP101                    | NIN100                    | NEN100                    | NLN100                    | 1.5 | 13 | 17 | 2.5 | 28.5 |
|          | Introduction to Electrical Engineering | Introduction to Engineering | Electromagnetic Waves and Quantum Mechanics | Calculus | Product Realization through Manufacturing | Introduction to Engineering (Non-graded) | Professional Ethics and Social Responsibility-1 (Non-graded) | Language and Writing Skills-1 (Non-graded) |          | 9.5 | 13 | 17 | 2.5 | 28.5 |
|          | 3 | 0 | 2 | 4 | 0.5 | 0 | 3 | 2 | 0 | 0 | 4 | 2 | 0 | 0 | 2 | 1 | 0 | 0 | 1 | 0.5 | 0 | 0 | 2 | 1 |
| II       | APL100                    | COL100                    | CML100                    | MTL101                    | CMP100                    | NEN100                    | NLN100                    |          |          | 12 | 2 | 6 | 17.0 | 1.5 | 23.0 |
|          | Engineering Mechanics     | Introduction to Computer Science | Introduction to Chemistry | Linear Algebra and Differential Equations | Chemistry Laboratory | Professional Ethics and Social Responsibility-2 (Non-graded) | Language and Writing Skills-2 (Non-graded) |          |          |        |   |   |   |   |   |   |
|          | 3 | 1 | 0 | 4 | 3 | 0 | 2 | 4 | 3 | 0 | 0 | 3 | 3 | 1 | 0 | 4 | 0 | 0 | 4 | 2 | 0 | 0 | 1 | 0.5 | 0 | 0 | 2 | 1 |

Note: Courses 1-6 above are attended in the given order by half of all first year students. The other half of First year students attend the Courses 1-6 of II semester first.

| III      | CLL110                    | CLL111                    | CLL113                    | MTL101                    | HUL2XX                    | CLT101                    |          |          |          |        |   |   |   |   |   |   |
|          | Transport Phenomena       | Material and Energy Balances | Numerical Methods in Chemical Engineering | Applied Chemistry; Chemistry at Interfaces | Introduction to Chemical Engineering (Non-graded) |          |          |          |          | 14 | 4 | 2 | 19.0 | 1 | 22.0 |
|          | 3 | 1 | 0 | 4 | 2 | 2 | 0 | 4 | 3 | 0 | 2 | 4 | 3 | 0 | 0 | 3 | 3 | 1 | 0 | 4 | 0 | 0 | 2 | 1 |

| IV       | CLL121                    | CLL122                    | CLL231                    | CLL251                    | SBL100                    | APL102                    |          |          |          |        |   |   |   |   |   |   |
|          | Chemical Engineering Thermodynamics | Chemical Reaction Engineering I | Fluid Mechanics for Chemical Engineers | Heat Transfer for Chemical Engineers | Introductory Biology for Engineers | Introduction to Materials Science and Engineering |          |          |          | 18 | 4 | 4 | 24.0 | 0 | 26.0 |
|          | 3 | 1 | 0 | 3 | 1 | 0 | 4 | 0 | 3 | 1 | 0 | 4 | 3 | 1 | 0 | 4 | 3 | 0 | 2 | 4 |          | 0 |   |   |   |

| V        | CLL252                    | CLL221                    | CLL331                    | CLL141                    | CLL261                    | CVL100                    | CLP311                    |          |          | 17 | 2 | 3 | 20.5 | 0 | 22.0 |
|          | Mass Transfer I           | Chemical Reaction Engineering II | Fluid-Particle Mechanics | Introduction to Materials for Chemical Engineers | Process Dynamics and Control | Environmental Sciences | Chemical Engineering Laboratory I |          |          |        |   |   |   |   |   |   |
|          | 3 | 0 | 0 | 3 | 3 | 1 | 0 | 4 | 3 | 0 | 0 | 3 | 3 | 1 | 0 | 4 | 2 | 0 | 0 | 2 | 0 | 0 | 3 | 1.5 |

| VI       | CLL352                    | DE 1                      | CLL271                    | CLL371                    | HUL2XX                    | CLP302                    |          |          |          |        |   |   |   |   |   |   |
|          | Mass Transfer II          | Introduction to Industrial Biotechnology | Chemical Process Technology and Economics | Instrumentation and Automation | Chemical Engineering Laboratory II |          |          |          | 16 | 3 | 6 | 22.0 | 0 | 25.0 |
|          | 3 | 1 | 0 | 4 | 3 | 0 | 0 | 3 | 3 | 0 | 0 | 3 | 3 | 1 | 0 | 4 | 1 | 0 | 3 | 2.5 | 0 | 0 | 3 | 1.5 |

| VII      | DE 2                      | PET 1                     | PE 2                      | CLL303                    | HUL2XX                    | OC 1                      |          |          |          |        |   |   |   |   |   |   |
|          | Chemical Engineering Laboratory II | Proc. Engg |          |          |          |          |          |          |          | 18 | 1 | 3 | 20.5 | 0 | 22.0 |
|          | 3 | 0 | 0 | 3 | 3 | 0 | 0 | 3 | 3 | 0 | 0 | 3 | 3 | 1 | 0 | 4 | 3 | 0 | 0 | 3 |          | 0 |   |   |   |

| VIII     | PE 3                      | DE 3                      | CLL880                    | HUL30X                    | CLL731                    | CLL373                    | Minor Project | Adv Trans Phen | Inst Multiple Res |          |        |   |   |   |   |
|          | 3 | 0 | 0 | 3 | 0 | 0 | 0 | 3 | 0 | 0 | 8 | 4 | 3 | 0 | 0 | 3 | 3 | 0 | 0 | 3 |          | 15 | 0 | 8 | 19.0 | 0 | 23.0 |

| Summer   | CLL081                    | PE 4                      | DE 1                      |          |          |          |          |          |          |          | 6.0 | 0 | 16 | 14.0 | 0 | 22.0 |

| IX       | Major Project I           | Major Project II          | 0 | 0 | 16 | 8 | 3 | 0 | 0 | 3 | 3 | 0 | 0 | 3 | 0 | 0 | 3 | 0 | 0 | 3 | 0 | 0 | 3 | 0 | 0 | 3 |

| X        | Major Project II          | 0 | 0 | 24 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
Bachelor of Technology in Civil Engineering
Department of Civil Engineering

The overall Credit Structure

Course Category | Credits
---|---
Institute Core Courses | 105
Programme-linked Courses | 18
Departmental Courses | 15
Non Graded Units | 15
Total Graded Credit requirement | 155

Departmental Electives

Course Category | Credits
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Practice | 6
Total Credits | 12

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**Note:** Courses 1-6 above are attended in the given order by half of all first year students. The other half of First year students attend the Courses 1-6 of II semester first.

**TOTAL=155.0**
# Bachelor of Technology in Computer Science and Engineering

Department of Computer Science and Engineering

## The overall Credit Structure

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## Programme-Linked Basic/Engineering Arts/Sciences Core

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<td>Principles of Artificial Intelligence*</td>
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<td>COL341</td>
<td>Machine Learning</td>
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<td>Introduction to Database Management Systems*</td>
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*Of one COL333 or COL362 will be considered as DC and other will be considered as DE

**DC for CS1 students with specialization, DE for other CS1 students but with at most 4 credits counted towards DE.

***DC for CS1 students with specialization.
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Note: Courses 1-6 above are attended in the given order by half of all first year students. The other half of First year students attend the Courses 1-6 of II semester first.

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TOTAL=145.0
**Programme Code: CS5**

**Dual Degree Programme: Bachelor of Technology and Master of Technology in Computer Science and Engineering**

Department of Computer Science and Engineering

### The overall Credit Structure

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### Programme-Linked Basic/Engineering Arts/Sciences Core

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*One of these three courses

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## Institute Core: Basic Sciences
- **CML100** General Chemistry: 3 0 0 3
- **CMP100** Chemistry Laboratory: 0 0 4 2
- **MTL100** Calculus: 3 1 0 4
- **MTL101** Linear Algebra and Differential Equations: 3 1 0 4
- **PYL100** Electromagnetic Waves and Quantum Mechanics: 3 0 0 3
- **PYP100** Physics Laboratory: 0 0 4 2
- **SBL100** Introductory Biology for Engineers: 3 0 2 4

**Total Credits**: 22

## Institute Core: Engineering Arts and Sciences
- **APL100** Engineering Mechanics: 3 1 0 4
- **COL100** Introduction to Computer Science: 3 0 2 4
- **CVL100** Environmental Science: 2 0 0 2
- **ELL100** Introduction to Electrical Engineering: 3 0 2 4
- **MCP100** Engineering Visualization: 0 0 4 2
- **MCP101** Introduction to Product Realization through Manufacturing: 0 0 4 2

**Total Credits**: 18

## Programme-Linked Basic/Engineering Arts/Sciences Core
- **COL106** Data Structures and Algorithms: 3 0 4 5
- **MTL106** Probability and Stochastic Processes: 3 1 0 4
- **MCL142** Thermal Science for Electrical Engineers: 3 0 0 3
- **PYL102** Principles of Electronic Materials: 3 0 0 3

**Total Credits**: 15

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## Departmental Core
- ELL201 Digital Electronics: 3 0 3 4.5
- ELL202 Circuit Theory: 3 1 0 4
- ELL203 Electromechanics: 3 1 0 4
- ELP203 Electromechanics Laboratory: 0 0 3 1.5
- ELL205 Signals and Systems: 3 1 0 4
- ELL211 Physical Electronics: 3 0 0 3
- ELL212 Engineering Electromagnetics: 3 1 0 4
- ELP212 Electromagnetics Laboratory: 0 0 3 1.5
- ELL225 Control Engineering-I: 3 1 0 4
- ELP225 Control Engineering Laboratory: 0 0 3 1.5
- ELL302 Power Electronics: 3 0 0 3
- ELP302 Power Electronics Laboratory: 0 0 3 1.5
- ELL303 Power Engineering-I: 3 1 0 4
- ELP303 Power Engineering Laboratory: 0 0 3 1.5
- ELL304 Analog Electronic Circuits: 3 1 3 5.5
- ELL305 Computer Architecture: 3 0 0 3
- ELP305 Design and System Laboratory: 0 0 3 1.5
- ELL311 Communication Engineering: 3 1 0 4
- ELP311 Communication Engineering Laboratory: 0 0 2 1
- ELD411 B.Tech. Project-I: 0 0 6 3

**Total Credits**: 60

## Departmental Electives
- ELL301 Electrical and Electronics Instrumentation: 3 0 0 3
- ELL312 Semiconductor process technology: 3 0 0 3
- ELL313 Antennas and Propagation: 3 0 0 3
- ELL315 Introduction to Analog Integrated Circuits: 3 0 0 3
- ELL316 Introduction to VLSI Design: 3 0 0 3
- ELL318 Digital Hardware Design: 3 0 0 3
- ELL319 Digital Signal Processing: 3 0 2 4
- ELL332 Electric Drives: 3 0 0 3
- ELL333 Multivariable Control: 3 0 0 3
- ELL365 Embedded Systems: 3 0 0 3
- ELL400 Power Systems Protection: 3 0 0 3
- ELL401 Advanced Electromechanics: 3 0 0 3
- ELL402 Computer Communication: 3 0 0 3
- ELL405 Operating Systems: 3 0 0 3
- ELL406 Robotics and Automation: 3 0 0 3
- ELL407 Power Quality: 3 0 2 4
- ELL409 Machine Intelligence and Learning: 3 0 2 4
- ELL410 Multicore Systems: 3 0 0 3
- ELL411 Digital Communications: 3 0 2 4
- ELS310 Independent Study (EL): 0 3 0 3

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Programme Code: **EE1**

Bachelor of Technology in Electrical Engineering

Department of Electrical Engineering

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### B.Tech. in Electrical Engineering

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**Note:** Courses 1-6 above are attended in the given order by half of all first year students. The other half of first year students attend the Courses 1-6 of II semester first.
### Bachelor of Technology in Electrical Engineering Power and Automation

#### Department of Electrical Engineering

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#### Institute Core : Basic Sciences

- **CML100** General Chemistry 3 0 0 3
- **CMP100** Chemistry Laboratory 0 0 4 2
- **MTL100** Calculus 3 1 0 4
- **MTL101** Linear Algebra and Differential Equations 3 1 0 4
- **PYL100** Electromagnetic Waves and Quantum Mechanics 3 0 0 3
- **PYP100** Physics Laboratory 0 0 4 2
- **SBL100** Introductory Biology for Engineers 3 0 2 4

**Total Credits** 22

#### Institute Core: Engineering Arts and Sciences

- **APL100** Engineering Mechanics 3 1 0 4
- **COL100** Introduction to Computer Science 3 0 2 4
- **CVL100** Environmental Science 2 0 0 2
- **ELL100** Introduction to Electrical Engineering 3 0 2 4
- **MCP100** Engineering Visualization 0 0 4 2
- **MCP101** Product Realization through Manufacturing 0 0 4 2

**Total Credits** 18

#### Programme-Linked Basic/Engineering Arts/Sciences Core

- **COL106** Data Structures and Algorithms 3 0 4 5
- **MTL106** Probability and Stochastic Processes 3 1 0 4
- **MCL142** Thermal Science for Electrical Engineers 3 0 0 3
- **PYL102** Principles of Electronic Materials 3 0 0 3

**Total Credits** 15

#### Departmental Core

- ELL201 Digital Electronics 3 0 3 4.5
- ELL202 Circuit Theory 3 1 0 4
- ELL203 Electromechanics 3 1 0 4
- ELP203 Electromechanics Laboratory 0 0 3 1.5
- ELL205 Signals and Systems 3 1 0 4
- ELL225 Control Engineering-I 3 1 0 4
- ELP225 Control Engineering Laboratory 0 0 3 1.5
- ELL231 Power Electronics and Energy Devices 3 0 0 3
- ELL302 Power Electronics 3 0 0 3
- ELP302 Power Electronics Laboratory 0 0 3 1.5
- ELL303 Power Engineering-I 3 1 0 4
- ELP303 Power Engineering Laboratory 0 0 3 1.5
- ELL304 Analog Electronic Circuits 3 1 3 5.5
- ELL305 Computer Architecture 3 0 0 3
- ELP305 Design and System Laboratory 0 0 3 1.5
- ELL332 Electric Drives 3 0 0 3
- ELP332 Electric Drives Laboratory 0 0 3 1.5
- ELL363 Power Engineering-II 3 0 0 3
- ELL365 Embedded Systems 3 0 0 3
- ELD431 B.Tech. Project-I 0 0 6 3

**Total Credits** 60

#### Departmental Electives

- ELL301 Electrical and Electronics Instrumentation 3 0 0 3
- ELL311 Communication Engineering 3 1 0 4
- ELL319 Digital Signal Processing 3 0 2 4
- ELL333 Multivariable Control 3 0 0 3
- ELL334 Multivariable Control 3 0 2 4
- ELL400 Power Systems Protection 3 0 0 3
- ELL401 Advanced Electromechanics 3 0 0 3
- ELL405 Operating Systems 3 0 0 3
- ELL406 Robotics and Automation 3 0 0 3
- ELL407 Power Quality 3 0 2 4
- ELL409 Machine Intelligence and Learning 3 0 0 3
- ELL410 Multicore Systems 3 0 0 3
- ELL417 Renewable Energy System 3 0 0 3
- ELL431 Power System Optimization 3 0 0 3
- ELL436 Digital Control 3 0 0 3
- ELL437 Switch Mode Power Conversion 3 0 0 3
- ELL453 Power System Dynamics and Control 3 0 0 3
- ELS330 Independent Study (EP) 0 3 0 3
### B.Tech. in Electrical Engineering Power and Automation

#### EE3

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**Note:** Courses 1-6 above are attended in the given order by half of all first year students. The other half of first year students attend the Courses 1-6 of II semester first.
The overall Credit Structure

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Bachelor of Technology in Mechanical Engineering

Department of Mechanical Engineering

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**TOTAL=152.0**

Note: Courses 1-6 above are attended in the given order by half of all first year students. The other half of First year students attend the Courses 1-6 of II semester first.
The overall Credit Structure

Course Category Credits
Institute Core Courses
Basic Sciences (BS) 22
Engineering Arts and Science (EAS) 18
Humanities and Social Sciences (HuSS) 15
Programme-linked Courses 11
Departmental Courses
Departmental Core 66
Departmental Electives 12
Open Category Courses 10
Total Graded Credit requirement 154
Non Graded Units 15

Institute Core: Basic Sciences
CML100 General Chemistry 3 0 0 3
CMP100 Chemistry Laboratory 0 0 4 2
MTL100 Calculus 3 1 0 4
MTL101 Linear Algebra and Differential Equations 3 1 0 4
PYL100 Electromagnetic Waves and Quantum Mechanics 3 0 0 3
PYP100 Physics Laboratory 0 0 4 2
SBL100 Introductory Biology for Engineers 3 0 2 4
Total Credits 22

Institute Core: Engineering Arts and Sciences
APL100 Engineering Mechanics 3 1 0 4
COL100 Introduction to Computer Science 3 0 2 4
CVL100 Environmental Science 2 0 0 2
ELL100 Introduction to Electrical Engineering 3 0 4 2
MCP100 Introduction to Engineering Visualization 0 0 4 2
MCP101 Product Realization through Manufacturing 0 0 4 2
Total Credits 18

Programme-Linked Basic/Engineering Arts/Sciences Core
APL102 Introduction to Materials Science and Engineering 3 0 2 4
MTL107 Numerical Methods and Computations 3 0 3 3
MTL108 Introduction to Statistics 3 1 0 4
Total Credits 11

Humanities and Social Sciences
Courses from Humanities, Social Sciences and Management offered under this category 15

Departmental Core
APL104 Solid Mechanics 3 1 0 4
MCL111 Kinematics and Dynamics of Machines 3 0 2 4
MCL132 Metal Forming and Press Tools 3 0 0 3
MCL133 Near Net Shape Manufacturing 3 0 0 3
MCL134 Metrology and Quality Assurance 3 0 1 3.5
MCL135 Welding and Allied Processes 3 0 0 3
MCL136 Material Removal Processes 3 0 0 3
MCL141 Thermal Science for Manufacturing 3 1 0 4
MCL201 Mechanical Engineering Drawing 2 0 3 3.5
MCL211 Design of Machines 3 0 2 4
MCL212 Control Theory and Applications 3 0 2 4
MCP232 Production Engineering Laboratory-I 0 0 2 1
MCP261 Introduction to Operations Research 3 0 0 3
MCP261 Industrial Engineering Laboratory-I 0 0 2 1
MCL262 Stochastic Modelling and Simulation 3 0 0 3
MCL311 CAD and Finite Element Analysis 3 0 2 4
MCL331 Micro and Nano Manufacturing 3 0 0 3
MCP332 Production Engineering Laboratory-II 0 0 2 1
MCL361 Manufacturing System Design 3 0 0 3
MCP361 Industrial Engineering Laboratory-II 0 0 2 1
MCD411 B.Tech. Project 0 0 8 4
MCL431 CAM and Automation 2 0 2 3
Total Credits 66

Departmental Electives
MCD310 Mini Project 0 0 6 3
MCL314 Acoustics and Noise Control 3 0 2 4
MCL321 Automotive Systems 3 0 2 4
MCL322 Power Train Design 3 0 0 3
MCL330 Special Topics Production Engg 3 0 0 3
MCL334 Industrial Automation 3 0 2 4
MCL336 Advances in Welding 3 0 2 4
MCL337 Advanced Machining Processes 3 0 0 3
MCL338 Mechatronic Applications in Manufacturing 3 0 2 4
MCL341 Gas Dynamics and Propulsion 3 0 2 4
MCL343 Introduction to Combustion 3 0 0 3
MCL344 Refrigeration and Air-conditioning 3 0 2 4
MCL345 Reciprocating Internal Combustion Engines 3 0 2 4
MCL347 Intermediate Heat Transfer 3 0 0 3
MCL348 Thermal Management of Electronics 3 0 0 3
MCL350 Mechanical Engineering Product Synthesis 1 0 2 2
MCL363 Investment Planning 3 0 0 3
MCL364 Value Engineering 3 0 2 4
MCL366 OR Methods in Policy Governance 3 0 0 3
MCL368 Quality and Reliability Engineering 3 0 0 3
MCL370 Special Topics in Industrial Engg 3 0 0 3
MCL380 Special Topics in Mechanical Engineering 3 0 0 3
MVC390 Special module in Mechanical Engineering 1 0 0 1
MCD412 B.Tech. Project-II 0 0 14 7
MCL421 Automotive Structural Design 2 0 2 3
MCL422 Design of Brake Systems 2 0 2 3
MCL441 Modelling and Experiments in Heat Transfer 2 0 4 4
MCL442 Thermo Fluid Analysis of Biosystems 3 0 0 3
MCL443 Electrochemical Energy Systems 3 0 0 3
MCL721 Automotive Prime Movers 3 0 0 3
MCL722 Mechanical Design of Prime Mover Elements 3 0 0 3
MCL723 Vehicle Dynamics 3 0 0 3
MCL724 Biomechanics of Trauma in Automotive Design 3 0 0 3
MCL725 Design Electronic Assist Systems in Automobiles 3 0 0 3
MCL726 Design of Steering Systems 3 0 0 3
MCL729 Nanomechanics 2 0 2 3
MCL747 Design of Precision Machines 2 0 2 3
MCL749 Mechatronics Product Design 3 0 2 4
MCL750 Product Design and Manufacturing 1 0 4 3
MCL753 Manufacturing Informatics 3 0 2 4
MCL755 Service System Design 3 0 0 3
MCL756 Supply Chain Management 3 0 0 3
MCL759 Entrepreneurship 3 0 0 3
MCL760 Project Management 3 0 0 3
MCL776 Advances in Metal Forming 3 0 0 3
MCL777 Machine Tool Design 3 0 2 4
MCL788 Surface Engineering 3 0 2 4

Bachelor of Technology in Production and Industrial Engineering
Department of Mechanical Engineering

Programme Code: ME2
# B. Tech. in Production and Industrial Engineering

## ME2

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Note: Courses 1-6 above are attended in the given order by half of all first year students. The other half of First Year students attend the Courses 1-6 of II semester first.
### Bachelor of Technology in Mathematics and Computing

#### Department of Mathematics

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Note: Courses 1-6 above are attended in the given order by half of all first year students. The other half of First year students attend the Courses 1-6 of II semester first.

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**TOTAL = 153.0**
### Department of Mathematics

#### The overall Credit Structure

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<tr>
<td>Departmental Electives</td>
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#### Departmental Core Courses

<table>
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<tbody>
<tr>
<td>Basic Sciences (BS)</td>
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<td>Humanities and Social Sciences (HuSS)</td>
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#### Departmental Electives

<table>
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<td>ELL365 Embedded Systems</td>
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<td>MTL145 Number Theory</td>
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<td>MTL146 Combinatorics</td>
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<tr>
<td>MTL260 Boundary Value Problems</td>
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<tr>
<td>MTL265 Mathematical Programming Techniques</td>
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<td>MTL270 Measure Integral and Probability</td>
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<td>MTD350 Mini Project</td>
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<td>MTL415 Parallel Algorithms</td>
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<td>MTL768 Graph Theory</td>
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<td>MTL773 Wavelets and Applications</td>
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#### Program Core

<table>
<thead>
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<tr>
<td>MTL766 Multivariate Statistical Methods</td>
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<td>MTD853* Major Project Part-I</td>
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<td>MTD854* Major Project Part-II</td>
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#### Total Credits

- Total M.Tech. Requirement: 42
- Total Departmental Electives: 33
- Total Program Electives: 18
- Total Credit Requirement: 187

#### Institute Core Courses

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
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<td>MTL100 Calculus</td>
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<td>PLY100 Electromagnetic Waves and Quantum Mechanics</td>
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<tr>
<td>PYP101 Physics Laboratory</td>
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<tr>
<td>SBL100 Introductory Biology for Engineers</td>
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**Total Credits:** 22

#### Institute Core: Engineering Arts and Sciences

<table>
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<tr>
<th>Course</th>
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<tbody>
<tr>
<td>APL100 Engineering Mechanics</td>
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<tr>
<td>COL100 Introduction to Computer Science</td>
<td>3 0 2 4</td>
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<tr>
<td>CVL100 Environmental Science</td>
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<td>ELL100 Introduction to Electrical Engineering</td>
<td>3 0 2 4</td>
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<tr>
<td>MCP100 Engineering Visualization</td>
<td>0 0 4 2</td>
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<td>MCP101 Product Realization through Manufacturing</td>
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**Total Credits:** 18

#### Programme-Linked Basic/Engineering Arts/Sciences Core

<table>
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<tbody>
<tr>
<td>COL106 Data Structures and Algorithms</td>
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<td>ELL201 Digital Electronics</td>
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<tr>
<td>PLY102 Principles of Electronic Materials</td>
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**Total Credits:** 12.5

#### Humanities and Social Sciences

Courses from Humanities, Social Sciences and Management offered under this category: 15

#### Departmental Core

<table>
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<tbody>
<tr>
<td>ELL305 Computer Architecture</td>
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<td>MTL102 Differential Equations</td>
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<td>MTL103 Optimization Methods and Applications</td>
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<td>MTL104 Linear Algebra and Applications</td>
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<tr>
<td>MTL105 Algebra</td>
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<td>MTL106 Probability and Stochastic Processes</td>
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<td>MTL107 Numerical Methods and Computations</td>
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<td>MTL122 Real and Complex Analysis</td>
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<td>MTL180 Discrete Mathematical Structures</td>
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<td>MTP290 Computing Laboratory</td>
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<td>MTL342 Analysis and Design of Algorithms</td>
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<td>MTL363 Theory of Computation</td>
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<td>MTL390 Statistical Methods</td>
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<td>MTL445 Computational Methods for Differential Equations</td>
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<td>MTL458 Operating Systems</td>
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**Total Credits:** 59.5

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### Programme Code: MT6

**Dual Degree Programme: Bachelor of Technology and Master of Technology in Mathematics and Computing**

**Department of Mathematics**

---

**Programme Electives**

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<td>ELL792 Computer Graphics</td>
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<td>ELL793 Computer Vision</td>
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<td>MTL704 Numerical Optimization</td>
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<td>MTL717 Fuzzy Sets and Applications</td>
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<td>MTL720 Neurocomputing and Applications</td>
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<td>MTL725 Stochastic Processes and its Applications</td>
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<td>MTL728 Category Theory</td>
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<td>MTL729 Computational Algebra and its Applications</td>
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<tr>
<td>MTL730 Cryptography</td>
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<tr>
<td>MTL731 Introduction to Chaotic Dynamical Systems</td>
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<td>MTL732 Financial Mathematics</td>
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<td>MTL733 Stochastic of Finance</td>
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<td>MTL735 Advanced Number Theory</td>
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<td>MTL738 Commutative Algebra</td>
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<td>MTL739 Representation of Finite Groups</td>
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<td>MTL741 Fractal Geometry</td>
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<td>MTL745 Advanced Matrix Theory</td>
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<td>MTL751 Symbolic Dynamics</td>
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<td>MTL754 Principles of Computer Graphics</td>
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<td>MTL755 Algebraic Geometry</td>
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<td>MTL756 Lie Algebras and Lie Groups</td>
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### The overall Credit Structure

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### Departmental Electives

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<td>PYL301</td>
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<tr>
<td>PYL302</td>
<td>Nuclear Science and Engineering</td>
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<td>PYL303</td>
<td>Materials Science and Engineering</td>
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<tr>
<td>PYL304</td>
<td>Superconductivity and Applications</td>
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<tr>
<td>PYL305</td>
<td>Engineering Applications of Plasmas</td>
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<tr>
<td>PYL306</td>
<td>Microelectronic Devices</td>
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<tr>
<td>PYL311</td>
<td>Lasers</td>
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<td>PYL312</td>
<td>Semiconductor Optoelectronics</td>
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<td>PYL313</td>
<td>Fourier Optics and Holography</td>
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<tr>
<td>PYL321</td>
<td>Low Dimensional Physics</td>
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<tr>
<td>PYL322</td>
<td>Nanoscale Fabrication</td>
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<td>PYL323</td>
<td>Nanoscale Microscopy</td>
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<td>Spectroscopy of Nanomaterials</td>
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<td>PYL331</td>
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<td>PYL332</td>
<td>General Theory of Relativity &amp; Cosmology</td>
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<td>Special Topics in Photonics</td>
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<td>PYL421</td>
<td>Functional Nanostructures</td>
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<td>PYL423</td>
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<td>Relativistic Quantum Mechanics</td>
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<td>Quantum Electrodynamics</td>
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<td>PYL433</td>
<td>Introduction to Gauge Field Theories</td>
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### Programme Code: PH1

**Bachelor of Technology in Engineering Physics**

**Department of Physics**

<table>
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<tbody>
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<td>PYL114</td>
<td>Solid State Physics</td>
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<td>PYL115</td>
<td>Applied Optics</td>
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<td>PYL116</td>
<td>Elements of Materials Processing</td>
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<td>PYL202</td>
<td>Statistical Physics</td>
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<td>PYL203</td>
<td>Classical Mechanics &amp; Relativity</td>
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<td>PYL204</td>
<td>Computational Physics</td>
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<td>PYP212</td>
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<td>PYP221</td>
<td>Engineering Physics Laboratory-III</td>
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<td>PYD411</td>
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**Total Credits**: 58

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**Programme Code:** PH1

**Bachelor of Technology in Engineering Physics**

**Department of Physics**

<table>
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<td>Chemistry Laboratory</td>
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<td>MTL100</td>
<td>Calculus</td>
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<td>Linear Algebra and Differential Equations</td>
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<td>PYL100</td>
<td>Electromagnetic Waves and Quantum Mechanics</td>
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<td>PYP100</td>
<td>Physics Laboratory</td>
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<tr>
<td>SBL100</td>
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**Total Credits**: 22

<table>
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<tbody>
<tr>
<td>APL100</td>
<td>Engineering Mechanics</td>
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<tr>
<td>COL100</td>
<td>Introduction to Computer Science</td>
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<tr>
<td>CVL100</td>
<td>Environmental Science</td>
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<tr>
<td>ELL100</td>
<td>Introduction to Electrical Engineering</td>
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<tr>
<td>MCP100</td>
<td>Engineering Visualization</td>
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<td>MCP101</td>
<td>Product Realization through Manufacturing</td>
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**Total Credits**: 18

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**Total Credits**: 14.5

### Humanities and Social Sciences

**Courses from Humanities, Social Sciences and Management offered under this category**: 15

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<td>PYL112</td>
<td>Quantum Mechanics</td>
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### B. Tech. in Engineering Physics

| Semester | Course-1 | Course-2 | Course-3 | Course-4 | Course-5 | Course-6 | Course-7 | Course-8 | Course-9 | L | T | P | Credits | Non-Graded Units | Contact Hours |
|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----|----|----|--------|----------------|-------------|-------------|
| I        | ELL100   | MCP100   | PYL100   | MTL100   | PYP100   | MCP101   | NIN100   | NEN100   | NLN100   |    |    |    | 4.0    | 0.0           |             |
|          | Introduction to Electrical Engineering | Introduction to Engineering Visualization | Electromagnetic Waves and Quantum Mechanics | Calculus | Physics Laboratory | Product Realization through Manufacturing | Introduction to Engineering (Non-graded) | Professional Ethics and Social Responsibility-1 (Non-graded) | Language and Writing Skills-1 (Non-Graded) |    |    |    |        |               |             |
|          | 3 0 2 4 | 0.5 0 3 2 | 3 0 0 3 | 3 1 0 4 | 0 0 4 2 | 0 0 4 2 | 0 0 2 1 | 0 0 1 0.5 | 0 0 2 1 |    | 9.5 | 13 | 17.0 | 2.5 | 28.5 |
| II       | APL100   | COL100   | CML100   | MTL101   | CMP100   | NEN100   | NLN100   |          |          |    |    |    | 4.5    |               |             |
|          | Engineering Mechanics | Introduction to Computer Science | Introduction to Chemistry | Linear Algebra and Differential Equations | Chemistry Laboratory | | | | |    |    |    |        |               |             |
|          | 3 1 0 4 | 3 0 2 4 | 3 0 0 3 | 3 1 0 4 | 0 0 4 2 | | | | 0 0 1 0.5 | 0 0 2 1 | 12 | 2 | 6 | 17.0 | 1.5 | 23.0 |

Note: Courses 1-6 above are attended in the given order by half of all first year students. The other half of first year students attend the Courses 1-6 of II semester first.

| III      | PYL111   | PYL113   | PYL115   | HUL2XX   | CVL100   | PYP111   | PYN101   |          | |    |    |    |        |               |             |
|          | Electrodynamics | Mathematical Physics | Applied Optics | Environmental Science | Engineering Physics Laboratory-I | Introduction To Engineering (Non-graded) | | | | | | | | | | | |
|          | 3 1 0 4 | 3 1 0 4 | 3 1 0 4 | 3 1 0 4 | 2 0 0 2 | 0 0 6 3 | 0 0 2 1 | | | | | | | | | | |
| IV       | PYL112   | PYL114   | ELL201   | PYP121   |          | | | | | | | | | | | | | | | |
|          | Quantum Mechanics | Solid State Physics | | Digital Electronics | Engineering Physics Laboratory-I | | | | | | | | | | | | | | | |
|          | 3 1 0 4 | 3 1 0 4 | 3 1 0 4 | 3 0 3 4.5 | 0 0 6 3 | | | | | | | | | | | | |
| V        | PYL201   | PYL203   | HUL2XX   | ELL205   | HUL2XX   | CML102   | PYP221   |          | |    |    |    |        |               |             |
|          | 3 1 0 4 | 3 1 0 4 | 3 1 0 4 | 3 1 0 4 | 3 0 3 3 | 0 0 8 4 | | | | | | | | | | | |
| VI       | PYL202   | PYL204   | ESL350   | HUL2XX   | SBL100   | PYP222   |          |   | |    |    |    |        |               |             |
|          | Statistical Physics | Computational Physics | Energy Conservation and Management | Introductory Biology for Engineers | Engineering Physics Laboratory-V | | | | | | | | | | | | | | | |
|          | 3 1 0 4 | 3 1 0 4 | 3 0 0 3 | 3 1 0 4 | 3 0 2 4 | 0 0 8 4 | | | | | | | | | | | |
| VII      | DE 1     | DE 2     | OC 1     | HUL3XX   | PYD411   |          |          | | | | | | | | | | | | |
|          | B. Tech. Project | | | | | | | | | | | | | | | | | |
|          | 3 0 0 3 | 3 0 0 3 | 3 0 0 3 | 3 0 0 3 | 3 0 0 3 | 0 0 8 4 | | | | | | | | | | | |
| VIII     | DE 3     | DE 4     | OC 2     | OC 3     |          | | | | | | | | | | | | | | | |
|          | 3 0 0 3 | 3 0 0 3 | 3 1 0 4 | 3 0 0 3 | | | | | | | | | | | | | | | |

**TOTAL=149.5**
# Bachelor of Technology in Textile Technology

**Department of Textile**

## The overall Credit Structure

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<tr>
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<td>SBL100</td>
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### Institute Core: Engineering Arts and Sciences

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### Programme-Linked Basic/Engineering Arts/Sciences Core

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### Humanities and Social Sciences

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### Departmental Core

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<td>Structure and Physical Properties of Fibres</td>
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<td>Professional Practices</td>
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Note: Courses 1-6 above are attended in the given order by half of all first year students. The other half of first year students attend the Courses 1-6 of II semester first.

TOTAL=145.0

B.Tech. in Textile Technology
7. CAPABILITY-LINKED OPTIONS FOR UNDERGRADUATE STUDENTS

As described in Section 4.8, students with CGPA higher than 7.0 and/or earned credits higher than 20 per semester are eligible to register for additional credits towards the following Capability-linked options. They can make use of these additional credits in two blocks of 20 credits to opt for

(a) Minor/Interdisciplinary Area Specialization
(b) Departmental Specialization

A student based on his/her performance and interest can choose either one on both. Successful completion of minor area credits and/or Interdisciplinary/Departmental Specialization will be indicated on the degree.

When a student opts for such a specialization and/or a minor area, he/she can use 10 open category (OC) credits (mandatory degree requirement) towards the specialization and/or minor area requirements. For example, a student registered for B.Tech (Chemical Engg.) and opting for minor area in Computer Science, can opt for courses prescribed for the minor area, as part of mandatory 10 credits requirements under OC. He/she will need to do additional 10 credits for completing the Minor area requirements.

A set of pre-defined courses of total 20 credits in a focus area comprises a Departmental Specialization if the courses belong to the parent Department of an undergraduate programme, or a Minor/Interdisciplinary Area Specialization if the courses belong to a different Department/Centre/School. Additional conditions and details are given in this section.

If any course of a Minor/Interdisciplinary area overlaps with any core course (DC or PC category courses) or elective course (DE or PE category courses) of the student’s programme, then credits from this course will not count towards the minor area credit requirements, though this course may contribute towards satisfying the requirement of the Minor/Interdisciplinary area. In such a case, the requirement of 20 credits must be completed by taking other courses of the Minor Area or Departmental/Interdisciplinary specialization. A student interested in opting for a Capability-linked option can register for the same online, on a first-come first served basis, after he/she completes at least 2 courses, preferably the core courses (wherever applicable) of the Minor Area/Interdisciplinary/Departmental Specialization being applied for.

**Minor Area in Atmospheric Sciences (Centre for Atmospheric Sciences)**

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<tr>
<td>ASL320 Climate Change: Impacts, Adaptation and Mitigation</td>
<td>3 0 2 4</td>
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<td>ASL410 Numerical Simulation of Atmospheric and Oceanic Phenomena</td>
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<td>ASL733 Physics of the Atmosphere</td>
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<td>ASL762 Air-Sea Interaction</td>
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**Minor Area Electives**

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**Total Credits**

**Minor Area in Business Management (Department of Management Studies)**

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**Total Credits**

**Minor Area Electives (9 credits required)**

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**Minor Area in Computational Mechanics (Department of Applied Mechanics)**

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<td>AC010</td>
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<td>Biomechanics</td>
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<td>ACL401</td>
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<td>ACL440</td>
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<td>ACL702</td>
<td>Finite Element Method</td>
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<td>Computer Aided Design</td>
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**Minor Area in Materials Engineering (Department of Applied Mechanics)**

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<td>AR012</td>
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<td>APS01</td>
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<td>Properties and Selection of Engineering Materials</td>
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<td>APQ06</td>
<td>Microstructural Characterization of Materials</td>
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<td>AR031</td>
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### Minor Area Non Departmental Electives in Material Science

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<td>Welding Science and Technology</td>
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**Minor Area in Computer Science (Department of Computer Science and Engineering)**

**Note:** A student needs to do a minimum of three courses out of Minor Area Core and remaining courses from Minor Area Electives.

### Minor Area Core

<table>
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**Total Credits (any three above courses)** 12-15

### Minor Area Electives

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**Minor Area in Cogeneration and Energy Efficiency (Centre for Energy Studies)**

### Minor Area Core

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**Total Credits** 9

### Minor Area Electives

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<td>Waste Heat Recovery</td>
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### Minor Area in Renewable Energy (Centre for Energy Studies)

### Minor Area Electives

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### Minor Area in Technologies for Sustainable Rural Development (Centre for Rural Development and Technology)

**Minor Area Core (Any three of the following courses)**

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<td>RDL705</td>
<td>Rural Resources and Livelihoods</td>
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<td>RDL722</td>
<td>Rural Energy Systems</td>
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<td>RDL724</td>
<td>Technologies for Water and Waste</td>
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<td>RDL730</td>
<td>Technology Alternatives for Rural Development</td>
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<td>RDL760</td>
<td>Food Quality and Safety</td>
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**Total Credits**: 9

**Minor Area Electives**

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<td>Herbal, Medicinal and Aromatic Plants</td>
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<td>Technology for Utilization of Wastelands and Weeds</td>
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<td>RDL801</td>
<td>Successful Forms of Grassroot Organizations</td>
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<td>RDL807</td>
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### Minor Area / Departmental Specialization in Biopharmaceuticals and Fine Chemicals (Department of Chemical Engineering)

**Minor Area / Specialization Electives**

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<td>Structure, Transport and Reactions in BioNano Systems</td>
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<td>CLL742</td>
<td>Experimental Characterization of BioMacromolecules</td>
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<td>CLL767</td>
<td>Polymers</td>
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<td>CLL775</td>
<td>Polymerization Process Modeling</td>
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<td>Interfacial Behaviour and Transport of Biomolecules</td>
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<td>Molecular Biotechnology and in-vitro Diagnostics</td>
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<td>Bioprocessing and Bioseparations</td>
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<td>Process Operations Scheduling</td>
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<td>CLL866</td>
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<tr>
<td>CLL791</td>
<td>Chemical Product and Process Integration</td>
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<td>CLL792</td>
<td>Chemical Product Development and Commercialization</td>
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<td>SBL705</td>
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**Total Credits**: 105

### Minor Area / Departmental Specialization in Complex Fluids and Materials (Department of Chemical Engineering)

**Minor Area / Specialization Core**

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<td>CLL761</td>
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<td>CLL768</td>
<td>Fundamentals of Computational Fluid Dynamics</td>
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<td>CLL769</td>
<td>Applications of Computational Fluid Dynamics</td>
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<td>CLL791</td>
<td>Membrane Science and Engineering</td>
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<td>CLL794</td>
<td>Petroleum Refinery Engineering</td>
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**Total Credits**: 105
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<td>MCL12*</td>
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<td>ELL229*</td>
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**Total Credits:** 13/14

*Students of ME1/ME2 to take only one of these courses as core.

# Students of CS1/CSS to take only one of these courses as core.

Core 1

**Total Credits:** 13/14

Core 2

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Core 3

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**Total Credits:** 13/14

Since the course may have pre-requisites, plan in advance. A student is required to complete (one of the core 1 course), (core 2 course) and (core 3 course).

**Specialization Electives**

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<td>Machine Learning</td>
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<td>COL351</td>
<td>Analysis and Design of Algorithms</td>
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**Departmental Specialization in Applications and Information Technology**

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**Specialization Electives**

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<td>Introduction to Database Mgmt. Systems*</td>
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<td>Introduction to Logic</td>
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<td>MCL786</td>
<td>Advanced Functional Brain Imaging</td>
<td>3 0 2 4</td>
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<tr>
<td>COL865</td>
<td>Special Topics in Computer Applications</td>
<td>3 0 0 3</td>
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<tr>
<td>COL869</td>
<td>Special Topics in Concurrency</td>
<td>3 0 0 3</td>
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<tr>
<td>COV885</td>
<td>Special Module in Database Systems</td>
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</tr>
<tr>
<td>COV889</td>
<td>Special Module in Concurrency</td>
<td>1 0 0 1</td>
</tr>
<tr>
<td>SIL769</td>
<td>Internet Traffic-Measurement, Modeling &amp; Analysis</td>
<td>3 0 2 4</td>
</tr>
<tr>
<td>SIL801</td>
<td>Special Topics in Multimedia System</td>
<td>3 0 0 3</td>
</tr>
<tr>
<td>SIL802</td>
<td>Special Topics in Web Based Computing</td>
<td>3 0 0 3</td>
</tr>
<tr>
<td>SIV813</td>
<td>Applications of Computer in Medicines</td>
<td>1 0 0 1</td>
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**Total Credits:** 12

*Courses of Study 2017-2018*
SIV861 Information and Comm Technologies 1 0 0 1 for Development
SIV864 Special Module on Media Processing & Communication 1 0 0 1
SIV871 Special Module in Computational Neuroscience 1 0 0 1
SIV889 Special Module in Human Computer Interaction 1 0 0 1
SIV895 Special Module on Intelligent Information Processing 1 0 0 1

Departmental Specialization in Architecture and Embedded Systems (Department of Computer Science and Engineering)

Specialization Core
COD494 B.Tech. Project Part-II 0 0 16 8
COL703 Logic for Computer Science 3 0 2 4

Total Credits 12

Specialization Electives
COP315 Embedded System Design Project 0 1 6 4
COL718 Architecture of High Performance Computers 3 0 2 4
COL719 Synthesis of Digital Systems 3 0 2 4
COL788 Advanced Topics in Embedded Computing 3 0 0 3
COL812 System Level Design and Modelling 3 0 0 3
COL818 Principles of Multiprocessor Systems 3 0 2 4
COL821 Reconfigurable Computing 3 0 0 3
COL861 Special Topics in Hardware Systems 3 0 0 3
COV881 Special Module in Hardware Systems 1 0 0 1

Departmental Specialization in Data Analytics and Artificial Intelligence (Department of Computer Science and Engineering)

Specialization Core
COD494 B.Tech. Project Part 2 0 0 16 8
COL703 Logic for Computer Science 3 0 2 4

Total Credits 12

Specialization Electives
COL333 Principles of Artificial Intelligence* 3 0 2 4
COL341 Machine Learning 3 0 2 4
COL362 Introduction to Database Mgmt. Systems* 3 0 2 4
COL760 Advanced Data Management 3 0 2 4
COL762 Database Implementation 3 0 2 4
COL765 Introduction to Logic and Functional Programming 3 0 2 4
COL770 Advanced Artificial Intelligence 3 0 2 4
COL772 Natural Language Processing 3 0 2 4
COL774 Machine Learning 3 0 2 4
COL776 Learning Probabilistic Graphical Models 3 0 2 4
COL786 Advanced Functional Brain Imaging 3 0 2 4
COL864 Special Topics in Artificial Intelligence 3 0 0 3
COL868 Special Topics in Database Systems 3 0 0 3
COL869 Special Topics in Concurrency 3 0 0 3
COL870 Special Topics in Machine Learning 3 0 0 3
COV878 Special Module in Machine Learning 1 0 0 1
COV884 Special Module in Artificial Intelligence 1 0 0 1
COV888 Special Module in Database Systems 1 0 0 1
COV889 Special Module in Concurrency 1 0 0 1

Departmental Specialization in Graphics and Vision (Department of Computer Science and Engineering)

Specialization Core
COD494 B.Tech. Project Part 2 0 0 16 8
COL703 Logic for Computer Science 3 0 2 4

Total Credits 12

Specialization Electives
COL780 Computer Vision 3 0 2 4
COL781 Computer Graphics 3 0 3 4.5
COL783 Digital Image Analysis 3 0 3 4.5
COL829 Advanced Computer Graphics 3 0 2 4
COV877 Special Module on Visual Computing 1 0 0 1
SIL801 Special Topics in Multimedia System 3 0 0 3

Departmental Specialization in Software Systems (Department of Computer Science and Engineering)

Specialization Core
COD494 B.Tech. Project Part 2 0 0 16 8
COL703 Logic for Computer Science 3 0 2 4

Total Credits 12

Specialization Electives
COL724 Advanced Computer Networks 3 0 2 4
COL728 Compiler Design 3 0 3 4.5
COL729 Compiler Optimization 3 0 3 4.5
COL730 Parallel Programming 3 0 2 4
COL732 Virtualization and Cloud Computing 3 0 2 4
COL733 Cloud Computing Technology Fundamentals 3 0 2 4
COL740 Software Engineering 3 0 2 4
COL768 Wireless Networks 3 0 2 4
COL819 Advanced Distributed Systems 3 0 2 4
COL851 Special Topics in Operating Systems 3 0 0 3
COL852 Special Topics in Compilers 3 0 0 3
COL860 Special Topics in Parallel Computation 3 0 0 3
COL862 Special Topics in Software Systems 3 0 0 3
COL867 Special Topics in High Speed Networks 3 0 0 3
COL871 Special Topics in Programming Languages and Compilers 3 0 0 3
COV876 Special Module on Automated Reasoning 1 0 0 1
COV880 Special Module in Parallel Computation 1 0 0 1
COV882 Special Module in Software Systems 1 0 0 1
COV887 Special Module in High Speed Networks 1 0 0 1
SIL765 Networks & System Security 3 0 2 4
SIL769 Internet Traffic - Measurement, Modeling & Analysis 3 0 2 4

Departmental Specialization in Theoretical Computer Science (Dept. of Computer Science and Engineering)

Specialization Core
COD494 B.Tech. Project Part 2 0 0 16 8
COL703 Logic for Computer Science 3 0 2 4

Total Credits 12

Specialization Electives
COL726 Numerical Algorithms 3 0 2 4
COL730 Parallel Programming 3 0 2 4
COL750 Foundations of Automatic Verification 3 0 2 4
COL751 Algorithmic Graph Theory 3 0 0 3
COL752 Geometric Algorithms 3 0 0 3
COL753 Complexity Theory 3 0 0 3
COL754 Approximation Algorithms 3 0 0 3
COL756 Mathematical Programming 3 0 0 3
COL757 Model Centric Algorithm Design 3 0 2 4
COL758 Advanced Algorithms 3 0 2 4
COL759 Cryptography & Computer Security 3 0 0 3
COL830 Distributed Computing 3 0 0 3
COL851 Semantics of Programming Languages 3 0 0 3
COL852 Proofs and Types 3 0 0 3
COL860 Special Topics in Parallel Computation 3 0 0 3
COL863 Special Topics in Theoretical Computer Science 3 0 0 3
COL866 Special Topics in Algorithms 3 0 0 3
COL872 Special Topics in Cryptography 3 0 0 3
COV879 Special Module in Financial Algorithms 2 0 0 2
COV883 Special Module in Theoretical Computer Science 1 0 0 1
COV886 Special Module in Algorithms 1 0 0 1

Departmental Specialization in Environmental Engineering (Department of Civil Engineering)

Specialization Core
CVD412 B.Tech. Project Part-II 0 0 12 6
CVL313 Air and Noise Pollution 3 0 0 3
CVL721 Solid Waste Engineering 3 0 0 3
CVL724 Environmental Systems Analysis 3 0 2 4

Total Credits 16

Specialization Electives (8 Credits)
CVL311 Industrial Waste Management 3 0 0 3
CVL312 Environmental Assessment Methodologies 3 0 0 3
CVL727 Environmental Risk Assessment 3 0 0 3
CVL820 Environmental Impact Assessment 3 0 0 3
CVL822 Emerging Technologies for Environmental Management 3 0 0 3
CVL823 Thermal Techniques for Waste Mgmt. 3 0 0 3
CVL824 Life Cycle Analysis & Design for Environment 3 0 0 3

**Departmental Specialization in Geotechnical Engineering (Department of Civil Engineering)**

**Specialization Core**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVD412</td>
<td>B.Tech. Project Part-II</td>
<td>0 0 126</td>
</tr>
<tr>
<td>CVL421</td>
<td>Ground Engineering</td>
<td>3 0 0 3</td>
</tr>
<tr>
<td>CVL422</td>
<td>Rock Engineering</td>
<td>3 0 0 3</td>
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<tr>
<td>CVL423</td>
<td>Soil Dynamics</td>
<td>3 0 0 3</td>
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<tr>
<td>CVP424</td>
<td>Environmental Geotechniques and Geosynthetics</td>
<td>3 0 0 3</td>
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**Total Credits:** 18

**Specialization Electives (6 Credits)**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>CVL431</td>
<td>Design of Foundations &amp; Retaining Structures</td>
<td>3 0 0 3</td>
</tr>
<tr>
<td>CVL432</td>
<td>Stability of Slopes</td>
<td>2 0 0 2</td>
</tr>
<tr>
<td>CVL433</td>
<td>FEM in Geotechnical Engineering</td>
<td>3 0 0 3</td>
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<tr>
<td>CVL434</td>
<td>Geotechnical Design Studio</td>
<td>0 0 4 2</td>
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<tr>
<td>CVL435</td>
<td>Underground Structures</td>
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**Departmental Specialization in Structural Engineering (Department of Civil Engineering)**

**Specialization Core**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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<tr>
<td>CVD412</td>
<td>B.Tech. Project Part-II</td>
<td>0 0 126</td>
</tr>
<tr>
<td>CVL441</td>
<td>Structural Design</td>
<td>3 0 0 3</td>
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<tr>
<td>CVL442</td>
<td>Structural Analysis-III</td>
<td>3 0 0 3</td>
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<tr>
<td>CVL443</td>
<td>Prestressed Concrete &amp; Industrial Structures</td>
<td>3 0 0 3</td>
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<tr>
<td>CVL758</td>
<td>Solid Mechanics in Structural Engineering</td>
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**Total Credits:** 18

**Specialization Electives (6 Credits)**

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<thead>
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<th>Credits</th>
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<tbody>
<tr>
<td>CVL763</td>
<td>Analytical and Numerical Methods for Struct. Eng.</td>
<td>2 1 0 3</td>
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<tr>
<td>CVL765</td>
<td>Concrete Mechanics</td>
<td>3 0 0 3</td>
</tr>
<tr>
<td>CVL766</td>
<td>Design of Bridge Structures</td>
<td>3 0 0 3</td>
</tr>
<tr>
<td>CVL768</td>
<td>Design of Masonry Structures</td>
<td>3 0 0 3</td>
</tr>
<tr>
<td>CVL769</td>
<td>Design of Tall Buildings</td>
<td>3 0 0 3</td>
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<tr>
<td>CVL770</td>
<td>Prestressed and Composite Structures</td>
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<td>CVL771</td>
<td>Advanced Concrete Technology</td>
<td>3 0 0 3</td>
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<tr>
<td>CVL857</td>
<td>Structural Safety and Reliability</td>
<td>3 0 0 3</td>
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<tr>
<td>CVL858</td>
<td>Theory of Plates and Shells</td>
<td>3 0 0 3</td>
</tr>
<tr>
<td>CVL859</td>
<td>Theory of Structural Stability</td>
<td>3 0 0 3</td>
</tr>
<tr>
<td>CVL862</td>
<td>Design of Offshore Structures</td>
<td>3 0 0 3</td>
</tr>
<tr>
<td>CVL866</td>
<td>Wind Resistant Design of Structures</td>
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**Departmental Specialization in Transportation Engineering (Department of Civil Engineering)**

**Specialization Core**

<table>
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<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>CVD412</td>
<td>B.Tech. Project Part-II</td>
<td>0 0 126</td>
</tr>
<tr>
<td>CVL740</td>
<td>Pavement Materials and Design of Pavements</td>
<td>2 0 2 3</td>
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<tr>
<td>CVL741</td>
<td>Urban and Regional Transportation Planning</td>
<td>2 0 2 3</td>
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<tr>
<td>CVL742</td>
<td>Traffic Engineering</td>
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**Total Credits:** 16

**Specialization Electives (8 Credits)**

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<td>CVL361</td>
<td>Introduction to Railway Engineering</td>
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<tr>
<td>CVL461</td>
<td>Logistics and Freight Transport</td>
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</tr>
<tr>
<td>CVL462</td>
<td>Introduction to Intelligent Transportation Systems</td>
<td>3 0 0 3</td>
</tr>
<tr>
<td>CVL743</td>
<td>Airport Planning and Design</td>
<td>3 0 0 3</td>
</tr>
<tr>
<td>CVL744</td>
<td>Transportation Infrastructure Design</td>
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<td>CVL746</td>
<td>Public Transportation Systems</td>
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<td>CVL841</td>
<td>Advanced Transportation Modelling</td>
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<tr>
<td>CVL842</td>
<td>Geometric Design of Roads</td>
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<td>CVL847</td>
<td>Transportation Economics</td>
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**Departmental Specialization in Water Resources**

**Engineering (Department of Civil Engineering)**

**Specialization Core**

<table>
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<tbody>
<tr>
<td>CVL382</td>
<td>Groundwater</td>
<td>2 0 0 2</td>
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<tr>
<td>CVL481</td>
<td>Water Resources Management</td>
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<tr>
<td>CVL482</td>
<td>Water Power Engineering</td>
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<tr>
<td>CVL483</td>
<td>Groundwater &amp; Surface-water Pollution</td>
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<tr>
<td>CVD412</td>
<td>B.Tech. Project Part-II</td>
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**Total Credits:** 16

**Specialization Electives (8 Credits)**

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<tr>
<td>CVL383</td>
<td>Water Resources Systems</td>
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<tr>
<td>CVL384</td>
<td>Urban Hydrology</td>
<td>2 0 0 2</td>
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<tr>
<td>CVL385</td>
<td>Frequency Analysis in Hydrology</td>
<td>2 0 0 2</td>
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<tr>
<td>CVL386</td>
<td>Fundamentals of Remote Sensing</td>
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<tr>
<td>CVL484</td>
<td>Computational Aspects in Water Resources</td>
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<td>CVL485</td>
<td>River Mechanics</td>
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<td>CVL486</td>
<td>Geo-informatics</td>
<td>2 0 2 3</td>
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<tr>
<td>CVL837</td>
<td>Mechanisms of Sediment Transport</td>
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**Departmental Specialization in Geotechnical Design (Department of Mechanical Engineering)**

**Specialization Core**

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<th>Course Code</th>
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<tr>
<td>MCD412</td>
<td>B.Tech. Project-II</td>
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<tr>
<td>MCL321</td>
<td>Automotive Systems</td>
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**Total Credits:** 11

**Specialization Electives**

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<tr>
<td>MCL322</td>
<td>Power Train Design</td>
<td>3 0 0 3</td>
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<tr>
<td>MCL421</td>
<td>Automotive Structural Design</td>
<td>2 0 2 3</td>
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<tr>
<td>MCL422</td>
<td>Design of Brake Systems</td>
<td>2 0 2 3</td>
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<tr>
<td>MCL721</td>
<td>Automotive Prime Movers</td>
<td>3 0 0 3</td>
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<tr>
<td>MCL722</td>
<td>Mechanical Design of Prime Mover Elements</td>
<td>3 0 0 3</td>
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<tr>
<td>MCL723</td>
<td>Vehicle Dynamics</td>
<td>3 0 0 3</td>
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<tr>
<td>MCL724</td>
<td>Biomechanics of Trauma in Automotive Design</td>
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<tr>
<td>MCL725</td>
<td>Design Electronic Assist Systems in Automobiles</td>
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<tr>
<td>MCL726</td>
<td>Design of Steering Systems</td>
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**Departmental Specialization in Technical and Innovative Textiles (Department of Textile Technology)**

**Specialization Electives**

<table>
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<th>Course Title</th>
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<td>TXD402</td>
<td>Major Project Part-II</td>
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<tr>
<td>TXL710</td>
<td>High Performance and Specialty Fibres</td>
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<tr>
<td>TXL719</td>
<td>Functional and Smart Textiles</td>
<td>3 0 0 3</td>
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<tr>
<td>TXL734</td>
<td>Nonwoven Science and Engineering</td>
<td>3 0 0 3</td>
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<tr>
<td>TXL740</td>
<td>Science &amp; App. of Nanotechnology in Textiles</td>
<td>3 0 0 3</td>
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<tr>
<td>TXL752</td>
<td>Design of Functional Clothing</td>
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<td>TXL773</td>
<td>Medical Textiles</td>
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<tr>
<td>TXL775</td>
<td>Technical Textiles</td>
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<tr>
<td>TXL776</td>
<td>Design &amp; Manuf. of Text. Reinforced Composites</td>
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**Departmental Specialization in Technical Business Management (Department of Textile Technology)**

**Specialization Electives**

<table>
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<tr>
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<tbody>
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<td>MCL756</td>
<td>Supply Chain Management</td>
<td>3 0 0 3</td>
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<tr>
<td>MCL760</td>
<td>Project Management</td>
<td>3 0 0 3</td>
</tr>
<tr>
<td>TXD402</td>
<td>Major Project Part-II</td>
<td>0 0 168</td>
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<tr>
<td>TXL381</td>
<td>Costing and its Application in Textiles</td>
<td>3 1 0 4</td>
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<tr>
<td>TXL781</td>
<td>Costing, Project Formulation and Appraisal</td>
<td>3 0 0 3</td>
</tr>
<tr>
<td>TXL782</td>
<td>Production and Operations</td>
<td>3 0 0 3</td>
</tr>
<tr>
<td>TXL783</td>
<td>Management in Textile Industry</td>
<td>3 0 0 3</td>
</tr>
<tr>
<td>TXL784</td>
<td>Design of Experiments and Statistical Techniques</td>
<td>3 0 0 3</td>
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<tr>
<td>TXV702</td>
<td>Management of Textile Business</td>
<td>1 0 0 1</td>
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**Departmental Specialization in Applied Engineering (Department of Electrical Engineering)**

**Specialization Electives**

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<td>ELD451</td>
<td>BTP Part-II</td>
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</tr>
<tr>
<td>ELL319</td>
<td>Digital Signal Processing</td>
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<tr>
<td>ELL365</td>
<td>Embedded Systems</td>
<td>3 0 0 3</td>
</tr>
<tr>
<td>ELL450</td>
<td>Special Topics in AE–I</td>
<td>3 0 0 3</td>
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<tr>
<td>ELL754</td>
<td>Permanent Magnet Machines</td>
<td>3 0 0 3</td>
</tr>
<tr>
<td>ELL756</td>
<td>Special Electrical Machines</td>
<td>3 0 0 3</td>
</tr>
<tr>
<td>ELL762</td>
<td>Intelligent Motor Controllers</td>
<td>3 0 0 3</td>
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<tr>
<td>ELL766</td>
<td>Appliance System</td>
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ELL762 Intelligent Motor Controllers 3 0 0 3
ELL779 Forecasting Techniques for Power Systems 3 0 0 3
ELL864 Introduction to Machine Learning 3 0 0 3
ELL886 Multimedia Systems 3 0 0 3
ELL888 Computational Cognition and Perception 3 0 0 3
ELL899 Natural Computing 3 0 0 3
ELV870 Special Modules in Computers 1 0 0 0

Departmental Specialization in Communication Systems and Networking (Dept. of Electrical Engg.)

ELD457 BTP Part-II 0 0 16 8
ELL409 Machine Intelligence and Learning 3 0 2 4
ELL457 Special Topics in C&IS – I 3 0 0 3
ELL704 Advanced Robotics 3 0 0 3
ELL707 Systems Biology 3 0 0 3
ELL715 Digital Image Processing 3 0 0 3
ELL741 Neuromorphic Engineering 3 0 0 3
ELL762 Intelligent Motor Controllers 3 0 0 3
ELL779 Forecasting Techniques for Power Systems 3 0 0 3
ELL864 Introduction to Machine Learning 3 0 0 3
ELL886 Multimedia Systems 3 0 0 3
ELL888 Computational Cognition and Perception 3 0 0 3

Departmental Specialization in Electric Transportation (Department of Electrical Engineering)

ELD458 BTP Part-II 0 0 16 8
ELL411 Digital Communications 3 0 2 4
ELL458 Special Topics in CSAN – I 3 0 0 3
ELL713 Microwave technique and theory 3 0 0 3
ELL714 Basic Information Theory 3 0 0 3
ELL717 Optical Communication Systems 3 0 0 3
ELL723 Broadband Communication Systems 3 0 0 3
ELL725 Wireless Communications 3 0 0 3
ELL785 Computer Communication Networks 3 0 0 3
ELV720 Special Modules in CS&N – I 1 0 0 1

Departmental Specialization in Energy-Efficient Technologies (Department of Electrical Engineering)

ELD453 BTP Part-II 0 0 16 8
ELL408 Low Power Circuit Design 3 0 0 3
ELL453 Special Topics in EET – I 3 0 0 3
ELL721 Introduction to Telecommunication Systems 3 0 0 3
ELL743 Photovoltaics 3 0 0 3
ELL757 Energy Efficient Motors 3 0 0 3
ELL763 Advanced Electrical Drives 3 0 0 3
ELL765 Smart Grid Technology 3 0 0 3
ELL797 Energy Efficient Computing 3 0 0 3
ELV752 Special Modules in EET – I 1 0 0 1

Departmental Specialization in Information Processing (Department of Electrical Engineering)

ELD459 BTP Part-II 0 0 16 8
ELL459 Special Topics in IP – I 3 0 0 3
ELL460 Special Topics in IP – II 3 0 0 3
ELL714 Basic Information Theory 3 0 0 3
ELL715 Digital Image processing 3 0 2 4
ELL718 Statistical signal processing 3 0 0 3
ELL719 Detection and Estimation Theory 3 0 0 3
ELL720 Advanced Digital Signal Processing 3 0 0 3
ELL784 Introduction to Machine Learning 3 0 0 3
ELL786 Multimedia Systems 3 0 0 3
ELL793 Computer Vision 3 0 0 3
ELL794 Human-Computer Interface 3 0 0 3
ELV781 Special Modules in IP – I 1 0 0 1

Departmental Specialization in Nano-electronic and Photonic Systems (Department of Electrical Engg.)

ELD456 BTP Part-II 0 0 16 8
ELL460 Special Topics in NE&PS – I 3 0 0 3
ELL732 Micro and Nanoelectronics 3 0 0 3
ELL737 Flexible Electronics 3 0 0 3
ELL738 Micro and Nano photonics 3 0 0 3
ELL739 Advanced semiconductor devices 3 0 0 3
ELL740 Compact Modeling of Semiconductor Devices 3 0 2 4
ELL741 Neuromorphic Engineering 3 0 0 3
ELL742 Introduction to MEMS Design 3 0 0 3
ELL743 Photovoltaics 3 0 0 3
ELL744 Electronic and Photonic Nanomaterials 3 0 0 3
ELL745 Quantum Electronics 3 0 0 3
ELV731 Special Modules in NE&PS – I 1 0 0 1

Departmental Specialization in Smart Grid and Renewable Energy (Department of Electrical Engineering)

ELD452 BTP Part-II 0 0 16 8
ELL402 Computer Communications 3 0 0 3
ELL417 Renewable Energy Systems 3 0 0 3
ELL765 Smart Grid Technology 3 0 0 3
ELL770 Power System Analysis 3 0 0 3
ELL771 Special Topics in SG&RE – I 3 0 0 3
ELL772 Planning and Operation of Smart Grid 3 0 0 3
ELL773 High Voltage DC Transmission 3 0 0 3
ELL774 Flexible AC Transmission Systems 3 0 0 3
ELL775 Power System Dynamics 3 0 0 3
ELL789 Intelligent Systems 3 0 0 3
ELV451 Special Modules in SG&RE – I 1 0 0 1

Departmental Specialization in Systems and Control (Department of Electrical Engineering)

ELD450 BTP Part-II 0 0 16 8
ELL436 Digital Control 3 0 0 3
ELL700 Linear Systems Theory 3 0 0 3
ELL702 Nonlinear Systems 3 0 0 3
ELL703 Optimal Control Theory 3 0 0 3
ELL704 Advanced Robotics 3 0 0 3
ELL705 Stochastic Filtering and Identification 3 0 0 3
ELL707 Systems Biology 3 0 0 3
ELL708 Selected Topics in Systems and Control 3 0 0 3
ELL762 Intelligent Motor Controllers 3 0 0 3
ELV700 Special Modules in Systems and Control 1 0 0 1

Departmental Specialization in VLSI and Embedded Systems (Department of Electrical Engineering)

ELD455 BTP Part-II 0 0 16 8
ELL365 Embedded Systems 3 0 0 3
ELL455 Special Topics in VLSI – I 3 0 0 3
ELL720 Advanced Digital Signal Processing 3 0 0 3
ELL730 IC Technology 3 0 0 3
ELL731 Mixed signal circuit design 3 0 0 3
ELL733 Digital ASIC Design 3 0 2 4
ELL734 MOS VLSI Design 3 0 0 3
ELL735 Analog Integrated Circuits 3 0 0 3
ELL736 Solid State Imaging Sensors 3 0 0 3
ELL740 Compact Modeling of Semiconductor Devices 3 0 2 4
ELL741 Neuromorphic Engineering 3 0 0 3
ELL747 Active and Passive Filter Design 3 0 0 3
ELL748 System-on-Chip Design and Test 3 0 0 3
ELL749 Semiconductor Memory Design 3 0 0 3
ELV730 Special Modules in V&S – I 1 0 0 1

ELL730 Mechatronics 3 0 0 3
ELV750 Special Modules in AE–I 1 0 0 1

Courses of Study 2017-2018
8. NON-GRADED CORE FOR UNDERGRADUATE STUDENTS

In order to synergize formal academics with informal outside-class-room learning experience, mechanisms for earning non-graded units have been introduced in the undergraduate curriculum in 2013. In order to earn these units, a student will need to involve himself/herself in activities beyond the classroom engagements. For earning 1 unit a student will typically need to work for 2-3 hours per week (28-42 hours per semester) in on-campus activities. In case of project/design/internship activities, the student engagement expected is typically 20 man-days of work per non-graded unit. A student would not be allowed to earn credits as well as non-graded units for the same effort - it is important that the efforts towards earning non-graded units should be distinct from that spent on earning credits. Also, the effort for earning different components of the non-graded units also should be distinct, i.e., the same effort would not be evaluated for more than one non-graded activity.

Non-graded core of the undergraduate curriculum comprises the following components:

1. Introduction to Engineering & Programme : 02 units
2. Language and Writing Skills : 02 units
3. NCC/NSO/NSS : 02 units
4. Professional Ethics and Social Responsibility : 02 units
5. Communication Skills/ Seminar : 02 units
6. Design/ Practical Experience : 05 units

Total : 15 units

These 15 units form a compulsory graduation requirement for all the undergraduate (B.Tech. as well as Dual degree) programmes. A student will need to earn these 15 units over the duration of the programme with special consideration and requirements for each component as detailed in the following sections. Each component would be constituted by one or more non-graded courses, and a student will need to get an ‘S’ grade in these courses to earn the respective non-graded unit(s). Incomplete status in such courses will be indicated by a ‘Z’ grade. The student would be required either to repeat the course/activity or continue with the project/internship until such time that the evaluating faculty member/committee is satisfied with the effort to award an ‘S’ grade. No partial/fractional units can be awarded. For example, if a particular activity carries 2 units, a student cannot be awarded 1 unit or fractional units for incomplete work, but would need to repeat/complete the work to the satisfaction of the evaluating faculty member/committee to become eligible for award of 2 units.

8.1 Introduction to Engineering and Programme

This non-graded component is aimed at orienting and exciting students in the subject of engineering in general and their respective disciplines in particular. The objectives of the component are:

- Exposing students to “Engineering” as a profession that creates wealth for nations, and as a vehicle for economic growth.
- Exposing students to Science/Engineering as a medium through which one can address problems facing society including some of the grand challenges.
- Excite students by enabling them to appreciate the role and enormous impact of research in science/engineering on our day to day lives.
- Enlighten students about the various career options available to them.
- Make students aware of the issues involved in engineering a product, and help them appreciate why the process of design and innovation leading to products and systems is both personally satisfying and professionally rewarding.
- Excite students about potential role models and successful alumni in engineering profession.
- Motivate students to take up some co-curricular activities on their own during their stay in the Institute.

The activities to realize the above-mentioned objectives as part of this non-graded component include:

- Understanding engineering through product dissection and reverse engineering. (The products given to students to dissect could be physical in form or in the form of videos).
- Screening of videos that bring out the strong relation between science/engineering and societal needs.
- Conducting design and innovation contests among students.
- Solving science/engineering puzzles in the class.
- Lectures by successful industrialists, alumni and entrepreneurs about their journey.
• Exposure to successful research cases from the Institute and the impact of the same.
• Exposure to successful products/innovations from the Institute which have reached people/industry/society.
• Some interesting demonstrations in laboratories.
• Hands-on exercises in laboratories including use of breadboard circuits, Lego sets, robot kits, balsa bridge engineering kits, fibre optics kits, mobile apps etc.
• Industry visits
• Visits to on-going exhibitions in the city
• Do-it-yourself projects in teams
• Lectures by faculty, visitors, alumni on some exciting topics.

This non-graded unit is administered in the form of two non-graded courses of one unit each:

(i) NIN100 Introduction to Engineering in the first semester of the undergraduate programme, and
(ii) XXN101/XXN111 Introduction to <the respective engineering discipline> in the third semester.

Here, XX stands for the Course code prefix of the Department offering the undergraduate programme and <the respective engineering discipline> stands for the name of the undergraduate programme to which the student belongs. Table 8.1 lists the courses corresponding to the different undergraduate programmes:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Programme Code(s)</th>
<th>Course Code</th>
<th>Course Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BB1, BB5</td>
<td>BBN101</td>
<td>Introduction to Biochemical Engineering and Biotechnology</td>
</tr>
<tr>
<td>2</td>
<td>CE1</td>
<td>CVN101</td>
<td>Introduction to Civil Engineering</td>
</tr>
<tr>
<td>3</td>
<td>CH1, CH7</td>
<td>CLN101</td>
<td>Introduction to Chemical Engineering</td>
</tr>
<tr>
<td>4</td>
<td>CS1, CS5</td>
<td>CON101</td>
<td>Introduction to Computer Science and Engineering</td>
</tr>
<tr>
<td>5</td>
<td>EE1</td>
<td>ELN101</td>
<td>Introduction to Electrical Engineering</td>
</tr>
<tr>
<td>6</td>
<td>EE3</td>
<td>ELN111</td>
<td>Introduction to Electrical Engineering – Power and Automation</td>
</tr>
<tr>
<td>7</td>
<td>ME1</td>
<td>MCN101</td>
<td>Introduction to Mechanical Engineering</td>
</tr>
<tr>
<td>8</td>
<td>ME2</td>
<td>MCN111</td>
<td>Introduction to Production and Industrial Engineering</td>
</tr>
<tr>
<td>9</td>
<td>MT1, MT6</td>
<td>MTN101</td>
<td>Introduction to Mathematics and Computing</td>
</tr>
<tr>
<td>10</td>
<td>PH1</td>
<td>PYN101</td>
<td>Introduction to Engineering Physics</td>
</tr>
<tr>
<td>11</td>
<td>TT1</td>
<td>TXN101</td>
<td>Introduction to Textile Technology</td>
</tr>
</tbody>
</table>

Course coordinator of NIN100 would be identified by the Dean Academics. For all the Departmental courses listed in Table 8.1, the departments offering UG programmes would identify the course coordinators. It is necessary to get a satisfactory (S) grade in both these courses for completing the degree requirements. Attendance would be one of the main criteria for evaluation. Apart from this, active participation and quiz based evaluation etc. would also be used as a basis to decide ‘S’ or ‘Z’ grade. The grades of NIN100 would be moderated by Dean Academics, and those of the Departmental courses would be moderated in the respective Departments. In case a student is awarded ‘Z’ grade he/she would need to repeat the course in the subsequent year(s).

8.2 Language and Writing Skills

All students, in the first two semesters, are required to undergo exercises designed to impart language skills-enhancing their ability of listening comprehension, reading and writing in English. These exercises would be tailored according to the background of the students. The English language ability of the students would be assessed through a test to be conducted in the beginning, typically during their admission and orientation period. The students would also be exposed to principles of English grammar and nuances of technical writing. Textual material and lectures would focus on the relationship between Engineering, Humanities and Social Sciences.

This component is also administered in the form of two courses, each of one unit: NLN100 Language and Writing Skills–I in the first semester and NLN101 Language and Writing Skills–II in the second semester. Course coordinators for these courses are identified by the Dean Academics in consultation with Head, Humanities and Social Sciences. Assessment of a student towards S grade in each of these courses would typically be on the basis of attendance, participation and performance in the exercises. A student could also be prescribed self learning exercises or additional practice sessions during vacations as requirement for securing S grade. Student’s involvement, during regular semester, would typically be two hours per week. The grades of these courses would be moderated by the Dean Academics.
8.3 NCC/NSO/NSS

A student is required to choose one of NCC/NSO/NSS by during his/her first semester, and complete the requirements within the first four registered semesters. Students will be required to earn 2 non-graded units from one of these activities, by completing 100 hours of work. The faculty coordinators of NCC/NSO/NSS decide and announce the policies on earning non-graded units in these activities from time to time. A student must complete the 100 hours of activities in one of these three options by the end of the fourth registered semester or the summer after the fourth semester, failing which he/she would not be allowed to register for the fifth semester.

8.4 Professional Ethics and Social Responsibility

There is increasing consensus worldwide that engineering ethics should be incorporated into the engineering curriculum to provide students with an exposure to the kind of professional ethical dilemmas they might face on an individual basis as well as in the larger context of ethical aspects of technology development. Workshops, discussion/debates, use of theatre-in-education, case-study based approaches, etc. are often used for illustration and discussion of engineering ethics and such inputs could be provided in a stand-alone manner, integrated into existing courses or both. The objective of this non-graded component is to sensitize students about Professional Ethics and Social Responsibility (PESR) through a combination of the above-mentioned approaches, supplemented by discussion fora and supplementary materials, to help students to become ethical professionals. A student is required to complete this non-graded component in the first six registered semesters of the undergraduate programme, through activities divided into four courses. The courses NEN100 and NEN101 together constitute one non-graded unit and the course NEN300 along with one of the three alternatives NEN201/202/203 constitutes the second non-graded unit for PESR:

i) NEN100 Professional Ethics and Social Responsibility - I
ii) NEN101 Professional Ethics and Social Responsibility - II
iii) One of the following three courses:
   a. NEN201 PESR Internships
   b. NEN202 PESR Workshops
   c. NEN203 PESR Projects
iv) NEN300 Case Studies in Professional Ethics

NEN100 and NEN101 are compulsory for all students, and these courses involve interactive sessions of a group of about 20 students with a faculty mentor in the first and second semesters respectively. The student will earn one unit by getting S grade in both these courses.

The second unit under PESR has two parts. For the first part, the students can choose to participate in any one out of a large variety of activities relevant to the core themes of PESR. With the considerable amount of flexibility allowed in the choice of activities, each student should be able to identify an activity of interest to him/her under the purview of PESR. These activities have been divided into three broad categories, viz., (a) PESR internships (b) PESR workshops (c) PESR projects, each of which corresponds to a separate course number NEN201, NEN202 and NEN203 respectively. After a student has got S grades in NEN100 and NEN101, the student can register for NEN201/202/203. The second part of this unit, Case Studies in Professional Ethics, is compulsory, and is offered under the course number NEN300.

Under NEN201 PESR Internships, students can take up field work outside the Institute during summer/winter vacation with organizations within the country. These organizations could be NGOs or CSR units of corporate houses. The students could also choose to work with organizations in their home towns. These internships must involve an exposure to the life of communities through field work. Before going for an internship with such an organization, the student will have to submit an online request to the Institute level PESR Committee, specifying the internship duration, nature of work and other details and requirements, and take prior approval. The student will be able to get an S grade in this course only if the student has attended the internship for at least the number of days specified in Table 8.2 and has satisfied the requirements committed in the prior approval. A documentary proof of the same from the organization should be submitted online by the student to the PESR Committee. No credit will be given to the student if he/she attends the internship for less number of days than specified in the prior approval as per Table 8.2.

If a student gets selected in one of the nation building initiatives organized by reputed organizations (Examples: Participating in Jagriti Yatra, working as a summer fellow with Rakshak foundation etc.) and successfully completes the same, he/she would be considered to have completed the requirements under NEN201 and hence would be awarded ‘S’ grade in the same. Even to exercise this option, it is mandatory that a prior approval of the PESR committee should be sought online, and a documentary proof of completion of the activity should be submitted.
Online to the PESR committee, as specified above for internships.

Under NEN202 PESR Workshops, students can participate in one or more workshops of duration of 3-8 days, approved by the PESR Committee and Dean Academics. These workshops would be organized on campus by a faculty coordinator and would be conducted by resource persons from within or outside the Institute. These workshops could be pertaining to any of the themes relevant to PESR and could be held during mid-semester break/summer/winter vacation or even long weekends during the semester. The students must follow the procedure announced by the faculty coordinator to register for the workshop. The S grade for attending a workshop will be awarded only if the student attends all sessions of the workshop on all the days for its full duration. The faculty coordinator organizing the workshop would submit a list of all such students to the PESR committee for award of S grade in NEN202 PESR Workshops.

Under NEN203 PESR Projects, the students can take up projects under the guidance of one or more faculty members to make positive contribution to campus life. This could include promoting wholesome practices on campus such as: ethical practices particularly among students through specially directed efforts; peer assistance for the students in need of help academically or otherwise; sustainable practices on campus like resource conservation, waste management, use of renewable resources and the like; working on technology for a social cause etc. This work could be done during a semester or mid-semester break or summer/winter vacation. The student must submit a project proposal online, with explicit statement of deliverables, through his/her faculty supervisor(s), for approval by the PESR committee. If the work is taken up in a team, each student's share of work must be defined in the proposal. It is expected that each student puts in at least 50 person-hours of effort in the project. On completion of the project, the students should submit a completion request online, again through the faculty supervisor, who should certify that each student has completed his/her share of the deliverables and each student has put in at least 50 person-hours of work into the project. The PESR Committee may also decide to evaluate the project by additional means as deemed fit.

The work done under NEN201/ NEN202/ NEN203 would also be evaluated, the mechanism for which will be decided by the PESR committee and notified to students accordingly.

If a student has a confirmed/approved registration in an internship/workshop or a project but does not turn up for the same, he/she can be penalized by the PESR committee with an increase in the number of PESR units to be completed by the student for the degree requirements.

In NEN300, every student will work on at least two case studies related to professional ethics, followed by discussions on the same, moderated by a faculty member. The details on how to select the case studies and the mode of discussions and their evaluation would be decided by the PESR Committee from time to time and notified to the students.

Table 8.2 summarizes the requirements of the non-graded component on Professional Ethics and Social Responsibility.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Course</th>
<th>Period of Activity</th>
<th>Description</th>
<th>Requirement for S grade</th>
<th>No. of units</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.</td>
<td>NEN100 Professional Ethics and Social Responsibility—I</td>
<td>1st Semester</td>
<td>Regular sessions of 1.5-2 hours with a faculty mentor. Activities in the sessions to be decided by the faculty.</td>
<td>15 hours in regular sessions</td>
<td>1</td>
</tr>
<tr>
<td>2.</td>
<td>NEN101 Professional Ethics and Social Responsibility—I</td>
<td>2nd Semester</td>
<td>Regular sessions of 1.5-2 hours with a faculty mentor. Activities in the sessions to be decided by the faculty.</td>
<td>15 hours in regular sessions</td>
<td>1</td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Part-2: Case Studies and Practical/Field Activity</td>
<td></td>
<td>• Each student should register for NEN300 and ANY ONE of NEN201, NEN202, NEN203&lt;br&gt;• To be completed before the beginning of 7th semester&lt;br&gt;• Activities as listed below followed by A PRESENTATION IN AN EVALUATION SESSION&lt;br&gt;• Satisfaction of ALL the requirements set out by the respective in-charge/resource persons/faculty. NO PART CREDIT.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Course Code</td>
<td>Description</td>
<td>Internship Details</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>-------------</td>
<td>-------------</td>
<td>--------------------</td>
<td>----</td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td>NEN201 : PESR</td>
<td>Internships</td>
<td>summer/winter vacations</td>
<td>Engagement with communities/NGOs OUTSIDE IITD involving technical or non-technical work or internship with the CSR unit of an industry involving field work.</td>
<td>For residential internship/ camp with an organisation: 6-8 days of stay in the camp. For non-residential internship: 20 working days of internship. Prior approval of PESR committee specifying the type and length of the internship/camp; S grade to be awarded only for full duration. No credit for attending the internship for less number of days than that specified in approval.</td>
</tr>
<tr>
<td>4.</td>
<td>NEN202 : PESR</td>
<td>Workshops</td>
<td>Mid-semester breaks/ summer/winter vacations.</td>
<td>Participation in intense ON-CAMPUS workshops approved by Dean Academics, of 3-8 days duration, conducted by professional resource persons, with special emphasis on themes related to PESR.</td>
<td>Completion of either a single workshop of at least 6 days’ duration OR two workshops of at least 3 days’ duration. S grade to be awarded only for attending the workshop for full duration. No credit for attending the workshop for less number of days.</td>
</tr>
<tr>
<td>5.</td>
<td>NEN203: PESR</td>
<td>Projects</td>
<td>Summer/ winter vacation /mid-semester break or during a semester.</td>
<td>Taking up on-campus projects under the guidance of a faculty mentor, related to any of the topics relevant to PESR, such as (but not limited to) A. Promoting ethical practices on campus in various spheres particularly related to student life on campus. B. Strengthening the existing systems and designing and implementing new ones for an active student community participation in addressing the academic as well as other problems of student community. C. Developing socially relevant technologies D. Promoting Sustainable Practices in hostels, academic area, residential areas etc., involving activities pertaining to conservation of water/electricity/paper/other resources, waste management, promoting use of bicycles, etc.</td>
<td>Prior approval of project proposal by PESR committee explicitly specifying deliverables and work share of each student in case of group projects; Completion of the project deliverables identified in the proposal - It must involve at least 50 hours of work by each student.</td>
</tr>
<tr>
<td>6.</td>
<td>NEN300 Case Studies in Professional Ethics</td>
<td></td>
<td>5th or 6th registered semester</td>
<td>Work on two case studies on professional ethics; participate in discussions moderated by a faculty member.</td>
<td>Recommendation of S grade by the faculty member(s) moderating the discussions.</td>
</tr>
</tbody>
</table>
8.5 Communication Skills / Seminar

The objective of this non-graded component is to provide the students with an opportunity to develop their skills in preparing write-ups and/or making presentations, and reading/listening to others’ write-ups/presentations. A student would be required to earn these non-graded units between their 5th and 8th semesters. This component would be administered in two parts:

(i) A set of topic specific seminar courses (XXQ301, XXQ302, etc.) introduced by the parent Department of each student (for example ELQ301 – Seminar on Embedded Systems – 1 unit). These courses would be non-credit electives, offered in each semester. These seminar sessions would be held for two hours per week. Many such courses could run in parallel. Students need to register for at least one such course in his/her parent department for earning one unit.

(ii) Students should earn the remaining one unit through any one of the following means:

a. By registering and completing an additional seminar course (XYQ301, XYQ302 etc.) offered by any other Department/Centre/School.

b. By participating in optional seminars which may be part of regular courses; for example regular ‘L’ courses can have an optional seminar component (e.g. ELL711 Optical Communications can have optional seminar component of 1 unit). This would, like any other seminar course, need to have seminar sessions of 2 hours duration every week for a whole semester. In such a case, a student should register for XXQ30y, and the course coordinator would send recommendations for ‘S’ grades to the Dean Academics, duly moderated by the Moderation Committee of the concerned Department/Centre/School.

c. By participating in special workshops on Communication Skills approved by Dean Academics. The faculty coordinator in charge of the workshop would submit a list of students who completed the activity with 100% attendance in all sessions on all days of the workshop for award of S grade in NQN301.

d. By submitting documentary evidence of excellence in debating and/or writing as certified by faculty in-charge of these activities, to the Dean Academics. In all such cases, the student should submit documentary evidence online, as detailed below.

- A student who wins first, second or third position in any event/competition conducted at inter-hostel level, by BRCA or by BSP or by BSW would qualify for this option. The event/competition must be either a debate/declamation/extempore. Since many such events do not have certificates issued, the student must submit a letter signed by the warden or the president of the respective board (in case of BRCA, president of the club would also suffice) stating the date, time, venue of the event/competition along with the number of participants and position secured. In case number of participants is less than 20, the event shall not be counted.

- A student who performs as a compere for any of the Institute functions (only those listed in the Institute calendar). The student will need to produce a signed letter from the faculty in-charge of the Institute function stating the student’s role as compere. The letter must include the date, time, venue and duration of the event. Any event lasting less than 1 hour will not be counted.

- A student winning a technical paper presentation award during TRYST will need to submit a copy of the certificate and the abstract of the paper presented. Technical publications in Journals or Conferences would also be considered, provided (i) the number of authors of the paper does not exceed 2 and (ii) the faculty member supervising the work certifies that the paper was written by the concerned student.

A minimum of three such documents certified by the Faculty in charge of the Board/Club/Activity as mentioned above would qualify a student to earn one unit of Communication Skills/Seminar. In each case, before recommending the award of non-graded units for the above activities, the Faculty in charge of the Board/Club/Activity should keep in mind that a student engagement/effort (including preparations and the actual event) of 28-42 hours would be necessary for the award of one non-graded unit.

In cases of options (i), (ii) a and (ii) b above, the faculty member in charge of the course should ensure that the student has 100% attendance in the seminars, and has done a satisfactory task of his/her contribution to the
course: the write-up, presentation, etc. before awarding an ‘S’ grade. These grades would be moderated by the respective Department/Centre/School. In case of unavoidable absence of up to 3 seminar sessions, appropriate compensation mechanism should be announced by the faculty member at the beginning of the course. For absence beyond 3 sessions, S graded cannot be awarded.

An Institute level Committee for Communication Skills/Seminar would be appointed by the Dean Academics. The convener of this committee would serve as the course coordinator of NQN301. This committee would moderate the non-graded units for Communication Skills/Seminar recommended for activities other than the courses XXQ30y.

A student needs to secure an S grade in both parts of the communication skills/seminar non-graded component to complete graduation requirements.

8.6 Design / Practical Experience

The objective of this non-graded component is to give opportunities to students to learn in an informal setting. This mode of learning, is often more effective than conventional lectures/laboratory work. Second and even more important objective of this non-graded component is to inculcate design thinking among students and facilitate them to gain some design immersion experience. Design/Practical Experience (DPE) component can promote learning by doing which does two important things: Firstly, it allows students to immerse themselves in the environment in which work is to be done, so that they can understand the values and expectations of the target beneficiaries. Secondly it enables a fresh look at problems, not only at the ways of defining them, but also at the ways to solve those including skill-sets that are required to address them. A shift from problem based learning (acquisition of knowledge) to project based learning (application of knowledge), in which the projects are grounded in problems outside the classrooms and laboratories, in everyday scenarios. Thus, DPE bridges division between the curricular and the co-curricular components, and encourages the curiosity and involvement that arises from total absorption in a subject of interest.

As a part of this requirement, every student is expected to earn a minimum of five non-graded units of DPE to complete the degree requirements. To earn one unit of DPE, a student is expected to put in 28-42 hours of effort or 20 working days depending on the type of activity. These units can be earned in multiple ways during the semester as well as during vacation and mid-semester breaks:

- Courses with design focus without any regular graded credits, which are designated to give design/practical experience units.
- Courses (core or elective) with optional design/practical experience component.
- Summer/semester internships by students in R&D/Industry/Universities in India or abroad.
- Summer/winter/semester projects under the guidance of faculty of the Institute.
- Participation in design/innovation projects by Innovation Center/CAIC, etc.
- One time activity such as design/practical experience workshop/course/event during semester/vacation/mid-semester breaks, etc.

DPE activities are not restricted to design of physical products but can also include system level design and experience. For example a team of students who under the supervision of faculty in collaboration with an NGO, would like to design a new financial inclusion system for marginalized section of population too can earn design/practical experience units.

The operational modalities of implementing the above-mentioned activities so that students can earn the required non-graded units, are presented in the following paragraphs.

8.6.1 Management of Non-graded DPE Units

Each Department offering UG programme(s) would constitute a DPE Committee with a Departmental DPE Coordinator to manage the non-graded Design/Practical Experience units.

a) The Departmental DPE Committee would coordinate with T&P Unit to identify and vet industries for internships.
b) The committee would also examine other types of internship (in Universities, research laboratories, start-ups etc.) requested by students and approve or deny as per a policy defined by the Department.

c) Students of the Department desirous of earning non-graded DPE units through any other mechanism listed above should request permission of this committee before embarking on the activity. The committee would also decide on the award of non-graded DPE units for all such activities for the students of the Department through appropriate evaluation mechanisms.

d) The committee would be responsible to evaluate the design activities carried out by the students during internships and recommending award of the non-graded DPE units, or continuation of the internship activity for more days to become eligible for the units, as per the efforts of the students during the internship. DPE Committee will moderate all Design units awarded to students of that Department. The Departmental DPE Coordinator also has responsibility of ensuring that units earned by heterogeneous activities meet the requirements in terms of learning efforts and experience.

e) The Dean Academics will appoint an Institute DPE Coordinator for Design / Practical Experience units.

f) Departmental DPE Coordinators, Institute DPE Coordinator and Associate Dean Academics-Curriculum together will form an institute level committee to moderate the non-graded units awarded under interdisciplinary work including the activities carried out by students in Departments / Centers / Schools not offering UG programmes. This committee would also review and modify policies as well as modalities administering DPE units.

8.6.2 Activities Covered Under Design / Practical Experience

8.6.2.1. Specialized Courses Related to Design / Practical Experience (Maximum 2 Units)

Departments/Departments/Centres/Schools may offer a basket of courses that will not have any credits associated with them but will have only Design / Practical Experience units linked to them. In other words, on successful completion of such courses the students will earn only DPE units but no graded credits. These courses offered by Departments/ Centers/Schools can be of one unit (28-42 hours of student effort) or two units (56-84 hours of student effort). Faculty offering these courses will award these units on successful completion of the course requirements, and the same would be moderated by the Departmental Committee for DPE in case of Departments offering undergraduate programmes. For other Departments / Centres / Schools, the moderation would be done by the Institute level DPE committee.

8.6.2.2. Semester / Summer / Winter Projects Under the Guidance of Institute Faculty (Maximum 2 Units)

Some of the co-curricular activities in the Institute that pertain to team based product building such as Robotics, Automobile, IGEM, Aero-modelling etc. can also be considered for earning DPE units. Students who successfully complete SURA / DISA projects related to design / practical experience will also be eligible for DPE units. Besides, students may also opt for working on semester / summer / winter projects involving design/practical experience activity under the guidance of faculty of the institute. In order to be evaluated for DPE Units in such cases, a student should register for X XD35y Minor Design Project floated by the parent Department XX of the student. In case the project is interdisciplinary or it is offered by faculty of other Departments / Centres / Schools, the faculty supervisor of the project may advise the students to register for NDN35y Minor Design Project. In either case, the project would be evaluated by the faculty supervisor. For award of DPE units, X XD35y would be moderated by the Departmental Committee for DPE while NDN35y would be moderated by the Institute level DPE committee.

The courses XXD351 – XXD355 would be Minor Design Projects with 1 non-graded DPE unit, and XXD356 – XXD358 would be Minor Design Projects with 2 non-graded units each. Courses NDN351 – 358 would also follow a similar definition.

8.6.2.3. Regular Courses with Optional Design / Practical Experience Component (Maximum 2 Units)

Course coordinators of regular core and elective courses can also offer optional design component in their courses. A proposal for this should be sent to the Departmental DPE committee prior to the commencement of the
course by the Course Coordinator. This would be notified to students by the Departmental DPE committee and also announced to the students by the course coordinator. Successful completion of the course will give graded credits to students and at the same time they will be eligible for earning (1 or 2) design units if they successfully complete the optional DPE component. The course coordinator will recommend these DPE units on successful completion of the assigned work. This would be moderated by the Departmental Committee for DPE. In case the course is offered by Departments/Centres/Schools which do not offer a UG programme, the notification prior to beginning of the course and moderation after the end of the course would be done by the Institute level DPE committee. In order to be evaluated for DPE Units, a student should register for XXD35y Minor Design Project or NDN35y Minor Design Project as the case may be.

8.6.2.4. Summer Internships (2 Units)

Students can undertake a minimum of 40 working days of internship to earn two design practical experience units during summer vacations in Industry, R&D institutions or Universities in India or abroad. This would be administered by the Departmental Committee for DPE with the help of the Training and Placement (T&P) unit. The Departmental DPE Committee would also be responsible for appointing a faculty supervisor for the internship. Students can proceed with the internship after the Departmental Committee for DPE approves the same. Design units for the internship would be awarded by the Departmental Committee after evaluation at the end of internship period. Rules governing administration of internships are given in section 8.6.3. In case an internship pertains to areas of expertise outside those of the parent Department, the DPE Committee may co-opt faculty members from other Departments/Centres/Schools for evaluating/supervising such internships.

8.6.2.5. One-Semester Internship (Maximum 5 Units)

Students can opt for one semester internship in Industry, R&D institutions or Universities in India or abroad, for a minimum of 100 working days, by appropriately planning for completion of credit requirements for the degree. The student can also opt for a break in coursework for a semester to initiate or work for his/her start up. These are the only two activities upon successful completion of which students would be eligible for 5 DPE units. It is mandatory that student’s work during the one-semester internship is supervised by two mentors, one from the institute (appointed by the DPE Committee of the student’s Department) and another from the host organization. In case of semester break for a start up, students will work under the mentorship of a faculty member of the Institute. Students desiring to opt for one semester internship or semester break for start-up as mentioned above are required to plan well in advance and submit a project proposal in consultation with their supervisors (in case of internship) or faculty mentor (in case of start-ups). Students can proceed with the internship/startup activity only after the Departmental Committee for DPE approves the same. DPE units for the activity would be awarded by the Departmental DPE Committee after evaluation at the end of the internship/startup period. In case an internship/startup pertains to areas of expertise outside those of the parent Department, the DPE Committee may co-opt faculty members from other Departments/Centres/Schools for evaluating/supervising such activities. Details of the procedure are given in section 8.6.3 on internships.

A semester in which a student earns DPE units through semester-long internship or start-up as discussed above would be counted as a registered semester for graduation requirements. In case the DPE committee does not approve the award of 5 units for such activity, the semester would not be counted as a registered semester.

8.6.2.6. One Time Design / Practical Experience Module (1 Unit)

One time DPE modules can be offered by Institute faculty as well as working professionals who would like to engage students in a workshop/course related to design/practical experience. A proposal for such a module should be sent by faculty member coordinating the course through the concerned Department/Centre/School to the Institute DPE Committee for approval. These modules can be typically of 28-42 hours duration, and may be offered during mid-semester breaks, winter/summer vacations and even during non-class hours during the semester.

Table 8.3 summarizes the information presented in section 8.6.2. Detailed rules pertaining to internships and their administration are given in section 8.6.3.
Table 8.3: Implementation and Evaluation Plan for Design/Practical Experience Units

<table>
<thead>
<tr>
<th>Activity</th>
<th>Norms for the Activity</th>
<th>Criteria for awarding Units</th>
<th>No. of Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Courses with design focus (which are primarily design courses or have significant design component)</td>
<td>Courses offered as per Institute procedure</td>
<td>Registration by the student in the respective course; Evaluation by course coordinator; Moderation by DPE committee of Department/Institute</td>
<td>1 2</td>
</tr>
<tr>
<td>Courses with optional design/practical experience component</td>
<td>Course Coordinator provides intimation to Departmental/Institute DPE Committee about offering optional design units prior to commencement of the course</td>
<td>Student to raise request online for prior permission, forwarded by course coordinator; Prior Approval by DPE coordinator; Evaluation by course coordinator; Moderation by DPE committee of Department/Institute</td>
<td>1 2</td>
</tr>
<tr>
<td>4-week project with Institute Faculty during winter/summer (20 working days)</td>
<td>Notification of projects by DPE Committee of Student’s Department/Institute</td>
<td>Student to raise request online for prior permission; Prior approval by DPE Committee of Student’s Department; Evaluation by Faculty Supervisor of the project; Completion approval request by student forwarded through supervisor; Moderation by DPE committee of Department/Institute</td>
<td>1 1</td>
</tr>
<tr>
<td>8-week project with Institute Faculty including SURA, DISA, etc. (40 working days)</td>
<td>Notification of projects by DPE Committee of Student’s Department/Institute OR Announcement and selection by appropriate Institute bodies</td>
<td>Student to raise request online for prior permission; Prior approval by DPE Committee of Student’s Department; Evaluation by Faculty Mentor of the project/appropriate committee; Completion approval request by student forwarded through supervisor; Moderation by DPE committee of Department/Institute</td>
<td>2 2</td>
</tr>
<tr>
<td>8-week internship during summer with Industry/R&amp;D/University (40 working days)</td>
<td>Arranged by T&amp;P or self-arranged by the student in coordination with T&amp;P</td>
<td>Student to raise request online for prior permission; Prior approval by DPE Committee of Student’s Department; Monitoring by Internship supervisor; Completion approval request by student forwarded through supervisor; Evaluation and Moderation by DPE committee of Department/Institute</td>
<td>2 2</td>
</tr>
<tr>
<td>One semester internship (100 working days) or One semester break for own start-ups (singly or jointly)</td>
<td>Arranged by T&amp;P or self-arranged by the student in coordination with T&amp;P for internships</td>
<td>Student to raise request online for prior permission; Prior approval of Institute DPE Committee on recommendation from DPE committee of Student’s Department; Monitoring by Internship supervisor; Completion approval request by student forwarded through supervisor; Evaluation and Moderation by DPE committee of Department/Institute</td>
<td>5 5</td>
</tr>
</tbody>
</table>
**Table: Design/Project Activities**

<table>
<thead>
<tr>
<th>Participation in design/ project activity under the supervision of faculty during semester</th>
<th>Notification of projects by DPE Committee of Student’s Department/Institute</th>
<th>Student to raise request online for prior permission; Prior approval by DPE Committee of Student’s Department; Evaluation by Faculty Mentor of the project; Completion approval request by student forwarded through supervisor; Moderation by DPE committee of Department/Institute</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participation in design/ practical/ experience workshop/course/event organized by industry/ other institutions or visitors including visiting faculty</td>
<td>Proposal for activity to be recommended by Department DPE Committee and approved by Institute DPE Committee</td>
<td>Registration by the student in the activity; Evaluation by Faculty Coordinator and Visiting Faculty offering the course if any; Moderation by DPE committee of Department/Institute</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Participation in design/ innovation activities of clubs (eg. Robotics, IGEM, etc.)</td>
<td>Notification by the Faculty in-charge of the corresponding activity</td>
<td>Student to raise request online for prior permission; Prior approval by DPE Committee of Student’s Department; Evaluation by faculty in-charge of activity/clubs; Completion approval request by student forwarded through supervisor; Moderation by Institute DPE committee</td>
<td>1</td>
<td>2</td>
</tr>
</tbody>
</table>

- A student cannot register for more than 3 non-graded DPE units per summer semester or per registered semester in which a student is on regular academic activity. To take part in activities that can result in more than 3 DPE units, a student has to take the semester off from regular courses.
- A single activity cannot be evaluated for more than one purpose. For example, the same project cannot be submitted for graded credits as well as for design units.

### 8.6.3 Rules Governing Internship

i) Internships for DPE units are permitted only in one of the two following formats:
   a. Summer internship of 40 days duration, in which a student can earn 2 DPE units.
   b. Semester-long internship of 100 days duration, in which a student can earn 5 DPE units.

   No other format of internship would be considered for the award of DPE units. DPE units would be awarded only if training for the stipulated number of working days, as mentioned above, is completed to the satisfaction of the concerned Departmental DPE Committee. DPE units would not be awarded against partial completion of the internship duration.

ii) A student can choose from one of the following options in order to complete the Non-Graded component of Design/Practical Experience:
   a. One semester internship, accounting for 5 DPE units.
   b. One summer internship, accounting for 2 DPE units and 3 DPE units from other activities at the Institute
   c. Two summer internships, accounting for a total of 4 DPE units, and 1 DPE unit from other activities at the Institute
   d. One summer internship accounting for 2 DPE units and one semester internship, accounting for 5 DPE units.
   e. No internships: all DPE units can be earned through design/project activities at the Institute

iii) A student can do at most two internships for DPE units, during his/her stay at the Institute. If any student does more than two internships, DPE units will be awarded for the first two registered internships only.

iv) Summer internships are allowed in the summer after the 4th registered semester of the student or later. Semester Internships are permitted from the seventh registered semester or later.
v) Internships are permitted in industry, research laboratories or academic institutions involved in research, development and/or technology transfer. Any student opting for semester long internship may also be allowed to work on a start-up. All internships must be approved by the departmental DPE committee in advance. In the case of non-industry internships, the work should be research/development/practice oriented, and not classroom course work.

vi) In all cases, for award of DPE units, after completion of the internship, the work must be evaluated by the DPE committee of the student’s Department. In case the work is found wanting in any respect, the student(s) will be advised to do more work and reappear before the committee. In any case, partial award of DPE units would not be allowed.

vii) Both for self-arranged internships and for internships arranged through T&P Unit, administration and correspondence would be handled by the Training and Placement Unit. For self-arranged internships, any documentation regarding the bona fide status of students (while applying for training) will be provided by UG section. T&P Unit will process the internship case of the student once the student submits all departmental approvals and the confirmed offer letter from the company to T&P.

8.6.3.1. Registration Procedure for Internships

Summer Internships:

i) At the beginning of first semester of each academic year, the data of all students who have earned at least 30 credits would be automatically enrolled by the T&P unit for internship in the subsequent summer.

ii) At the beginning of the internship in the following summer, the student must have completed 50 credits to be eligible.

iii) T&P unit would allow the students to opt out of the process for allocation of internships until a specified deadline, if a student would like to try for self-arranged internship.

iv) Students who do not opt out of the process are considered for allocation of internship by the T&P unit. If a student is selected for an internship through T&P, he/she is bound to accept the internship. If the student does not take up or complete the internship, he/she will be debarred from all further T&P activities including further internship opportunities and placement procedure. This is to discourage non-serious students from depriving other students of the opportunity, and damaging the reputation of IIT Delhi with the companies offering internships through T&P.

v) The T&P Unit would handle correspondences and training certificates of all internships, both self-arranged and those arranged by the T&P unit.

vi) T&P Unit will try and arrange internships for as many students as it can. However, it may not be possible for the T&P Unit to arrange internships for all the students who participate in the process.

vii) The T&P unit typically starts the process of selections for internships in August and ends in February-March. The exact dates would be notified by the T&P unit each year.

viii) T&P unit would also notify students about the deadlines to submit documents related to self-arranged internship. Only those students who submit relevant papers by this deadline will be considered for the internship.

ix) At the end of the process, T&P will send a list of students whose internships are to be approved, to the respective departments. The internship coordinators of the department will then enroll the students on the online portal for non-graded units, in one of the two courses XXT200 or XXT300. A student will be enrolled in XXT200 if it is his/her first summer internship. Otherwise the student will be enrolled in XXT300.

Semester Internship:

i) Semester internship, as mentioned in section 8.6.2.5, is permitted in the seventh registered semester or later, for students with at least 75 earned credits.

ii) A student needs to submit an online request for prior approval of semester internship. The request for internship will be evaluated by the DPE committee of the student’s parent Department and approved by the Institute DPE committee upon recommendation of the former.

iii) Process of monitoring/mentoring the internship is described in section 8.6.2.5. Upon completion, the student should submit an online request for approval of the completion of the internship through the supervisor and Departmental DPE committee to the Institute DPE committee. The grade for semester internship is awarded by the Institute DPE committee.
The list of courses offered in connection with non-graded units listed in sections 8.1-8.6 along with the respective pre-requisites is summarized in Table 8.4.

**Table 8.4 : Summary of courses for non-graded unit**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Course Number</th>
<th>Course Name and/or Description</th>
<th>Pre-Requisites</th>
<th>No. of Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Introduction to Engineering &amp; Programme: 02 units</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>NIN100</td>
<td>Introduction to Engineering in the first semester</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>XXN101/XXN111</td>
<td>Introduction to &lt;the respective engineering programme&gt; in the third semester</td>
<td>NIN100</td>
<td>1</td>
</tr>
<tr>
<td><strong>Language and Writing Skills: 02 units</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>NLN100</td>
<td>Language and Writing Skills – I in I semester</td>
<td>—</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>NLN101</td>
<td>Language and Writing Skills – II in II semester</td>
<td>NLN100</td>
<td>1</td>
</tr>
<tr>
<td><strong>NCC/NSO/NSS: 02 units</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>NCN100</td>
<td>NCC</td>
<td>—</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>NPN100</td>
<td>NSO</td>
<td>—</td>
<td>2</td>
</tr>
<tr>
<td>7</td>
<td>NSN100</td>
<td>NSS</td>
<td>—</td>
<td>2</td>
</tr>
<tr>
<td><strong>Professional Ethics and Social Responsibility: 02 units</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>NEN100</td>
<td>Professional Ethics and Social Responsibility – I in first semester – 15 hours</td>
<td>—</td>
<td>(Both) 1</td>
</tr>
<tr>
<td>9</td>
<td>NEN101</td>
<td>Professional Ethics and Social Responsibility – II in second semester – 15 hours</td>
<td>NEN100</td>
<td>1</td>
</tr>
<tr>
<td>10</td>
<td>NEN201</td>
<td>PESR Internships: 20 working days followed by a presentation and evaluation</td>
<td>(Any one of the three) NEN101</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>NEN202</td>
<td>PESR Workshops: 40 hours followed by presentation and evaluation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>NEN203</td>
<td>PESR projects: 50 man hours of work followed by presentation and evaluation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>NEN300</td>
<td>Case Studies in Professional Ethics</td>
<td>NEN101</td>
<td></td>
</tr>
<tr>
<td><strong>Communication Skills/Seminar: 02 units</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>XXQ301, XXQ302, etc.</td>
<td>Topic specific Seminar courses introduced by parent Department</td>
<td>EC 50</td>
<td>1</td>
</tr>
<tr>
<td>15</td>
<td>XYQ301, XYQ302, etc.</td>
<td>Additional Seminar courses introduced by any other Department/ Centre/ School</td>
<td>EC 50</td>
<td>(Any one) 1</td>
</tr>
<tr>
<td>16</td>
<td>NQN301</td>
<td>Seminar component of regular courses OR Three extracurricular activities involving communication skills</td>
<td>EC 50</td>
<td></td>
</tr>
<tr>
<td><strong>Design/ Practical Experience: 05 units</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>XXD351</td>
<td>Minor Design Project – 1</td>
<td>EC 30</td>
<td>1</td>
</tr>
<tr>
<td>18</td>
<td>XXD352</td>
<td>Minor Design Project – 2</td>
<td>EC 30</td>
<td>1</td>
</tr>
<tr>
<td>19</td>
<td>XXD353</td>
<td>Minor Design Project – 3</td>
<td>EC 30</td>
<td>1</td>
</tr>
<tr>
<td>20</td>
<td>XXD354</td>
<td>Minor Design Project – 4</td>
<td>EC 30</td>
<td>1</td>
</tr>
<tr>
<td>21</td>
<td>XXD355</td>
<td>Minor Design Project – 5</td>
<td>EC 30</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Courses of Study 2017-2018</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| 22 | XXD356  
 Minor Design Project – 6  
 EC 30  
 2 |
| 23 | XXD357  
 Minor Design Project – 7  
 EC 30  
 2 |
| 24 | XXD358  
 Minor Design Project – 8  
 EC 30  
 2 |
| 25 | NDN351  
 Minor Design Project – 1  
 EC 30  
 1 |
| 26 | NDN352  
 Minor Design Project – 2  
 EC 30  
 1 |
| 27 | NDN353  
 Minor Design Project – 3  
 EC 30  
 1 |
| 28 | NDN354  
 Minor Design Project – 4  
 EC 30  
 1 |
| 29 | NDN355  
 Minor Design Project – 5  
 EC 30  
 1 |
| 30 | NDN356  
 Minor Design Project – 6  
 EC 30  
 2 |
| 31 | NDN357  
 Minor Design Project – 7  
 EC 30  
 2 |
| 32 | NDN358  
 Minor Design Project – 8  
 EC 30  
 2 |
| 33 | XXT200  
 Summer Internship – 1  
 EC 30  
 2 |
| 34 | XXT300  
 Summer Internship – 2  
 XXT200  
 2 |
| 35 | XXT400  
 Semester Internship  
 EC 75  
 5 |

In all above course descriptions, XX and XY stand for the two-letter prefix corresponding to course numbers of academic units (Table 1 of Chapter 1): example, XXD351 corresponding to Department of Textile Technology would be TXL351.

8.7 Overlapping Activities

Many of the activities listed in sections 8.1-8.6 could also qualify as valid activities under other non-graded components: for example, an internship under NEN201 may qualify to be a valid NSS activity; a technical project done as part of NEN203 may qualify to be submitted for DPE units under XXD35y, etc. Some of the technical projects may also qualify as valid activities under Minor/ Mini/ Major projects towards earning graded credits. In this regard, the following would be strictly followed:

a) In case a project is evaluated for graded credits or for any other non-graded activity, it would not be allowed to be re-submitted for any other non-graded unit. While submitting the completion request of the project online, a student should submit an undertaking to this effect, approved online by the faculty supervisor of the project.

b) Additional work which is not evaluated for such projects, either done prior to such projects or done after the completion of such projects, could be considered. In such a case, prior written permission must be taken from the concerned committee (PESR, DPE, etc.), explicitly describing components of work being submitted for the other graded/non-graded evaluations and for the current submission separately. In this regard, note the following examples:

(i) The workshops organised by NSS and under NEN202 would be generally distinct. Under NEN202, workshops would have minimum duration of 3 days and would be designated as “PESR WORKSHOP”. Workshops organized by NSS would not be counted for NEN202 and vice-versa.

(ii) In case a student desires to do internship as part of NSS activities as well as under PESR through NEN201, each of these internships must have distinct time spans and special approvals of the PESR Committee and the NSS Coordinator are required for the same.
9. POSTGRADUATE PROGRAMME STRUCTURES
**Master of Science in Chemistry**

**Department of Chemistry**

**The overall credits structure**

<table>
<thead>
<tr>
<th>Category</th>
<th>PC</th>
<th>PE</th>
<th>OC</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Program Core</strong></td>
<td>60</td>
<td>9</td>
<td>6</td>
<td>75</td>
</tr>
</tbody>
</table>

**Program Electives**

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CML661 Solid state chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CML662 Statistical Mechanics &amp; Molecular Simulation Methods</td>
<td>3</td>
</tr>
<tr>
<td>CML664 Microbial Biochemistry</td>
<td>3</td>
</tr>
<tr>
<td>CML665 Food Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CML671 Applied organometallic Chemistry</td>
<td>3</td>
</tr>
<tr>
<td>CML672 Inorganic Polymers</td>
<td>3</td>
</tr>
<tr>
<td>CML673 Structural Methods of Inorganic Compounds</td>
<td>3</td>
</tr>
<tr>
<td>CML739 Applied Biocatalysis</td>
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**Programme Code:** CYS

**Master of Science in Chemistry**

**Department of Chemistry**

**The overall credits structure**

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**Total = 75**
# Master of Science in Mathematics

Department of Mathematics

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**Total Credits**: 75

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**Master of Science in Physics**  
Department of Physics  

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Optional Departmental specialization: Additional 6 credits: Total Credits: 86 with specialization

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**Total Credits**: 62

**Program Electives**

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**Specialization in Photonics Min. 12 credits**

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**Specialization in Condensed Matter Physics Min. 12 credits**

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**Total Credits**: 75-81

**Courses**  
(Number, Abbreviated Title, L-T-P, credits)

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**Total = 75-81**
# Master of Design in Industrial Design

**Interdisciplinary Programme**

The overall credits structure

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## Program Core

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<tr>
<td>DSL732 Adv. Mat. Processes &amp; Die Design</td>
<td>2-0-2 3</td>
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<tr>
<td>DSL751 Form and Aesthetics</td>
<td>2-0-2 3</td>
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<tr>
<td>DSP711 Computer Aided Product Detailing</td>
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<td>DSP721 Design and Innovation Methods</td>
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<td>DSP722 Applied Ergonomics</td>
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<td>DSP731 Communication and presentation skills</td>
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<td>DSP741 Product Interface &amp; Design</td>
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**Total Credits** 39

## Program Electives

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<td>DSL841 Design Management and Professional Practice</td>
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<td>DSR782 Vehicle Design</td>
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**Total = 51**

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### Sem. Courses (Number, Abbreviated Title, L-T-P, credits)

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Total = 51
## Master of Business Administration

### Department of Management

The overall credits structure

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<th>Streamed Electives SE (Total 12 credits)</th>
<th>Non-credit Core NC</th>
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<td>People Skills Stream</td>
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### Program Core

- MSL705* HRM Systems 1.5 0 0 1.5
- MSL708** Business Laws 3 0 0 3
- MSL707* Management Accounting 3 0 0 3
- MSL708* Financial Management 3 0 0 3
- MSL709* Business Research Methods 1.5 0 0 1.5
- MSL711* Strategic Management 3 0 0 3
- MSL712* Ethics & Values Based Leadership 1.5 0 0 1.5
- MSL713* Information Systems Management 3 0 0 3
- MSL720* Macroeconomic Environment of Business 3 0 0 3
- MSL745 Operations Management 3 0 0 3
- MSL760 Marketing Management 3 0 0 3
- MSL780* Managerial Economics 1.5 0 0 1.5
- MSL890 Major Project (Unique Core) 0 0 12 6

### Analytical Skills Stream

- MSL719* Statistics for Management 3 0 0 3
- MSL721* Econometrics 3 0 0 3
- MSL740 Quantitative Methods in Management 3 0 0 3
- MTL732 Financial Mathematics 3 1 0 4

### People Skills Stream

- MSL710 Creative Problem Solving 3 0 0 3
- MSL724* Business Communication 1.5 0 0 1.5
- MSL725* Business Negotiations 1.5 0 0 1.5
- MSL727* Interpersonal Behavior & Team Dynamics 1.5 0 0 1.5
- MSL729* Individual Behavior in Organization 1.5 0 0 1.5
- MSL730* Managing With Power 1.5 0 0 1.5
- MSL731* Developing Self Awareness 1.5 0 0 1.5
- MSL733* Organization Theory 1.5 0 0 1.5

### Non-credit Core (NC)

- MST893 Corporate Sector Attachment 0 0 4 2
- MST894* Social Sector Attachment 0 0 2 1

### Program Electives (PE)

- MSL716* Fundamentals of Management Systems 3 0 0 3
- MSL717* Business Systems Analysis & Design 3 0 0 3
- MSL811 Management Control Systems 3 0 0 3
- MSL802 Management of Intellectual Property Rights 3 0 0 3
- MSL835 Labor Legislation and Industrial Relations 3 0 0 3
- MSL704 Science & Technology Policy Systems 3 0 0 3

### Notes:

- The UC will include the major project which would focus on a research driven application of skills acquired in a particular functional area, through the programme.

### Total Credits

- Total Credits 36

### Streamed Electives (SE)

Streamed Electives consist of Analytical Skills (AS) Stream and People Skills (PS) Stream. The total credits of Streamed Electives would be 12 – 6 from AS and 6 from PS.

### a) Analytical Skills (AS) Stream

- MSL719* Statistics for Management 3 0 0 3
- MSL721* Econometrics 3 0 0 3
- MSL740 Quantitative Methods in Management 3 0 0 3

### b) People Skills (PS) Stream

- MSL710 Creative Problem Solving 3 0 0 3
- MSL724* Business Communication 1.5 0 0 1.5
- MSL725* Business Negotiations 1.5 0 0 1.5
- MSL727* Interpersonal Behavior & Team Dynamics 1.5 0 0 1.5
- MSL729* Individual Behavior in Organization 1.5 0 0 1.5
- MSL730* Managing With Power 1.5 0 0 1.5
- MSL731* Developing Self Awareness 1.5 0 0 1.5
- MSL733* Organization Theory 1.5 0 0 1.5

### Program Electives (PE)

- MSL716* Fundamentals of Management Systems 3 0 0 3
- MSL717* Business Systems Analysis & Design 3 0 0 3
- MSL811 Management Control Systems 3 0 0 3
- MSL802 Management of Intellectual Property Rights 3 0 0 3
- MSL835 Labor Legislation and Industrial Relations 3 0 0 3
- MSL704 Science & Technology Policy Systems 3 0 0 3

### Notes:

- The UC will include the major project which would focus on a research driven application of skills acquired in a particular functional area, through the programme.

- These are new courses which have been designed and/or modified as a part of the curriculum review.

- MSL706 was initially an elective, MSL887. This course’s content is the same, only the number has been changed to now reflect a core course.

### Total Credits

- Total Credits 36

### Non-credit Core (NC)

- MST893 Corporate Sector Attachment 0 0 4 2
- MST894* Social Sector Attachment 0 0 2 1

### Program Electives (PE)

- MSL716* Fundamentals of Management Systems 3 0 0 3
- MSL717* Business Systems Analysis & Design 3 0 0 3
- MSL811 Management Control Systems 3 0 0 3
- MSL802 Management of Intellectual Property Rights 3 0 0 3
- MSL835 Labor Legislation and Industrial Relations 3 0 0 3
- MSL704 Science & Technology Policy Systems 3 0 0 3

### Notes:

- The UC will include the major project which would focus on a research driven application of skills acquired in a particular functional area, through the programme.

- These are new courses which have been designed and/or modified as a part of the curriculum review.

### Total Credits

- Total Credits 36
<table>
<thead>
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SE = Streamed Electives, AS = Analytical Skills Stream, PS = People Skills Stream, FE = Focus Electives, PE = Programme Electives

Total = 72
# Master of Business Administration (Telecom Management)

## Department of Management

The overall credits structure

<table>
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<tr>
<th>Category</th>
<th>Programme Core (Total 36 Credits)</th>
<th>Streamed Electives (Total 12 credits)</th>
<th>Focus Electives</th>
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**Program Core (PC)**

- MSL705* HRM Systems: 1.5 0 0 1.5
- MSL706* Business Laws: 3 0 0 3
- MSL707* Management Accounting: 3 0 0 3
- MSL708 Financial Management: 3 0 0 3
- MSL709* Business Research Methods: 1.5 0 0 1.5
- MSL711* Strategic Management: 3 0 0 3
- MSL712* Ethics & Values Based Leadership: 1.5 0 0 1.5
- MSL713* Information Systems Management: 3 0 0 3
- MSL720* Macroeconomic Environment of Business: 3 0 0 3
- MSL745 Operations Management: 3 0 0 3
- MSL760 Marketing Management: 3 0 0 3
- MSL780* Managerial Economics: 1.5 0 0 1.5
- MSD691 Major Project (Unique Core): 0 0 12.6

**Non-credit Core (NC)**

- MST893 Corporate Sector Attachment: 0 0 4 2
- MST894* Social Sector Attachment: 0 0 2 1

**Focus Electives (FE)**

- MSL723 Telecommunication Systems: 3 0 0 3
- MSL726 Telecom System Analysis, Planning & Design: 3 0 0 3
- MSL728 International Telecommunication Management: 3 0 0 3
- EEL767 Telecom Systems: 3 0 0 3

**Program Electives (PE)**

- MSL716 Fundamentals of Management Systems: 3 0 0 3
- MSL717* Business Systems Analysis & Design: 3 0 0 3
- MSL811 Management Control Systems: 3 0 0 3
- MSL802 Management of Intellectual Property Rights: 3 0 0 3
- MSL835 Labor Legislation and Industrial Relations: 3 0 0 3
- MSL704 Science & Technology Policy Systems: 3 0 0 3
- MSL801 Technology Forecasting & Assessment: 3 0 0 3
- MSL803 Technical Entrepreneurship: 3 0 0 3
- MSL806* Mergers & Acquisitions: 3 0 0 3
- MSL807* Selected Topics in Strategic Management: 3 0 0 3
- MSL808* Systems Thinking: 3 0 0 3
- MSL812 Flexible Systems Management: 3 0 0 3
- MSL813 Systems Methodology for Management: 3 0 0 3
- MSL817 Systems Waste & Sustainability: 3 0 0 3
- MSL819 Business Process Re-engineering: 3 0 0 3
- MSL820 Global Business Environment: 3 0 0 3
- MSL821* Strategy Execution Excellence: 3 0 0 3
- MSL822 International Business: 3 0 0 3
- MSL823 Strategic Change & Flexibility: 3 0 0 3
- MSL824 Policy Dynamics & Learning Organization: 3 0 0 3
- MSL825 Strategies in Functional Management: 3 0 0 3
- MSL826 Business Ethics: 3 0 0 3
- MSL827 International Competitiveness: 3 0 0 3
- MSL828 Global Strategic Management: 3 0 0 3
- MSL829 Current & Emerging Issues in Strategic Management: 3 0 0 3
- MSL851* Strategic Alliance: 1.5 0 0 1.5
- MSL714 Organizational Dynamics and Environment: 3 0 0 3
- MSL830 Organizational Structure and Processes: 3 0 0 3
- MSL831 Management of Change: 3 0 0 3
- MSL832 Managing Innovation for Organizational Effectiveness: 3 0 0 3
- MSL833 Organizational Development: 3 0 0 3
- MSL834* Managing Diversity at Workplace: 1.5 0 0 1.5
- MSL836* International Human Resources Management: 1.5 0 0 1.5
- MSL839 Current & Emerging Issues in Organizational Management: 3 0 0 3
- MSL840 Manufacturing Strategy: 3 0 0 3
- MSL841* Supply Chain Analytics: 3 0 0 3
- MSL842* Supply Chain Modeling: 3 0 0 3
- MSL843 Supply Chain Logistics Management: 3 0 0 3
- MSL844 Systems Reliability, Safety and Maintenance Management: 3 0 0 3
- MSL845 Total Project Systems Management: 3 0 0 3
- MSL846 Total Productivity Management: 3 0 0 3
- MSL848* Applied Operations Research: 3 0 0 3
- MSL849 Current & Emerging Issues in Manufacturing: 3 0 0 3
- MSL850 Management of Information Technology: 3 0 0 3

**Notes:**

- The UC will include the major project which would focus on a research driven application of skills acquired in a particular functional area, through the programme.
- These are new courses which have been designed and/or modified as a part of the curriculum review.
- MSL706 was initially an elective, MSL887. This course’s content is the same, only the number has been changed to now reflect a core course.

**Total Credits:** 36

**Streamed Electives (SE)**

Streamed Electives consist of Analytical Skills (AS) Stream and People Skills (PS) Stream. The total credits of Streamed Electives would be 12 – 6 from AS and 6 from PS.

**a) Analytical Skills (AS) Stream**

- MSL719* Statistics for Management: 3 0 0 3
- MSL721* Econometrics: 3 0 0 3
- MSL740 Quantitative Methods in Management: 3 0 0 3
- MTL732 Financial Mathematics: 3 0 0 3

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**b) People Skills (PS) Stream**

- MSL710 Creative Problem Solving: 3 0 0 3
- MSL724* Business Communication: 1.5 0 0 1.5
- MSL725* Business Negotiations: 1.5 0 0 1.5
- MSL727* Interpersonal Behavior & Team Dynamics: 1.5 0 0 1.5
- MSL729* Individual Behavior in Organization: 1.5 0 0 1.5
- MSL730* Managing With Power: 1.5 0 0 1.5
- MSL731* Developing Self Awareness: 1.5 0 0 1.5
- MSL733* Organization Theory: 1.5 0 0 1.5

* These are new courses which have been designed and/or modified as a part of the curriculum review.

**Focus Electives (FE)**

- MSL723 Telecommunication Systems: 3 0 0 3
- MSL726 Telecom System Analysis, Planning & Design: 3 0 0 3
- MSL728 International Telecommunication Management: 3 0 0 3
- EEL767 Telecom Systems: 3 0 0 3

**Non-credit Core (NC)**

- MST893 Corporate Sector Attachment: 0 0 4 2
- MST894* Social Sector Attachment: 0 0 2 1

* This is a new course which has been designed as a part of the curriculum review.

**Programme Code:** SMT

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SE = Streamed Electives, AS = Analytical Skills Stream, PS = People Skills Stream, FE = Focus Electives, PE = Programme Electives

Total = 72
**Programme Code: SMN**

**Master of Business Administration (Technology Management)**

Department of Management

The overall credits structure

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<th>Category</th>
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<th>Streamed Electives (SE) (Total 12 credits)</th>
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**Program Electives (PC)**

- MSL705* HRM Systems
- MSL706** Business Laws
- MSL707* Management Accounting
- MSL708 Financial Management
- MSL709* Business Research Methods
- MSL711* Strategic Management
- MSL712* Ethics & Values Based Leadership
- MSL713* Information Systems Management
- MSL720* Macroeconomic Environment of Business
- MSL745 Operations Management
- MSL760 Marketing Management
- MSL780* Managerial Economics
- MSD892 Major Project (Unique Core)

**Notes:**
- The UC will include the major project which would focus on a research driven application of skills acquired in a particular functional area, through the programme.
- * These are new courses which have been designed and/or modified as a part of the curriculum review.

**Total Credits 36**

**Streamed Electives (SE)**

Streamed Electives consist of Analytical Skills (AS) Stream and People Skills (PS) Stream. The total credits of Streamed Electives would be 12 – 6 from AS and 6 from PS.

**a) Analytical Skills (AS) Stream**

- MSL719* Statistics for Management
- MSL721* Econometrics
- MSL740 Quantitative Methods in Management
- MTL732 Financial Mathematics

- * These are new courses which have been designed and/or modified as a part of the curriculum review.

**b) People Skills (PS) Stream**

- MSL710 Creative Problem Solving
- MSL724* Business Communication
- MSL725* Business Negotiations
- MSL727* Interpersonal Behavior & Team Dynamics
- MSL729* Individual Behavior in Organization
- MSL730* Managing With Power
- MSL731* Developing Self Awareness
- MSL733* Organization Theory

- * These are new courses which have been designed and/or modified as a part of the curriculum review.

**Focus Electives (FE)**

- MSL700 Fundamentals of Management of Technology
- MSL701 Strategic Technology Management
- MSL702 Management of Innovation and R&D
- MSL703 Management of Technology Transfer and Absorption

**Non-credit Core (NC)**

- MSL800* Seminar

- * This is a new course which has been designed as a part of the curriculum review.

**Program Electives (PE)**

- MSL716 Fundamentals of Management Systems
- MSL717* Business Systems Analysis & Design
- MSL811 Management Control Systems
- MSL802 Management of Intellectual Property Rights
- MSL826 Labor Legislation and Industrial Relations
- MSL704 Science & Technology Policy Systems
- MSL601 Technology Forecasting & Assessment
- MSL603 Technical Entrepreneurship
- MSL806* Mergers & Acquisitions
- MSL807* Selected Topics in Strategic Management
- MSL808* Systems Thinking
- MSL812 Flexible Systems Management
- MSL613 Systems Methodology for Management
- MSL617 Systems Waste & Sustainability
- MSL819 Business Process Re-engineering
- MSL820 Global Business Environment
- MSL821* Strategy Execution Excellence
- MSL822 International Business
- MSL823 Strategic Change & Flexibility
- MSL824 Policy Dynamics & Learning Organization
- MSL825 Strategies in Functional Management
- MSL826 Business Ethics
- MSL827 International Competitiveness
- MSL828 Global Strategic Management
- MSL829 Current & Emerging Issues in Strategic Mgmt.
- MSL830* Strategic Alliance
- MSL714 Organizational Dynamics and Environment
- MSL830 Organizational Structure and Processes
- MSL831 Management of Change
- MSL832 Managing Innovation for Organizational Effectiveness
- MSL833 Organizational Development
- MSL834* Managing Diversity at Workplace
- MSL835 Labor Legislation and Industrial Relations
- MSL836* International Human Resources Management
- MSL839 Current & Emerging Issues in Organizational Management
- MSL840* Procurement Management
- MSL850 Management of Information Technology
- MSL842 Supply Chain Modeling
- MSL843* Supply Chain Logistics Management
- MSL844 Systems Reliability, Safety and Maintenance Mgmt.
- MSL845 Total Project Systems Management
- MSL846 Total Productivity Management
- MSL848* Applied Operations Research
- MSL849 Current & Emerging Issues in Manufacturing Mgmt.
- MSL850 Management of Information Technology
- MSL852 Network System: Applications and Management
- MSL853* Software Project Management
- MSL854* Big Data Analytics & Data Science
- MSL855* Electronic Commerce

**Notes:**
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**Total Credits 36**

**Notes:**
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SE = Streamed Electives, AS = Analytical Skills Stream, PS = People Skills Stream, FE = Focus Electives, PE = Programme Electives

Total = 72
**Master of Technology in Engineering Analysis and Design**

**Department of Applied Mechanics**

The overall credits structure

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**APL713** Turbulence and its Modeling | 3 0 0 | 3 |
**APL715** Physics of Turbulent Flows | 3 0 0 | 3 |
**APL716** Fluid Transportation Systems | 3 0 0 | 3 |
**APL720** Computational Fluid Dynamics | 3 0 2 | 4 |
**APL734** Advanced Dynamics | 3 0 0 | 3 |
**APL765** Fracture Mechanics | 3 0 0 | 3 |
**APL781** Theory of Plates and Shells | 3 0 0 | 3 |
**APL835** Mechanics of Composite Materials | 3 0 0 | 3 |

**APL750** Modern Engineering Materials | 3 0 0 | 3 |
**APL756** Microstructural Characterization of Materials | 3 0 2 | 4 |
**APL759** Phase Transformations | 3 0 0 | 3 |
**APL763** Micro & Nanoscale Mechanical Behaviour of Materials | 3 0 2 | 4 |
**APL764** Mechanical Behaviour of Biomaterials | 3 0 0 | 3 |
**APL765** Fracture Mechanics | 3 0 0 | 3 |
**APL767** Engineering Failure Analysis and Prevention | 3 0 0 | 3 |
**APLXX** Selected Topics in Material Engineering | 3 0 0 | 3 |

**Programme Code:** AMA

**Semester wise course breakup for three streams**

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<td>APL753 Properties &amp; Selection of Engg. Materials (3-0-0) 3</td>
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**Total = 52**
### The overall credits structure

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#### Program Core

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<td>CLD781</td>
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<td>CLD782</td>
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<td>CLL701</td>
<td>Modelling of Transport Processes</td>
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<td>CLL702</td>
<td>Principles of Thermodynamics, Reaction Kinetics and Reactors</td>
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<td>CLL703</td>
<td>Process Engineering</td>
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#### Program Electives

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#### Total = 52
**Programme Code: CYM**

**Master of Technology in Molecular Engineering: Chemical Synthesis and Analysis**

Department of Chemistry

The overall credits structure

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**Total Credits = 42**

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**Total Credits = 24**

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**Total = 54**
# Master of Technology in Construction Technology and Management

**Department of Civil Engineering**

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MCL753  Manufacturing Informatics  3 0 2 4  MCL787  Welding Science and Technology  3 0 2 4
MCL755  Service System Design  3 0 0 3  MCL788  Surface Engineering  3 0 2 4
MCL769  Metal Forming Analysis  3 0 2 4  MCL791  Processing and Mechanics of Composite Materials  3 0 2 4
MCL776  Advances in Metal Forming  3 0 0 3  MCL792  Injection Molding and Mold Design  2 0 2 3
MCL778  Design and Metallurgy of Welded Joints  3 0 2 4  MCL818  Heating, Ventilating and Air-conditioning  3 0 0 3
MCL780  Casting Technology  3 0 2 4  MCL866  Maintenance management  3 0 0 3
MCL783  Automation in Manufacturing  3 0 2 4

Total = 52.5
## Programme Code: CEG

### Master of Technology in Geotechnical and Geoenvironmental Engineering
Department of Civil Engineering

The overall credits structure

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**Total = 48**
## Master of Technology in Transportation Engineering
Department of Civil Engineering

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**Total Credits** 36

**Program Electives**

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* Should be listed in restricted elective course category.
# Any course (relevant to research area) offered in that semester with consent of thesis supervisor. Alternatively minor project can be opted.

Total = 54
Master of Technology in Structural Engineering  
Department of Civil Engineering

The overall credits structure

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**Total Credits**

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**Total = 54**
## Master of Technology in Construction Engineering and Management

Department of Civil Engineering

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**Total Credits: 42**

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**Total Credits: 42**

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<td>6   0 18</td>
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**Total = 54**
Master of Technology in Rock Engineering and Underground Structures
Department of Civil Engineering

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### Total Credits

- **Sem. I**
  - CVL725: Environmental Chemistry and Microbiology (1-0-4) 3
  - CVL722: Water Engineering (3-0-0) 3
  - CVL720: Air pollution and control (3-0-0) 3
  - PE-1: (3-0-0) 3 or (2-0-2) 3 or (1-0-4) 4
  - Total Credits: 12

- **Sem. II**
  - CVL721: Solid Waste Engineering (3-0-0) 3
  - CVL724: Environmental Systems Analysis (3-0-0) 3
  - CVL723: Wastewater Engineering (3-0-0) 3
  - PE-2: (3-0-0) 3 or (2-0-2) 3 or (1-0-4) 5
  - OE-1: (3-0-0) 3
  - Total Credits: 15

- **Summer**
  - CVD726: Minor project (0-0-6) 3
  - Total Credits: 3

- **Sem. III**
  - Major Thesis Part-I (0-0-12) 6
  - PE-3: (3-0-0) 3 or (2-0-2) 3 or (1-0-4) 2
  - OE-2: (3-0-0) 3
  - Total Credits: 12

- **Sem. IV**
  - Major Thesis Part-II (0-0-24) 12
  - Total Credits: 24

**Total = 54**

---

_Note: Program Code: CEV
Department of Civil Engineering_
Programme Code: CEW

Master of Technology in Water Resources Engineering
Department of Civil Engineering

The overall credits structure

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**Total Credits**  39

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**Total = 54**

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Sem.

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**Total = 54**
**Master of Technology in Computer Science and Engineering**
Department of Computer Science and Engineering

The overall credits structure

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**Program Core**
- COD891 Minor Project 0 0 6 3
- COD892 M.Tech. Project Part-I 0 0 14 7
- COL702 Advanced Data Structures 3 0 2 4
- COL765 Logic & Functional Programming 3 0 2 4
- COP701 Software Systems Laboratory 0 0 6 3

**Total Credits = 21**

**Bridge Courses**
- COL632 Introduction to Data Base Systems 3 0 2 4
- COL693 Resources Management in Computer Systems 3 0 2 4
- COL671 Artificial Intelligence 3 0 2 4
- COL672 Computer Networks 3 0 2 4

**Program Electives (PE)**
- COD891 Minor Project Part-II 0 0 28 14
- COS799 Independent Study 0 3 0 3

**Specialization Streams**
- **1. Architecture & Embedded Systems (AES)**
  - COL718 Architecture of High Performance Computers 3 0 2 4
  - COL719 Synthesis of Digital Systems 3 0 2 4
  - COL788 Embedded Computing 3 0 2 4
  - COL812 System Level Design and Modelling 3 0 2 4
  - COL818 Principles of Multiprocessor Systems 3 0 2 4
  - COL821 Reconfigurable Computing 3 0 2 4
  - COL846 Special Topics in Hardware Systems 3 0 2 4
  - COV881 Special Module in Hardware Systems 1 0 0 1

- **2. Graphic & Vision (GV)**
  - COL726 Numerical Algorithms 3 0 2 4
  - COL780 Computer Vision 3 0 2 4

- **3. Software Systems (SS)**
  - COL724 Advanced Computer Networks 3 0 2 4
  - COL728 Compiler Design 3 0 3 4.5
  - COL731 Compiler Optimization 3 0 3 4.5
  - COL740 Software Engineering 3 0 2 4
  - COL746 Wireless Networks 3 0 2 4
  - COL751 Advanced Distributed Systems 3 0 2 4
  - COL851 Special Topics in Operating Systems 3 0 0 3
  - COL852 Special Topics in Compilers 3 0 0 3
  - COL860 Special Topics in Parallel Computation 3 0 0 3
  - COL862 Special Topics in Software Systems 3 0 0 3
  - COL867 Special Topics in High Speed Networks 3 0 0 3
  - COL871 Special Topics in Programming Languages & Compilers

- **4. Theoretical Computer Science (TH)**
  - COL703 Logic for CS (LCS) 3 0 2 4
  - COL726 Numerical Algorithms 3 0 2 4
  - COL730 Parallel Programming 3 0 2 4
  - COL750 Foundations of Automatic Verification 3 0 2 4
  - COL751 Algorithmic Graph Theory 3 0 0 3

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*Thesis option has a requirement of Min. CGPA 7.5 at the end 3rd sem and B Grade in COD892.
In exceptional cases DRC may waive the CGPA requirement.

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**Semester Courses (Number, Abbreviated Title, L-T-P, credits)**

- **I**
  - COL702 Advanced Data Structures (3-0-2) 4
  - Bridge Course 1 (3-4)
  - COL765 Logic and Functional Programming (3-0-2) 4
  - COP701 Software Lab (0-8-3)
  - PE-2 (3-4)
  - PE-3 PE-4 (3-4)
  - PE-5 PE-6 PE-7 OC (3-4)

- **II**
  - PE-1 (3-4)
  - Bridge Course 2 (3-4)
  - COD891 Minor Project (3-0-0) 3
  - PE-2 (3-4)
  - PE-3 PE-4 (3-4)
  - PE-5 PE-6 PE-7 OC (3-4)

- **III**
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  - PE-5 PE-6 PE-7 OC (3-4)
  - PE-8 OC (3-4)

- **Summer**
  - MTP II (Contd.)
## Master of Technology in Computer Science and Engineering

**Department of Computer Science and Engineering**

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116
## Master of Technology in Control and Automation

**Department of Electrical Engineering**

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**Total Credits**: 24

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**Total = 48**
## Master of Technology in Communication Engineering

### Department of Electrical Engineering

The overall credits structure

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**Total Credits:** 24

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Total = 48
Master of Technology in Power Electronics, Electrical Machines and Drives
Department of Electrical Engineering

The overall credits structure

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### Program Electives

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### Sem. (number, Abbreviated Title, L-T-P, credits)

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Total = 48
### Master of Technology in Computer Technology
Department of Electrical Engineering

The overall credits structure

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#### Program Core
- ELD780 Minor Project: 0 0 4 2
- ELD880 Major Project Part-I: 0 0 12 6
- ELL780 Mathematical Foundations of Computer Technology: 3 0 0 3
- ELL781 Software Fundamentals of Computer Technology: 3 0 0 3
- ELL782 Computer Architecture: 3 0 0 3
- ELL783 Operating Systems: 0 0 2 4

**Total Credits:** 21

#### Program Electives
- ELD881 Major Project Part-II: 0 0 24 12
- ELL880 Special Topics in Computers-I: 0 0 4 2
- ELL881 Special Topics in Computers-II: 0 0 12 6
- ELL780 Mathematical Foundations of Computer Technology: 3 0 0 3
- ELL781 Software Fundamentals of Computer Technology: 3 0 0 3
- ELL782 Computer Architecture: 3 0 0 3
- ELL783 Operating Systems: 0 0 2 4

#### Streamed Electives (EET) in (Cognitive and Intelligent Systems)

##### Required Electives
- ELL784 Introduction to Machine Learning: 3 0 0 3
- ELL786 Multimedia Systems: 3 0 0 3

##### Other Electives
- ELL704 Advanced Robotics: 3 0 0 3
- ELL707 Systems Biology: 3 0 0 3
- ELL715 Digital Image Processing: 3 0 2 4
- ELL741 Neuromorphic Engineering: 3 0 0 3
- ELL785 Computer Communication Networks: 3 0 0 3
- ELL786 Multimedia Systems: 3 0 0 3
- ELL787 Embedded Systems and Applications: 3 0 0 3
- ELL788 Computational Perception and Cognition: 3 0 0 3
- ELL789 Intelligent Systems: 3 0 0 3
- ELL791 Neural Systems and Learning Machines: 3 0 2 4
- ELL793 Computer Vision: 3 0 0 3
- ELL794 Human-Computer Interface: 3 0 0 3
- ELL795 Swarm Intelligence: 3 0 0 3
- ELL796 Signals and Systems in Biology: 3 0 0 3
- ELL799 Natural Computing: 3 0 0 3
- ELL882 Large-Scale Machine Learning: 3 0 0 3
- ELL883 Embedded Intelligence: 3 0 0 3
- ELL884 Information Retrieval: 3 0 0 3
- ELL885 Machine Learning for Computational Finance: 3 0 0 3
- ELL886 Big Data Systems: 3 0 0 3
- ELL887 Cloud Computing: 3 0 0 3
- ELL888 Advanced Machine Learning: 3 0 0 3
- ELL890 Computational Neuroscience: 3 0 0 3
- ELL891 Computational Linguistics: 3 0 0 3
- ELL893 Cyber-Physical Systems: 3 0 0 3

#### Streamed Electives (EET) in (Embedded Intelligent Systems)

##### Required Electives
- ELL784 Introduction to Machine Learning: 3 0 0 3
- ELL787 Embedded Systems and Applications: 3 0 0 3

##### Other Electives
- COL719 Synthesis of Digital Systems: 3 0 2 4
- COL812 System Level Design and Modelling: 3 0 0 3
- ELL704 Advanced Robotics: 3 0 0 3
- ELL710 Coding Theory: 3 0 0 3
- ELL720 Advanced Digital Signal Processing: 3 0 0 3
- ELL728 Optoelectronic Instrumentation: 3 0 0 3
- ELL731 Mixed Signal Circuit Design: 3 0 0 3
- ELL733 Digital ASIC Design: 3 0 2 4
- ELL734 MOS VLSI design: 3 0 0 3
- ELL735 Analog Integrated Circuits: 3 0 0 3

#### Streamed Electives (EET) in (Computer Communication and Networks)

##### Required Electives
- ELL785 Computer Communication Networks: 3 0 0 3
- ELL786 Multimedia Systems: 3 0 0 3

##### Other Electives
- ELL710 Coding Theory: 3 0 0 3
- ELL711 Signal Theory: 3 0 0 3
- ELL712 Digital Communications: 3 0 0 3
- ELL714 Basic Information Theory: 3 0 0 3
- ELL716 Telecommunication Switching and Transmission: 3 0 0 3
- ELL717 Optical Communication Systems: 3 0 0 3
- ELL723 Broadband Communication Systems: 3 0 0 3
- ELL725 Wireless Communications: 3 0 0 3
- ELL784 Introduction to Machine Learning: 3 0 0 3
- ELL787 Embedded Systems and Applications: 3 0 0 3
- ELL797 Energy-Efficient Computing: 3 0 0 3
- ELL813 Advanced Information Theory: 3 0 0 3
- ELL816 Satellite Communication: 3 0 0 3
- ELL817 Access Networks: 3 0 0 3
- ELL818 Telecommunication Technologies: 3 0 0 3
- ELL820 Photonic Switching and Networking: 3 0 0 3
- ELL823 Broadband Communication Systems: 3 0 0 3
- ELL825 Wireless Communications: 3 0 0 3
- ELL827 Cloud Computing: 3 0 0 3
- ELL829 Protocol Engineering: 3 0 0 3
- ELL832 Internet Technologies: 3 0 0 3
- ELL894 Network Performance Modeling and Analysis: 3 0 0 3
- ELL895 Network Security: 3 0 0 3
- ELL896 Mobile Computing: 3 0 0 3
- ELL897 Network Management: 3 0 0 3
- ELL898 Pervasive Computing: 3 0 0 3
- ELL899 Protocol Engineering: 3 0 0 3
- ELP720 Telecommunication Networks Laboratory: 0 1 4 3
- ELP780 Software Lab: 0 1 4 3
- ELP781 Digital Systems Lab: 0 1 4 3
- ELP821 Advanced Telecommunication Networks Laboratory: 0 1 4 3
- ELP822 Network Software Laboratory: 0 1 4 3

#### Streamed Electives (EET) in (Multimedia Information Processing)

##### Required Electives
- ELL786 Multimedia Systems: 3 0 0 3
- ELL787 Embedded Systems and Applications: 3 0 0 3

##### Other Electives
- ELL710 Coding Theory: 3 0 0 3
ELL711  Signal Theory  3 0 0 3  
ELL714  Basic Information Theory  3 0 0 3  
ELL715  Digital Image Processing  3 0 2 4  
ELL718  Statistical Signal Processing  3 0 0 3  
ELL719  Detection and Estimation Theory  3 0 0 3  
ELL720  Advanced Digital Signal Processing  3 0 0 3  
ELL784  Introduction to Machine Learning  3 0 0 3  
ELL785  Computer Communication Networks  3 0 0 3  
ELL788  Computational Perception and Cognition  3 0 0 3  
ELL792  Computer Graphics  3 0 0 3  
ELL793  Computer Vision  3 0 0 3  
ELL813  Advanced Information Theory  3 0 0 3  
ELL882  Large-Scale Machine Learning  3 0 0 3  
CRL707  Human & Machine Speech Communication  3 0 0 3  

**Streamed Electives (EET) in (Internet Technologies)**

**Required Electives**

ELL784  Introduction to Machine Learning  3 0 0 3  
ELL785  Computer Communication Networks  3 0 0 3  

**Other Electives**

ELL723  Broadband Communication Systems  3 0 0 3  
ELL765  Smart Grid Technology  3 0 0 3  
ELL766  Appliance Systems  3 0 0 3  
ELL772  Planning and Operation of a Smart Grid  3 0 0 3  
ELL786  Multimedia Systems  3 0 0 3  
ELL787  Embedded Systems and Applications  3 0 0 3  
ELL797  Energy-Efficient Computing  3 0 0 3  
ELL798  Agent Technologies  3 0 0 3  
ELL884  Information Retrieval  3 0 0 3  
ELL887  Cloud Computing  3 0 0 3  
ELL892  Internet Technologies  3 0 0 3  
ELL895  Network Security  3 0 0 3  
ELL896  Mobile Computing  3 0 0 3  
ELL898  Pervasive Computing  3 0 0 3  
ELP721  Embedded Telecommunication Systems Laboratory  0 1 4 3  
ELP780  Software Lab  0 1 4 3  
ELP781  Digital Systems Lab  0 1 4 3  
ELP782  Computer Networks Lab  0 1 4 3  
ELP855  Smart Grids Laboratory  0 1 4 3  

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123
## Master of Technology in Industrial Engineering

### Department of Mechanical Engineering

**The overall credits structure**

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### Streamed Electives (MEE) in (Analytics and Optimization)

| MCL753 Manufacturing Informatics | 3 | 0 | 2 | 4 |
| MCL758 Optimization | 3 | 0 | 0 | 3 |
| MCL770 Stochastic Modeling and Simulation | 3 | 0 | 0 | 3 |
| MCL865 Advanced Operations Research | 3 | 0 | 0 | 3 |

### Streamed Electives (MEE) in (Product Life Cycle Management)

| MCL771 Value Engineering and Life Cycle Costing | 3 | 0 | 0 | 3 |
| MCL772 Reliability Engineering | 3 | 0 | 0 | 3 |
| MCL773 Quality Systems | 3 | 0 | 0 | 3 |

### Streamed Electives (MEE) in (Operations Management)

| MCL755 Service System Design | 3 | 0 | 0 | 3 |
| MCL756 Supply Chain Management | 3 | 0 | 0 | 3 |
| MCL757 Logistics | 3 | 0 | 0 | 3 |
| MCL759 Entrepreneurship | 3 | 0 | 0 | 3 |
| MCL760 Project Management | 3 | 0 | 0 | 3 |
| MCL775 Special Topics in IE | 3 | 0 | 0 | 3 |
| MCL866 Maintenance management | 3 | 0 | 0 | 3 |

### Program Code: MEE

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### Professional Project Activity In Summer Vacation

| MCD861 Major Project Part-I (0-0-24) 12 | OE-1 (3-0-0) 3 | 1 | 3 | 0 | 24 | 27 | 15 |

### IV

| MCD862 Major Project Part-II (0-0-24) 12 | | | | | | |

**Total = 51**

124
# Master of Technology in Mechanical Design

## Department of Mechanical Engineering

### The overall credits structure

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<td>MCD832</td>
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<td>Analytical Dynamics</td>
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**Total Credits:** 32

#### Streamed Electives MEM - (A1) (atleast 12 credits)

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**Total Credits:** 12

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**Total Credits:** 10

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**Total Credits:** 54

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Programme Code: MEM

Master of Technology in Mechanical Design

Department of Mechanical Engineering

Programme Code: MEM

Master of Technology in Mechanical Design

Department of Mechanical Engineering
### Master of Technology in Production Engineering
Department of Mechanical Engineering

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**Program Core**

- MCD881 Major Project Part-I: 0 0 12 6
- MCL705 Experimental Methods: 3 0 2 4
- MCL769 Metal Forming Analysis: 3 0 2 4
- MCL781 Machining Processes and Analysis: 3 0 2 4
- MCL784 Computer Aided Manufacturing: 3 0 2 4
- MCL786 Metrology: 2 0 2 3
- MCL787 Welding Science and Technology: 3 0 2 4

**Total Credits**: 31

**Program Electives**

- MCD882 Major Project Part-II: 0 0 24 12
- MCL729 Nanomechanics: 3 0 0 3
- MCL749 Mechatronics Product Design: 3 0 2 4
- MCL750 Product Design and Manufacturing: 1 0 4 3
- MCL788 Surface Engineering: 3 0 2 4
- MCL791 Processing and Mechanics of Composite Materials: 3 0 2 4
- MCL792 Injection Molding and Mold Design: 2 0 2 3
- MCL796 Additive Manufacturing: 3 0 2 4
- MCP790 Process Engineering: 2 0 4 4

**Total Credits**: 31

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Professional Project Activity In Summer Vacation

- MCD881 Major Project Part-I (Core) (0-0-12) 6: 2 6 0 12 18 12
- MCD882 Major Project Part-II (PE) (0-0-24) 12: 0 0 0 24 24 12

**Total = 49**
### Master of Technology in Thermal Engineering

**Department of Mechanical Engineering**

**The overall credits structure**

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**Sem.**

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|         | OE-1 (3-0-0) 3 |               |

| IV      | MED812 Major Project Part-II (MET) (0-0-24) 12 | 0 0 0 24 24 12 |
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**Total = 51**
# Master of Technology in Applied Optics

## Department of Physics

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| Total Credits                      | 39 |

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<td>PYL772 Plasmonic sensors</td>
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<td>PYL780 Diffractive and micro optics</td>
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- PYL755 Basic Optics and Optical Instrumentation (3-0-0) 3
- PYL751 Optical Sources, Photometry and Metrology (3-0-0) 3
- PYL753 Optical Systems Design (3-0-0) 3
- PYP761 Optical Fabrication and Metrology Laboratory (0-0-6) 3
- PE-1 (3-0-0) 3

### Sem. II

- PYL752 Laser Systems and Application (3-0-0) 3
- PYL756 Fourier Optics and Holography (3-0-0) 3
- PYP762 Advanced Optics Laboratory (0-0-6) 3
- PE-2 (3-0-0) 3
- PE-3 (3-0-0) 3

### Summer

- OE-1 (3-0-0) 3
- PYD801 Maj. Proj. Part-I (0-0-12) 6

### Sem. IV

- PYD802 Maj. Proj. Part-II (0-0-24) 12

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**Total = 51**
## Programme Structure

### Master of Technology in Textile Engineering

#### Department of Textile Technology

The overall credits structure

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**Total Credits**: 42

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**Total = 54**
# Master of Technology in Textile Chemical Processing

Department of Textile Technology

The overall credits structure

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**Program Core**

- **TXL712** Polymer and Fibre Physics (3-0-0) 3
- **TXL747** Colour Science (3-0-0) 3
- **TXL749** Theory and Practice of Dyeing (3-0-0) 3
- **TXL753** Advanced Textile Printing Technology (2-0-0) 2
- **TXL748** Advances in Finishing of Textiles (3-0-0) 3
- **TXL754** Sustainable Chemical Processing of Textiles (2-0-0) 2
- **TXL783** Design of Experiments and Statistical Techniques 3
- **TXP748** Textile Preparation and Finishing Lab (0-0-2) 1
- **TXP749** Textile Coloration Lab (0-0-2) 1
- **TXP751** Characterization of Chemicals and Finished Textiles Lab (0-0-2) 1
- **TXR752** Professional Practices 0
- **TXT800** Industrial Summer Training Non credit

**Total Credits** 42

**Program Electives**

- **MSL760** Marketing Management 2
- **MSL802** Management of Intellectual Property Rights 3
- **MSL816** Total Quality Management 2
- **TXD805** Major Project Part-I (TCP) (0-0-12) 6
- **TXD806** Major Project Part-II (TCP) (0-0-24) 12
- **TXS751** Research Seminar 0
- **TXR752** Professional Practices (0-0-0) 0
- **TXL711** Polymer and Fibre Chemistry 3
- **TXL713** Technology of Melt Spun Fibres 3

**Total = 54**

---

Sem. Courses (Number, Abbreviated Title, L-T-P, credits) Lecture Contact h/week Credits

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*From TCP PE Basket*
### Program Electives

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**Sem.**

| I      | TXL715 Technology of Soln Spun Fibres (3-0-0) 3 |
|        | TXP716 Fibre Production & Post Spinning Operation Lab (0-0-4) 2 |
|        | TXL748 Advances in Finishing of Textiles (3-0-0) 3 |

**Summer**

| III     | TXD802 Maj. Proj. Part-I (TTF) (0-0-12) 6 |
|         | PE-3 (3-0-0) 3 |
|         | PE-4 (3-0-0) 3 |

| IV      | TXD804 Maj. Proj. Part-II (TTF) (0-0-24) 12 |
|         | 0 0 0 24 24 12 |

**Total Credits = 54**
**Master of Technology in Radio Frequency Design and Technology**
Centre for Applied Research and Electronics

### The overall credits structure

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* For students with M.Tech Dissertation
** For students without M.Tech Dissertation

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**Total Credits:** 24

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<td>ELL714</td>
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<td>ELL718</td>
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<td>ELL719</td>
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<td>ELL720</td>
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<td>ELL725</td>
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<td>ELL731</td>
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<td>ELL734</td>
<td>MOS VLSI design</td>
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**Programme Code:** CRF

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**Total = 51**

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*Note: Minimum eligibility criterion for doing CRD812 (M.Tech. Project 2) in final semester leading to M.Tech. with Dissertation shall be B grade in CRD811. However, additional/higher criteria may be set CFB based on which CRC shall approve/disapprove this option for each student.
# Programme Code: AST

## Master of Technology in Atmospheric-Oceanic Science and Technology
Centre for Atmospheric Sciences

The overall credits structure

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<td>ASL733</td>
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<td>Dynamics of the Atmosphere</td>
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<td>ASL735</td>
<td>Atmospheric Chemistry and Air Pollution</td>
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<td>ASL736</td>
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**Total Credits**: 18

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**Total Credits**: 33

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**Total Credits**: 15

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**Total = 54**
# Master of Technology in Biomedical Engineering

## Centre for Biomedical Engineering

### The overall credits structure

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**Bridge Courses (Core)**

- BMV701 Basic Electronics 1 0 0 1
- BMV702 Basic Mathematics for Biologists 1 0 0 1
- BMV703 Basic Biology & Physiology 1 0 0 0
- BMV705 Mechanics of Biomaterials 1 0 0 1

**Total Credits** 2

1. Students shall take any two core bridge courses based on their background (Engg. / Biology) on suggestion of the program adviser.

**Program Core**

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<td>BML710 Industrial Biomaterial Technology</td>
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<td>BML720 Medical Imaging</td>
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<td>BML736 Application of Mathematics in Biomedical Engineering</td>
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<td>BML760 Biomedical Ethics, Safety and Regulatory Affairs</td>
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<td>BML740 Biomedical Instrumentation</td>
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<td>BMP743 Basic Biomedical Laboratory</td>
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**BMD801** Major Project-1 0 0 0 9

**BMD802** Major Project-2 0 0 0 12

**Total Credits** 39

**Program Electives**

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<td>BML810 Tissue Engineering</td>
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<td>BML741 Medical Device Design</td>
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<td>BML860 Nanomedicine</td>
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<td>BML830 Biosensor Technology</td>
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### Courses

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# PE-1, 2 & 3; OE-1: Minimum 2 to maximum 4 credits can be taken by students towards each program or open elective courses.

1. Total credits for three program electives and one open electives should be a minimum of 12.

Total course credits for students in each semester should not exceed 15 for the first two semesters.

Total = 53
# Master of Technology in Energy Studies

**Interdisciplinary Programme**

The overall credits structure

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**Program Electives**

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**Total Credits = 54**
**Programme Code: JIT**

**Master of Technology in Industrial Tribology and Maintenance Engineering**

*Interdisciplinary Programme*

The overall credits structure

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**Total = 48**

137
### Master of Technology in Instrument Technology

**Programme Code: JID**

**Interdisciplinary Programme**

#### The overall credits structure

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**PYL780 Diffraction and micro optics** | 3  | 0  | 0   | 3     |
**PYL790 Integrated Optics** | 3  | 0  | 0   | 3     |
**PYL792 Optical Electronics** | 3  | 0  | 0   | 3     |
**PYL793 Photonic Devices** | 3  | 0  | 0   | 3     |
**PYP761 Optical fabrication and metrology laboratory** | 0  | 0  | 6   | 3     |
**CRL725 Technology of RF and Microwave** | 3  | 0  | 0   | 3     |
**Solid State Devices** |       |       |       |       |

*For students with non-electrical Engineering background.

**Contact h/week**

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| IV    | DSD802 (0-0-24) 12 | 0 0 0 24 | 24 12 |

*For students with Electrical Engineering background.

**Total = 54**
### Programme Code: JOP

#### Master of Technology in Optoelectronics and Optical Communication

**Interdisciplinary Programme**

#### The overall credits structure

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<td>3-0-3</td>
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<td>PYL771</td>
<td>Green Photonics</td>
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<td>PYL790</td>
<td>Integrated Optics</td>
<td>3-0-3</td>
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<td>PYL793</td>
<td>Photonic Devices</td>
<td>3-0-3</td>
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<tr>
<td>PYL795</td>
<td>Optics and Lasers</td>
<td>3-0-3</td>
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<tr>
<td>PYL891</td>
<td>Fiber Optic Components and Devices</td>
<td>3-0-3</td>
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<tr>
<td>PYL892</td>
<td>Guided Wave Photonic Sensors</td>
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#### Sem. Courses

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<td>ELL727 Digital Comm. &amp; Information Systems (3-0-0) 3</td>
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**Total = 51**
# Master of Technology in Polymer Science and Technology
## Interdisciplinary Programme

### The overall credits structure

<table>
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### Program Core

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<td>Polymer Chemistry</td>
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<td>PTL702</td>
<td>Polymer Processing</td>
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<td>PTL703</td>
<td>Polymer Physics</td>
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<td>PTL704</td>
<td>Polymer Technology</td>
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<td>PTL705</td>
<td>Polymer Characterization</td>
<td>3-0-0</td>
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<tr>
<td>PTL707</td>
<td>Polymer Engineering and Rheology</td>
<td>3-0-0</td>
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<td>PTP709</td>
<td>Polymer Science Laboratory</td>
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<td>PTP710</td>
<td>Polymer Engineering Lab</td>
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<td>PTL713</td>
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**Total Credits**: 42

### Program Electives

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<td>PTL712</td>
<td>Polymer Blends and Composites</td>
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<td>PTL716</td>
<td>Rubber Technology</td>
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<td>PTL718</td>
<td>Polymer Reaction Engineering</td>
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<td>PTL720</td>
<td>Polymer Product and Mould Design</td>
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<td>PTL722</td>
<td>Polymer Degradation and Stabilization</td>
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<td>PTL724</td>
<td>Polymeric Coatings</td>
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<td>PTL726</td>
<td>Polymeric Nanomaterials and Nanocomposites</td>
<td>3-0-0</td>
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<td>PTL714</td>
<td>Biodegradable Polymeric Materials</td>
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<td>Independent Study</td>
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<td>PTV700</td>
<td>Special Lectures in Polymers</td>
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**Total = 54**
Programme Code: JTM

Master of Technology in Telecommunication Technology & Management
Interdisciplinary Programme

The overall credits structure

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Program Core

- ELL711 Signal Theory
  - Credits: 3
- ELL712 Digital Communications
  - Credits: 3
- ELL785 Computer Communication Networks
  - Credits: 3
- ELL818 Telecommunication Technologies
  - Credits: 3
- ELP718 Telecommunication Software Laboratory
  - Credits: 0, 1
- ELP720 Telecommunication Networks Laboratory
  - Credits: 0, 1
- ELP725 Wireless Communication Laboratory
  - Credits: 0, 1
- JTD601 Minor Project
  - Credits: 0
- MSL723 Telecommunications Systems Management
  - Credits: 3

Total Credits: 33

Program Electives

- ELL233 Broadband Communication Systems
  - Credits: 3

Streamed Electives (JTM) in (Signal and Information Processing)

- ELL715 Digital Image Processing
  - Credits: 3, 0, 2
- ELL718 Statistical Signal Processing
  - Credits: 3
- ELL720 Advanced Digital Signal Processing
  - Credits: 3
- ELL784 Introduction to Machine Learning
  - Credits: 3
- ELL786 Multimedia Systems
  - Credits: 3
- ELL92 Computer Graphics
  - Credits: 3
- ELL93 Computer Vision
  - Credits: 3
- CR707 Human & Machine Speech Communication
  - Credits: 3

Streamed Electives (JTM) in (Communication Systems)

- ELL710 Coding Theory
  - Credits: 3
- ELL714 Basic Information Theory
  - Credits: 3
- ELL717 Optical Communication Systems
  - Credits: 3
- ELL718 Statistical Signal Processing
  - Credits: 3
- ELL719 Detection and Estimation Theory
  - Credits: 3
- ELL720 Advanced Digital Signal Processing
  - Credits: 3
- ELL813 Advanced Information Theory
  - Credits: 3
- ELL814 Wireless Optical Communications
  - Credits: 3
- ELL815 MIMO Wireless Communications
  - Credits: 3
- ELL816 Satellite Communication
  - Credits: 3

Streamed Electives (JTM) in (Telecom Management)

- MSL700 Fundamentals of Management of Technology
  - Credits: 3
- MSL701 Strategic Technology Management
  - Credits: 2
- MSL707 Management Accounting
  - Credits: 3
- MSL713 Information Systems Management
  - Credits: 2
- MSL726 Telecom Systems Analysis, Planning and Design
  - Credits: 3
- MSL728 International Telecommunication Management
  - Credits: 3
- MSL760 Marketing Management
  - Credits: 2
- MSL815 Decision Support and Expert Systems
  - Credits: 2
- MSL850 Management of Information Technology
  - Credits: 3

Streamed Electives (JTM) in (Telecom Analytics)

- COL765 Database Implementation
  - Credits: 3
- ELL784 Introduction to Machine Learning
  - Credits: 3
- ELL791 Neural Systems and Learning Machines
  - Credits: 3
- ELL795 Swarm Intelligence
  - Credits: 3
- ELL798 Agent Technologies
  - Credits: 3
- ELL882 Large-Scale Machine Learning
  - Credits: 3
- ELL884 Information Retrieval
  - Credits: 3
- ELL886 Big Data Systems
  - Credits: 3
- ELL887 Cloud Computing
  - Credits: 3
- ELL888 Advanced Machine Learning
  - Credits: 3
- ELL892 Internet Technologies
  - Credits: 3

Streamed Electives (JTM) in (Embedded Systems and Network Appliance Engineering)

- COL719 Synthesis of Digital Systems
  - Credits: 3
- COL740 Software Engineering
  - Credits: 3
- ELL766 Appliance Systems
  - Credits: 3
- ELL787 Embedded Systems and Applications
  - Credits: 3
- ELL790 Digital Hardware Design
  - Credits: 3
- ELL857 Cloud Computing
  - Credits: 3
- ELL898 Pervasive Computing
  - Credits: 3
- ELL899 Testing and Fault Tolerance
  - Credits: 3
- ELP721 Embedded Telecommunication Systems Laboratory
  - Credits: 0
- ELP781 Digital Systems Lab
  - Credits: 0

Streamed Electives (JTM) in (Computer and Communication Networks)

- COL724 Advanced Computer Networks
  - Credits: 3
- ELL716 Telecommunication Switching and Transmission
  - Credits: 3
- ELL725 Wireless Communications
  - Credits: 3
- ELL816 Satellite Communication
  - Credits: 3
- ELL817 Access Networks
  - Credits: 3
- ELL820 Photonic Switching and Networking
  - Credits: 3
- ELL887 Cloud Computing
  - Credits: 3
- ELL889 Protocol Engineering
  - Credits: 3
- ELL892 Internet Technologies
  - Credits: 3
- ELL894 Network Performance Modeling and Analysis
  - Credits: 3
- ELL895 Network Security
  - Credits: 3
- ELL896 Mobile Computing
  - Credits: 3
- ELL897 Network Management
  - Credits: 3
- ELL898 Pervasive Computing
  - Credits: 3
- ELP782 Computer Networks Lab
  - Credits: 0
- ELP821 Advanced Telecommunication Networks Laboratory
  - Credits: 0
- ELP822 Network Software Laboratory
  - Credits: 0

Sem. | Courses | Credits | Contact h/week | Total |
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<td>ELL785</td>
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<td>JTD601</td>
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Summer

- JTD601 Major Project Part-I (JTM)
  - Credits: 0
- PE-2  | 3         | 2         | 12     |
- PE-3  | 3         | 6         | 12     |

IV (Course based) OR
- PE-3  | 3         | 6         | 12     |

IV (Project based)
- JTD602 Major Project Part-II (JTM)
  - Credits: 0
- PE-5  | 3         | 4         | 12     |

Total = 54

141
## Programme Code: JVL

### Master of Technology in VLSI Design Tools and Technology

**Interdisciplinary Programme**

The overall credits structure

<table>
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<th>PC</th>
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**Program Core**

- ELL734 MOS VLSI design \(3-0-0\) 3
- ELP736 Physical Design Laboratory \(0-0-6\) 3
- JVD811 Major Project-I \(0-0-24\) 12

**Total Credits** 18

**Program Electives**

- COL702 Advanced Data Structures \(3-0-2\) 4
- COL718 Architecture of High Performance Computers \(3-0-2\) 4
- ELL737 Flexible Electronics \(3-0-0\) 3
- ELL742 Introduction to MEMS Design \(3-0-0\) 3
- ELL743 Photovoltaics \(3-0-0\) 3
- ELL745 Quantum Electronics \(3-0-0\) 3
- ELL746 Biomedical Electronics \(3-0-0\) 3
- ELL747 Active and Passive Filter Design \(3-0-0\) 3
- ELL830 Issues in Deep Submicron VLSI Design \(3-0-0\) 3
- ELL831 CAD for VLSI, MEMS, and Nanoassembly \(3-0-0\) 3
- ELL832 Selected Topics in IEC-I \(3-0-0\) 3
- ELL833 CMOS RF IC Design \(3-0-0\) 3
- ELL883 Embedded Intelligence \(3-0-0\) 3
- ELP831 IEC Laboratory-I \(0-0-6\) 3
- ELV830 Special Module in Low Power IC Design \(1-0-0\) 1
- ELV831 Special Module in VLSI Testing \(1-0-0\) 1
- JVD799 Minor Project \(0-0-126\) 12
- JVD812 Major Project-II \(0-0-24\) 12
- JVS801 Independent Study \(0-3-0\) 3
- MTL704 Numerical Optimization \(3-0-0\) 3

**Total = 48**

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<th>Lecture courses</th>
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<td>ELL734 MOS VLSI Design (3-0-0) 3</td>
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**Total = 48**
10. COURSE DESCRIPTIONS

The details about every course are given in this section. Information about each course includes course number, credits, L-T-P structure, Pre-requisites, overlapped courses and course contents.
For some 700 and 800 level courses, the Pre-requisites have been explicitly indicated. Where these are not mentioned, the default Pre-requisites shall be applicable for UG students (see sections 2.6 and 3.11).
For additional information see the website or contact the concerned course coordinator or head of the department/centre/school or the programme coordinator.
APL100 Engineering Mechanics
4 Credits (3-1-0)
Kinematics, Statics, Equations of Motion, Rigid body dynamics, Introduction to variational mechanics.

APL102 Introduction to Materials Science and Engineering
4 Credits (3-0-2)
Structure of Solids: atomic and inter-atomic bonding, crystal structure and imperfection in solids.
Properties of Materials: Mechanical, chemical, electrical and magnetic properties of metals, ceramics and polymers.
Processing of Materials: Thermodynamics basics, Phase diagrams and phase transformation of metallic systems, fabrication and processing of metals, polymers and ceramics.
Performance of Materials: Creep, fatigue, failure and corrosion of metals, ceramics (including cement and concrete), polymers, and composites (including fiber reinforced structure, sandwich panels, and wood).
Selection of Materials: selection of materials for various applications, materials selection charts, CSE software, Example case studies such as materials for large astronomical telescopes, springs, flywheels, safe pressure vessels and reactors.
Laboratory: The behavior of different types of materials (e.g. metals, ceramics, composites, polymers) will be studied through carefully designed experiments. The fundamentals of structure and properties of various materials will be communicated through hands on experiments and model demonstration.

APL103 Experimental Methods
4 Credits (3-0-2)
Experimental Analysis: Types of measurements and errors, Relative frequency distribution, Histogram, True value, Precision of measurement, Method of least squares, the curve fitting, General linear regression, Theory of errors, Binomial and Gaussian distribution, Chi-square test.
Dynamics of Measurements: Dynamic Response of a Measuring Instrument, Response to Transient and Periodic Signals, First and Second order systems as well as their Dynamic Response Characteristics.
Laboratory: The experiments have been designed to understand Experimental Analysis physically. Laboratory will enable the students to apply various statistical methodologies (viz. Mean, Median, Mode, Std. Dev. etc) to get the optimum output from the day to day Engineering life experiment.

APL104 Solid Mechanics
4 Credits (3-1-0)
Pre-requisites: APL100
Overlaps with: APL105, APL108

APL105 Mechanics of Solids and Fluids
4 Credits (3-1-0)
Pre-requisites: APL100
Overlaps with: APL104, APL106, APL107, APL108

APL106 Fluid Mechanics
4 Credits (3-1-0)
Pre-requisites: APL100
Overlaps with: APL107, APL105
Introduction to Fluids and the concept of viscosity, Flow visualization, Fluid Statics, Physical laws for a control volume including continuity, momentum and energy equations, Bernoulli equation, Differential equations of fluid motion, Navier Stokes equations, vorticity and potential flows, dimensional analysis and similitude, Boundary layer theory, 1-D compressible flow.

APL107 Mechanics of Fluids
5 Credits (3-1-2)
Pre-requisites: APL100
Overlaps with: APL106, APL105
Introduction to Fluids and the concept of viscosity, Flow visualization, Fluid Statics, Physical laws for a control volume including continuity, momentum and energy equations, Bernoulli equation, Differential equations of fluid motion, Navier Stokes equations, vorticity and potential flows, dimensional analysis and similitude, Boundary layer theory, viscous flow in ducts and applications to turbomachinery. Laboratory experiments will demonstrate the concepts learnt in the theory and appreciation of their limitations.

APL108 Mechanics of Solids
5 Credits (3-1-2)
Pre-requisites: APL100
Overlaps with: APL104, APL105

APL190 Design Engineering
4 Credits (3-0-2)
Modern Design Cycle, Craftsman versus Designer, Need Analysis and Broad Engineering Specifications, Concept Design, Feasibility
study and Evaluation of alternatives, Engineering Economics, Modelling Techniques-Mathematical, Graphical, iconic, solid, Analysis and Simulation (FEM, Monte Carlo, CFD, Dimensional analysis, Experimental Techniques), Material Selection (strength, stiffness, fatigue life consideration), Manufacturing Processes and Design for Manufacture, Reliability/Availability/Maintainability, Sustainability, and Environment, Safety, Ergonomics and Human Factors, Detailed Drawings/Assembly Drawings/ Assembly Instructions /Maintenance Manuals, Case Studies.

**APL300 Computational Mechanics**
4 Credits (3-0-2)
Pre-requisites: APL104/APL105/APL108/CHL231

Concept of continuum; introduction to stress, strain and rate of strain tensors; Principal stress and strains; Equation of equilibrium/ motion in solid and fluid mechanics; Lagrangian and eulerian view point; Constitutive equations in the context of both solids and fluids; System of simultaneous linear and non-linear equations: how they arise in mechanics; Determination of substitute curves; interpolation techniques; Application of numerical integration and differentiation to axial vibration of bars and beams; solution techniques for boundary value problems arising in bending of beams, one dimensional fluid flows and boundary layer equations; stability analysis – computation of eigenvalues; Direct and indirect methods of solution of linear equations; Emphasis will be on using the finite difference method (FDM) to solve problems in solid and fluid mechanics.

**APD310 Mini Project**
3 Credits (0-0-6)
Pre-requisites: EC 50

**APL310 Constitutive Modeling**
4 Credits (3-0-2)
Pre-requisites: APL104/APL105/APL108 EC 50

Mathematical Preliminaries (scalar, vector, tensor operation) Thermodynamics (thermodynamical framework for constitutive modeling), Kinematics of Deformation & Motion, Stress-strain principles, Elasticity, Anisotropy, viscoelasticity, multi-physical coupling effect, plasticity, viscoplasticity. Experimental: Experimental characterization, data analysis, Model fitting.

**APD311 Project**
4 Credits (0-0-8)
Pre-requisites: EC 50, 12 credits of Minor Area in Computational Mechanics

**APL340 Chaos**
4 Credits (3-1-0)
Pre-requisites: APL100 and EC 50

Introduction to linear systems and its classification, Fixed point and stability, linear stability analysis, Linearization of nonlinear systems, Types of bifurcation and examples, imperfect bifurcations and catastrophes, Coupled oscillators and quasiperiodicity, Poincare Maps, Introduction to Chaos, Lorenz equation, one-dimensional map, fractals.

**APL360 Engineering Fluid Flow**
4 Credits (3-0-2)
Pre-requisites: APL100 and EC 50

Introduction to Cartesian tensors. The Navier Stokes Equations: Derivation via continuum mechanics; Boundary conditions; surface tension; Exact Solutions; Steady and unsteady problems; Similarity solutions. Laminar Boundary-Layers: Order of magnitude analysis; Blasius solution; Von Kármán Momentum Integral; Free-shear flows. Low Reynolds Number flows: Stokes Flow; Oseen’s Correction. Lubrication Approximation. Hydrodynamic Stability Theory: Capillary Instability; Orr-Sommerfeld Equation; Rayleigh Equation. Inflection Point Criterion. Rotating flows. Introduction to Turbulent Flows: Reynolds decomposition; Closure problem. Scaling arguments; energy cascade and vorticity dynamics.

**APL380 Biomechanics**
4 Credits (3-0-2)
Pre-requisites: APL100 and EC 50

Basics of rigid body mechanics, solid mechanics, and fluid mechanics applied in biological system; Basic introduction to anatomy and physiology; Mechanics of Human Motion; Mechanics of response of tissues including bones; Mechanics of Blood flow, Biosolid-fluid interaction. Computer Lab contents: Matlab Programming basics, Image processing basics, Design of Joint: Rigid Body Mechanics based approach, Matlab programming for bone or Aortic Tissue; Matlab programming for blood flow analysis.

**APL440 Parallel Processing in Computational**
4 Credits (3-0-2)
Pre-requisites: APL310

Introduction to multi-processor, multi-core, multi-threaded processing and their clusters, GPUs and CUDA programming, Introduction to parallel processing hardware and software, Open MP, MPI, MPICH, HPC/Clustering tools and software suits. Exploring parallelism in solid/fluid mechanics problems and formulation of numerical methods, Partitioning and divide-and-conquer strategies, Parallel algorithms for solving dynamical and non-linear systems, Finite difference and Finite element analysis of plate and shells, Finite elements in fluids, Reduced integration patch test, Dynamic FE analysis, Geometrically nonlinear problems, Material nonlinearity, Automated mesh generation, Pre and post processing, Solid fluid interaction problems, Efficient solution technique-PDG, Domain decomposition, Point source method, Boundary element method, Aero elastic flutter, Other special topics.

**APL700 Experimental Methods for Solids and Fluids**
3 Credits (2-0-2)

Types of Measurement and errors, Internal and external estimates of errors, Relative frequency distribution, Histogram, True Value, Precision of measurement, Best estimate of true value and standard deviation, Combination of measurements, accuracy of the mean, significant digits. Methods of least squares and its application to the calculation of best estimate of the true value, the curve fitting, general linear regression, comparison and combination of measurements. Extensions of least square method, Principle of maximum likelihood, and goodness of fit, chi-square test, Dynamic response of a measuring instrument, Response to transient and periodic signals, first and second order systems as well as their dynamics response characteristics.

**AML701 Engineering Mathematics & Mechanics**
3 Credits (3-0-0)


**APL701 Continuum Mechanics**
3 Credits (3-0-0)

Concept of continuum, kinematics of deformation, concept of stress and strain tensor – their transformation and decomposition, finite strain tensor and its linearization with examples, rate of deformation tensor – velocity gradient and spin tensor, derivation of conservation laws – mass continuity, linear and angular momentum conservation, derivation of linear equations of elasticity and Navier Stokes equations in both cartesian and polar co-ordinates, principle of minimum potential energy, virtual work theorem, uniqueness and reciprocal theorem, constitutive laws for linearly elastic solids and newtonian viscous fluids, incompressible case, applications in solid and fluid mechanics problems.

**AML702 Applied Computational Methods**
4 Credits (3-0-2)


**APL703 Engineering Mathematics and Computation**
4 Credits (3-0-2)
Tensors, Vector Calculus; Linear Algebra – Solution of Linear Systems, Eigenvalue Problems; Variational calculus; Fourier Series and transform, Analytical and Numerical Solution methods of ODEs, Partial Differential Equations – properties and solution techniques, Probability and Statistics.

**APL705 Finite Element Method**
4 Credits (3-0-2)
Pre-requisites: EC 75

**AML706 Finite Element Methods and its Applications to Marine Structures**
3 Credits (3-0-0)

**APL710 Computer Aided Design**
4 Credits (3-0-2)
Pre-requisites: EC 75

**APL711 Advanced Fluid Mechanics**
3 Credits (3-0-0)

**AML713 Applied Fluid Mechanics**
4 Credits (3-1-0)
Basic equations of fluid motion, Dynamics of ideal fluid motion, Generalised Bernoulli equation and special cases, Governing equations for viscous fluid flows, creeping fluid flows, Boundary layer approximation, Transition to turbulence, Fundamentals of turbulent flow, turbulent boundary layer over a flat plate.

**APL713 Turbulence and its Modeling**
3 Credits (3-0-0)

**APL715 Physics of Turbulent Flows**
3 Credits (3-0-0)

**APL716 Fluid Transportation Systems**
3 Credits (3-0-0)
Mechanism of transportation of materials by fluid flow, rheology and classification of complex mixtures, fundamentals of two-phase flow, Phase separation and settling behavior, Slurry Pipeline Transportation, Design methods, terminal facilities, pipe protection, pneumatic conveying, pneumocapsule and hydrocapsule pipelines, metrology associated with pipelines.

**APL720 Computational Fluid Dynamics**
4 Credits (3-0-2)
Pre-requisites: EC 75
Review of governing equations for fluid flow, finite volume method and its application to steady 1-D, 2-D and 3-D convection-diffusion problems, extension of FVM to unsteady 1-D, 2-D and 3-D convection diffusion problems, pressure-velocity coupling, staggered and colocated grids, solution of discretized equations, physical description of turbulence, Reynolds-Averaged Navier-Stokes equations, closure problem; RANS based turbulence models; DNS and LES.

**AML732 Ship Resistance & Propulsion**
3 Credits (3-0-0)

**AML733 Dynamics**
3 Credits (3-0-0)

**APL734 Advanced Dynamics**
3 Credits (3-0-0)
Single Degrees of Freedom systems, Multi-degree of freedom systems, Response spectrum, Time integration schemes, Lagrange’s equations, Principle of virtual work, continuous system.

**APL736 Multiscale Modeling of Crystalline Materials**
4 Credits (3-0-2)
Pre-requisites: EC 75
Review of continuum mechanics, material symmetry, thermodynamics and constitutive relations, symmetry in crystals, empirical and semi-empirical models of inter-atomic potential, molecular statics and dynamics, finite temperature effects in molecular systems, probabilistic behavior of material characteristics at macro scale, multiscale methods - Cauchy-Born rule and Quasi-continuum method, Mechanics of helical nanostructures (e.g., carbon nanotubes, DNA, polymers), Bending and twisting of nanotubes and nanorods. Computer Lab contents: Programming molecular statics and molecular dynamics, molecular statics via conjugate gradient minimization and Newton-Raphson method, Monte Carlo simulation. Implementation of Cauchy-Born rule and Quasi-continuum method, Exposure to LAMMPS and AMBER.

**APL740 Mechanics of Biological Cells**
4 Credits (3-0-2)
Pre-requisites: EC 75
Theoretical Part: Basic Introduction to mechano-biology, Concept of Length Scale, Mechanical Forces, Mass, Stiffness and Damping of Proteins, Thermal Forces and Diffusion, Chemical Forces, Polymer Mechanics. Intracellular Mechanics: Structures of Cytoskeleton Filaments, Dynamics
of Cell Filaments, Molecular motors, Introduction to Entropic Elasticity and Persistence Length, Force Generation by Cytoskeleton Filaments.

Extracellular Mechanics: The Extracellular matrix (ECM), cell-ECM Interactions, Cell Migration, Forces and Adhesion.


Experimental Part: Different Experimental Methods for Probing Cell Mechanical Properties. Intro to indentation, aspiration, tweezer, Nanopatterened platform based techniques etc.

APL750 Modern Engineering Materials
3 Credits (3-0-0)
Pre-requisites: EC 75

Elastic moduli, coefficient of thermal expansion: how properties are related with the bonding between the atoms, packing of atoms in solids, crystal structure, Plastic deformation of materials: yield strength, tensile strength, ductility and toughness of materials, perfect crystal, role of dislocations, strengthening methods, continuum aspects of plastic flow, Fatigue, fracture and creep of materials, ductile and brittle failure, micromechanism of failure, fatigue failure, Creep deformation and failure, mechanism of creep, Oxidation and corrosion of materials, carbon steels, alloy steels, TRIP steel, Dual phase steel, Bainitic steel, Martensitic steel, aluminum alloys, titanium alloys, carbon nanotubes, structure and properties of novel engineering materials: Composite materials, hybrid materials, metal foams, nanocrystalline materials, smart materials, case studies of materials applications in automotive, aerospace, power generation sectors etc.

AML751 Materials for Marine Vehicles
3 Credits (3-0-0)


APL753 Properties and Selection of Engineering Materials
3 Credits (3-0-0)
Pre-requisites: EC 75

Historical evolution of engineering materials, evolution of materials in products, Engineering materials and their properties: families of engineering materials, materials information for design, materials properties, Materials property chart: exploring materials properties, materials property charts e.g. the modulus-density chart, the strength-density chart, the fracture toughness-modulus chart, thermal conductivity-electrical resistivity chart, Materials selection-the basics: the selection strategy, materials indices, the selection procedure, Multiple constraints and conflicting objectives: selection with multiple constraints, conflicting objectives. Selection of materials and shape: shape factors, limits to shape efficiency, exploring the materials shape combinations, materials indices that include shape, architectured materials, Processes and process selection: classification of processes: shaping, joining and finishing, processing for properties, process selection, ranking process cost, Designing hybrid materials: holes in materials property space, composites, sandwich structures, cellular structures, segmented structures, case studies.

APL756 Microstructural Characterization of Materials
4 Credits (3-0-2)
Pre-requisites: EC 75

The concept of microstructure, diffraction analysis of crystal structure: X-ray and electron diffraction, optical microscopy, transmission electron microscopy, scanning electron microscopy, micro-analysis in electron microscopy, scanning probe microscopy and related techniques, chemical analysis of surface composition, quantitative and tomographic analysis of microstructures.

APL759 Phase Transformations
3 Credits (3-0-0)
Pre-requisites: EC 75


APL763 Micro & Nanoscale Mechanical Behaviour of Materials
4 Credits (3-0-2)
Pre-requisites: EC 75

Elastic anisotropy of crystalline materials, defects in crystals: point defects and interfaces, dislocations and analysis of plasticity, geometric and energetic aspects of dislocations, microscale mechanisms of plastic deformation such as slip and twinning, single and polycrystal deformation, crystallographic textures, theory of work hardening in crystals, strengthening mechanisms in crystals, nanoscale testing of materials: in-situ SEM/TEM, nanindentation, nano-wear, correlation of nanoscale measured response to macroscale response of materials.

APL764 Biomaterials
3 Credits (3-0-0)
Pre-requisites: EC 75

Introduction and history of biomaterials; Basic classes of engineering materials and structure property correlation; Structure and property of cells and tissues; Property requirement of biomaterials including biocompatibility, and biodegradability; Basic types of biomaterials; Mechanical testing of biomaterials; application of biomaterials (orthopedic, cardiovascular, dental) including detailed case study; Materials for biomedical devices and packaging (electronic interfacing etc.)

APL765 Fracture Mechanics
3 Credits (3-0-0)
Pre-requisites: EC 75


APL767 Engineering Failure Analysis and Prevention
3 Credits (3-0-0)
Pre-requisites: EC 75

Common causes of failure, principles of failure analysis, fracture mechanics approach to failure problems, techniques of failure analysis, service failure mechanisms, ductile and brittle fracture, fatigue failure, wear failure, hydrogen induced failure, environment induced failures, high temperature failure, faulty heat treatment and design failures, processing failure (forging, casting, machining etc.), failure problems in joints and weldments, case studies for failure analysis of structural components and mechanical system.

APL771 Design Optimization and Decision Theory
3 Credits (3-0-0)

Introduction, classification of optimization problems, single variable and multi variable unconstrained optimization problems, constrained optimization, integer programming, genetic algorithms and simulated annealing, review of probability theory, decision theory.

APL774 Modeling & Analysis of Mechanical Systems
3 Credits (3-0-0)

Introduction, constitutive modeling of elastic orthotropic, elasto-plastic isotropic, and viscoelastic isotropic solids. Plane stress problems in polar
coordinate system, bending of rectangular plates–Navier and Levy’s solution, bending of circular plates, membrane theory of shells, bending of cylindrical shells, vibration and buckling of rectangular plates. Flow measurement, velocity measurement, multi-hole probes and optical measurements. External flows, boundary layers (laminar and turbulent); estimation of lift and drag, internal flows, application to pipe lines.

**APL775 Design Methods**

3 Credits (3-0-0)

Introduction, design cycle, need analysis, product specifications, quality function deployment (QFD), concept generation, concept selection, TRIZ, concept testing, preliminary design, architecture design. Modeling, sensitivity, compatibility, stability analyses. Design for manufacturing, material, maintenance and safety. Industrial design, detailed design, prototype/model testing. Axiomatic design. Detailed Drawings/Assembly Drawings/ Assembly Instructions /Maintenance Manuals, Case Studies.

**APL776 Product Design and Feasibility Study (Stream Core)**

4 Credits (2-0-4)


**AML792 Structural Design of Ships**

3 Credits (3-0-0)

Introduction, Ship as beam, long term loading of ship structure, periodic wave loading, longitudinal response & dynamic behaviour, Criteria of failure, Analysis of plates and grillages, Buckling of plates and panels, Recent advances in load definition, transverse strength, torsional strength, bulkhead design, design of special structures, structural design of unconventional crafts like hydrofoils, hovercrafts, SES, SWATH, Catamarans, trimarans etc., design of submarine structures, pressure hull, design of cylindrical shells, cones, bulkheads etc., Applications of computers to ship structures and structural optimization.

**AML793 Ship Dynamics**

3 Credits (3-0-0)


**AML794 Warship Design**

3 Credits (3-0-0)


**AML795 Submarine Design**

3 Credits (3-0-0)


**APL796 Advanced Solid Mechanics**

3 Credits (3-0-0)

Large deformation kinematics, lagrangian stress and strain tensors, balance laws in lagrangian framework, nonlinear constitutive modeling, nonlinear theory of beams and buckling, wave propagation, theory of plasticity, solution of elasticity problems – contact modeling, multiscale modeling etc.
Department of Biochemical Engineering and Biotechnology

BBL110 Molecular Biotechnology
3 Credits (3-0-0)
Overlaps with: BBL131, BBL132
The topics include introduction to cell, membrane structure and transport, enzyme technology, gene technology, Protein engineering and design, glycolysis and gluconeogenesis, citric acid cycle, ATP production, cell cycle, cell signalling, recombinant DNA technology including PCR, electrophoresis, cloning, and application of biological principles in Environmental Biotechnology.

BBL131 Principles of Biochemistry
4.5 Credits (3-0-3)
Introduction - aims and Scope; Non-covalent interactions in biological systems, Carbohydrates-structure and function; Proteins-structure and function; Nucleic acids-structure and function Protein purification techniques; Introduction to enzymes; Vitamins and coenzymes; Lipids and biological membranes; Transport across cell membrane; Design of metabolism; Metabolic pathways for breakdown of carbohydrates-glycolysis, pentose phosphate pathway, citric acid cycle, electron transport chain, Photo-phosphorylation; Oxidation of fatty acids; Gluconeogenesis and control of glycogen metabolism, Signal transduction.
Laboratory: Estimation of proteins and nucleic acids; Extraction of lipids; Separation of lipids using thin layer chromatography, filtration and ion exchange chromatography; Gel electrophoresis, Determination of enzymatic activities and determination of Km, Vmax. Identification of intermediates of EMP pathway.

BBL132 General Microbiology
4.5 Credits (3-0-3)
The topics include introduction to prokaryotic and eukaryotic cell structure; different groups of microorganisms; microbial nutrition and growth; metabolism including important pathways; reproduction and recombination; preservation and control of microbial cultures; viruses; microbial pathogenicity.
Laboratory: Preparation and sterilisation of culture media, isolation of bacteria, Staining, Biochemical tests for identification of microorganisms, Antibiotic sensitivity, Bacterial growth curve, effect of environmental factors on bacterial growth, microbial diversity in environmental samples.

BBL133 Mass and Energy Balances in Biochemical Engineering
3 Credits (3-0-0)
Overlaps with: CLL231, CHL251

BBL231 Molecular Biology and Genetics
4.5 Credits (3-0-3)
Pre-requisites: BBL131, BBL132
Laboratory: Isolation of genomic and plasmid DNA, Agarose Gel Electrophoresis of DNA, Restriction digestion of DNA, RNA isolation, Primer design, PCR, RT-PCR, Competent cell preparation and Transformation, Gene Induction.

BBL331 Bioprocess Engineering
3 Credits (3-0-0)
Pre-requisites: BBL132, BBL133
Microbial growth, substrate utilisation, and product formation kinetics; simple structured models; batch, fed-batch, repeated fed-batch, CSTR, CSTR with recycle, multistage CSTRs, and PFR; aeration and agitator; rheology of fermentation fluids; mixing and scale-up; air sterilization; media sterilization; design of fermentation media; aseptic transfer.

BBP332 Bioprocess Engineering Laboratory
1.5 Credits (0-0-3)
Pre-requisites: BBL131, BBL132
Laboratory: Design and execution of simple laboratory scale experiments on the following topics: Estimation of cell mass; different phases of microbial growth; Mass and energy balance in a typical biocconversion process; Concept of limiting nutrient and its effect on cell growth; growth inhibition kinetics; product formation kinetics in a fermentation process; aerobic and anaerobic biocconversion process; power consumption in a fermentation process and its correlation with rheology of the fermentation fluid; different agitator types; mixing time in a bioreactor; quantification of KLa in a fermentation process; Heat balance across a batch sterilization process; Assembly and characterization of pH/DO electrodes.

BBL341 Environmental Biotechnology
3 Credits (3-0-0)
Pre-requisites: CVL100 and EC 80
Principles and concepts of ecosystem; Energy transfer in an ecosystem; Nutrient cycling; Basics of Environmental Microbiology, Environmental health: Ecotoxicology – Heavy metals, pesticides and their effects, Indices of toxicity, Measurement of pollution (techniques and instrumentation), Dose–response relationship. Microbial biosensors in environmental monitoring, Environmental technologies: Microorganisms and renewable sources of energy, Biodegradation and bioremediation (phyo and microbial), Energy and nutrient recovery during waste treatment, Molecular tools in Environmental Biotechnology, Role of biotechnology in environmental protection.

BBL342 Physical and Chemical Properties of Biomolecules
3 Credits (2-1-0)
Pre-requisites: BBL131

BBL343 Carbohydrates and Lipids in Biotechnology
3 Credits (2-1-0)
Pre-requisites: BBL131 and EC 60
Introduction, Molecular structure of polysaccharides, Enzymes degrading polysaccharides, Physical properties of polysaccharides, Production of microbial Polysaccharides, Food usage of exopolysaccharides, Industrial Usage of exopolysaccharides, Medical applications of exopolysaccharides Molecular structure of lipids, Physical properties of lipids, Oleaginous microorganisms and their principal lipids, Production of microbial lipids, Modification of lipids for commercial applications, Extracellular microbial lipids and biosurfactants, Micelles and reverse micelles in biology, Liposomes in drug delivery.
BBV350 Special Module in Biochemical Engineering and Biotechnology
1 Credit (1-0-0)

BBD351 Mini Project (BB)
3 Credits (0-0-6)
Pre-requisites: EC 60

BBL431 Bioprocess Technology
2 Credits (2-0-0)
Pre-requisites: EC25
Chemical vs biochemical processing; Substrates for bioconversion processes; Process technology for production of primary and secondary metabolites such as ethanol, lactic acid, citric acid, amino acids, biopolymers, industrial enzymes, penicillin, recombinant glutathione and insulin.

BBL432 Fluid Solid Systems
2 Credits (2-0-0)
Pre-requisites: CLL231
Size reduction; crushing and grinding; equipment for size reduction; screening; design procedure; Flow of fluids past a stationary particle for low, medium and high Reynolds numbers; sedimentation and sedimentation theory; thickeners and classifiers; flow through packed beds; flow distribution, packing and pressure drop calculations; fluidization; filtration theory and its application in plate and frame and rotary vacuum filters; solid-liquid separation using centrifugation; Δ concept in centrifugation for scale-up; different types of centrifuges and their design; application for biological suspensions.

BBL433 Enzyme Science and Engineering
4 Credits (3-0-2)
Pre-requisites: BBL431
Introduction and scope; Chemical and functional nature of enzymes; Application of enzymes in process industries and health care; microbial production and purification of industrial enzymes; kinetics of enzyme catalysed reactions; immobilization of enzymes; stabilization of enzymes. Bioreactors for soluble and immobilized enzymes, mass transfer and catalysis in immobilized reactors. Enzyme based biosensors; enzyme catalysed process with cofactor regeneration; Enzyme reactions in micro-aqueous medium and non-conventional medium. Laboratory: Assay of enzyme activity and specific activity; kinetic analysis of an enzyme catalysed reaction; immobilization of enzymes by adsorption and covalent binding; salt precipitation of enzymes by adsorption and covalent binding; salt precipitation of enzymes by adsorption and covalent binding; salt precipitation of enzymes by adsorption and covalent binding; salt precipitation of enzymes by adsorption and covalent binding; salt precipitation of enzymes by adsorption and covalent binding.

BBL434 Bioinformatics
3 Credits (2-0-2)
Pre-requisites: BBL131, BBL132
The topics include introduction to bioinformatics - resources and applications, Biological sequence analysis, sequence alignment, molecular phylogenetic analysis, genome organization and analysis, protein analysis, molecular modeling and drug design.

BBL435 Membrane Applications in Bioprocessing
3 Credits (3-0-0)
Milk/cheese processing, Fruit/sugarcane juice processing, Pharmaceuticals/ Therapeutic drugs processing and membrane coupled separation of biomolecules; Membrane based bioreactor for cell/enzyme recycle; Mammalian/plant cell culture; Case studies.

BBL436 Biophysics
3 Credits (3-0-2)
Pre-requisites: PYL100, BBL131
Spectroscopic methods in biophysics, conformational changes in biological processes, biological energy conservation and transduction, photosynthesis, transport across biomembranes, the biophysics of motility, the biophysics of the nerve impulse, single molecule biophysical studies.

BBL437 Enzyme Catalyzed Organic Synthesis
3 Credits (2-0-2)
Pre-requisites: BBL131 and EC 90
Enzymes as biocatalysts. Various reaction media for enzyme catalyzed reaction [water, water poor media such as organic solvents, ionic liquids] and mixed solvents. Advantages of medium engineering. Fundamentals of non-aqueous enzymology [pH memory, molecular imprinting]. Improving biocatalysis in water and water poor media [chemical modification, immobilization, applications of protein engineering/directed evolution]. Enzyme promiscuity and its applications in organic synthesis. Biocatalytic applications in organic synthesis, hydrolytic reactions, oxidation reduction reactions, formation of C-C bond, addition and elimination reactions, glycosyl transfer reactions, isomerization, halogenation/dehalogenation reactions.
BBD451 Major Project Part 1 (BB1)  
3 Credits (0-0-6)

BBD452 Major Project Part 2 (BB1)  
8 Credits (0-0-16)

BBL731 Bioseparation Engineering  
4.5 Credits (3-0-3)  
Pre-requisites: BBL331, BBL432, BBL433  
Characteristics of bio product, flocculation and conditioning of fermented medium, Revision of mechanical separation (filtration, Centrifugation etc.), cell disruption, Protein precipitation and its separation, Extraction, Adsorption Desorption processes, Chromatographic methods based on size, charge, shape, biological affinity etc., Membrane separations- ultrafiltration and electrodialysis, Electrophoresis, Crystallization, Drying, Case studies. Laboratory: Conventional filtration batch & continuous, Centrifugation in batch and continuous centrifuge, Cell disruption, Protein precipitation and its recovery, Thin Layer Chromatography (TLC), Membrane based filtration- ultrafiltration in cross. Flow modules and microfiltration, electrodialysis, Adsorption, Adsorption Column Studies and Freeze Drying Studies.

BBL732 Bioprocess Plant Design  
4 Credits (3-0-2)  
Pre-requisites: APL100 CLL251 CLL252 BBL331 BBL432  
Introduction; General design information; Mass and energy balance; Flow sheeting; Piping and instrumentation; Materials of construction for bioprocess plants; Mechanical design of process equipment; Vessels for biotechnology applications; Design considerations for maintaining sterility of process streams and processing equipment; Selection and specification of equipment for handling fluids and solids; Selection, specification and design of heat and mass transfer equipment used in bioprocess industries; Utilities for biotechnology production plants; Process economics; Bioprocess validation; Safety considerations; Case studies.  
Laboratory: Design of the complete process plant for an identified product or service. Each student to choose a separate product/industry

BBL733 Recombinant DNA Technology  
3.5 Credits (2-0-3)  
Pre-requisites: BBL131, BBL132, BBL231 or Masters’ degree in Bioscience  
Restriction and other modifying enzymes, Cloning vectors (plasmid, (-based, phagemids, high capacity) and expression vectors, Expression in bacterial, yeast and mammalian systems, Construction of genomic and CDNA libraries, DNA Sequencing, Polymerase chain reaction, Invitro mutagenesis, Genome mapping, Stability of recombinant cells in production of biochemicals.

BBL734 Metabolic Regulation and Engineering  
3 Credits (3-0-0)  
Pre-requisites: BBL331, BBL431  
Regulatory mechanisms for control of enzyme synthesis - an overview; Control of enzyme activity- proteolysis, covalent modification and ligand binding; Metabolic control theory and metabolic flux analysis; Metabolic regulation of a few major metabolic pathways especially those relevant to bioprocess industries; Pathway engineering; Application of gene cloning in re-directing cellular metabolism for over-production of a few industrial products; Strategies to overcome regulatory mechanisms for over-production of several industrially important primary and secondary metabolites such as alcohols, organic acids, amino acids, enzymes and therapeutic compounds.

BBL735 Genomics and Proteomics  
3 Credits (2-0-2)  
Pre-requisites: BBL231, BBL733  
Introduction to -omes and -omics; GENOMICS - Genome sequencing and assembly; Next-generation sequencing; Studying gene expression and function; High throughput gene expression and analysis. PROTEOMICS - Sample preparation; Separation methods; Mass Spectroscopy and de novo sequencing; Comparative Proteomics; Protein-protein interactions.

BBL736 Dynamics of Microbial Systems  
3 Credits (3-0-0)  
Pre-requisites: BBL331, BBL432, BBL433  
Stability analysis; analysis of multiple interacting microbial populations; stability of recombinant cells; Structured models of gene expression and growth, Cell cycle and age-dependent (segregated) models, Single-cell (stochastic) models of gene expression.

BBL737 Instrumentation and Analytical Methods in Bioengineering  
3 Credits (2-0-2)  
Pre-requisites: BBL131  
Introduction to methods used in Analytical Bioengineering, Electrophoretic methods, Principles and applications of chromatography (GC, HPLC, FPLC, HPTLC), Spectrophotometry (UV-visible), Fluorescence methods, FTIR, Circular dichroism, Mass spectrometry (GC-MS, LC-MS, ICP-MS), Immunology based analytical methods (ELISA, qPCR, Advanced Microscopy techniques (Electron Microscopy, Confocal Microscopy).

BBL740 Plant cell technology  
3 Credits (2-0-2)  
Pre-requisites: BBL331  
Laboratory: Development of callus and suspension cultures of plant cells; shear sensitivity; growth and product formation kinetics in suspension cultures; development of hairy root cultures & study of growth kinetics; production of secondary metabolites in bioreactors using suspension cultures/hairy roots/ immobilized cells

BBL741 Protein Science and Engineering  
3 Credits (3-0-0)  
Pre-requisites: BBL131 BBL231 or Masters’ degree in Bioscience  
Introduction and aim; Basic structural principles of proteins-amino acids; Motifs of protein structure and their packing: alpha domain, alpha/Beta domain, Antiparallel B structures; Protein folding and assembly – protein folding pathways for single and multiple domain proteins; Recovery of active proteins from inclusion bodies; Structure prediction-structural classes, secondary and tertiary protein structure prediction; Sequence homology searches; Strategies for protein engineering – random, site-directed, case studies; Drug-protein interactions and design, Rational protein design.

BBL742 Biological Waste Treatment  
4 Credits (3-0-2)  
Pre-requisites: BBL132, BBL331 or Bachelor’s degree in Engineering or Masters’ degree in Science  
Qualitative and quantitative characterization of wastes; Waste
Pre-requisites: BBL131 or Masters' degree in Bioscience

Pre-requisites: BBL744 Animal Cell Technology
4 Credits (3-0-0)

BBL745 Combinatorial Biotechnology
3 Credits (3-0-0)

BBL746 Current Topics in Biochemical Engineering and Biotechnology
3 Credits (3-0-0)
Pre-requisites: BBL131, BBL331

BBL747 Bionanotechnology
3 Credits (3-0-0)
Pre-requisites: BBL131 or Masters’ degree in Bioscience

Introduction, Self-assembly of biomolecules in nanotechnology; Bacterial S-Layer, Biomimetic Ferritin, Biodegradable nanoparticles for drug delivery to cells and tissues, Polymer Nanocounters, Ion channels as molecular switches, Patch clamp technique, Protein based nanoelectronics, Bacteriorhodopsin and its technical applications, Carbon Nanotubes: Towards next generation biosensors, Molecular Lego: Design for molecular actuators, Biological Membranes, Magnetosomes: Trapping nano-magnets in biological membranes, Biomolecular Motors, Techniques used in Biotechnology, Nanoanalytics: Fluorescent Quantum Dots for Biological Labelling, Nanoparticle Molecular Labels.

BBL748 Data Analysis for DNA Microarrays
4 Credits (3-0-2)
Pre-requisites: BBL131, BBL231, BBL733

Microarray technology, Basic digital imaging and image processing, Probabilities, common distributions, Bayes’ theorem, Analyzing microarray data with classical hypothesis testing, Analysis of variance, Experimental Design, Analysis and visualization tools: Box plots, Scatter plots, Histograms, Cluster Analysis: one-way, two-way, Graph, Methods for selection of differentially regulated genes, Hypothesis driven experiments using focused microarrays, Biological interpretation, Commercial software available.

BBL749 Cancer Cell Biology
4.5 Credits (3-0-3)
Pre-requisites: BBL131 BBL132 BBL231

This course provides students with a deeper understanding of cancer biology and is heavily focused on experiments: Topics include: Cancer Biology Overview, Types of Cancer, Causes for cancer, Oncogenes and Tumor suppressors, Cell Cycle and Regulation, Cell Differentiation, Cell Death Pathways (Apoptosis, Autophagy), Necrosis, Cell Senescence, Cell Adhesion and Motility, Cancer Epigenetics and sRNAs, Cancer Genome instability, Tumor Immunity, Growth Signaling pathways, Tumor angiogenesis, Cancer Stem Cell, Diagnosis, prognosis and treatment of cancer.

Laboratory: Experiments on Cell cycle, Differentiation, Necrosis and Apoptosis, Senescence, Anchorage Independence, Cell Migration and Invasion, MicroRNAs, Stem cell, Fluorescence Microscopy.

BBL750 Genome Engineering
3 Credits (3-0-2)

Genome engineering methods for bacteria, yeast, plants and mammalian cells, Newer gene delivery methods, Next generation cloning technologies.

BBV750 Bioreaction Engineering
1 Credit (1-0-0)


BBL810 Enzyme and Microbial Technology
3 Credits (3-0-0)

Isolation, development and preservation of industrial microorganisms; Substrates for industrial microbial processes; Regulatory mechanisms of metabolic pathways in industrial strains; Analysis of various microbial processes used in production of biomass, primary and secondary metabolites; Microbial leaching of minerals; Microorganisms in degradation of xenobiotics and removal of heavy metals; Biotransformations. Enzymes as industrial biocatalysts; production; Isolation; purification and application of industrial enzymes; immobilized enzymes; stabilization of enzymes; enzyme catalyzed organic synthesis; multienzyme systems.

BBL820 Downstream Processing
3 Credits (3-0-0)

Characteristics of biological materials; Pre-treatment.; Microbial separation: Centrifugation and filtration, Cell disruption methods, Protein precipitation, Extraction, Adsorption, Electrophoresis, Chromatography, Ultrafiltration, Reverse osmosis, Isoelectric focusing, Affinity based separations, Case Studies.

BBL830 Microbial Biochemistry
3 Credits (3-0-0)

Structure and function of biomolecules amino acids, proteins, lipids, nucleotides and nucleic acids: Enzymes-structure and kinetics, Vitamins and coenzymes, Metabolic pathways: Carbohydrate metabolism: glycolysis, pentose phosphate pathway, citric acid cycle; Bioenergetics oxidative phosphorylation and photo-synthesis: Fatty acid metabolism; Amino acid metabolism; Regulatory mechanisms- feedback inhibition, induction, catabolite repression; Nucleic acid and protein biosynthesis.

BPP840 Laboratory Techniques in Microbial Biochemistry
2 Credits (0-0-4)

Estimation of carbohydrates/proteins/nucleic acids; separation of phospho-lipids by thin layer chromatography; chromatographic...
separation of proteins; identification and estimation of intermediates of glycolytic pathway; oxidative phosphorylation; cell fractionation; aseptic techniques; microscopic examination of bacteria & fungi; selected biochemical tests; plasmid DNA preparation; expression of cloned DNA in bacteria; isolation of auxotrophic mutants.

**BBL850 Advanced Biochemical Engineering**  
*5 Credits (3-0-4)*

Kinetics of cell growth; Mathematical models for substrate uptake and product formation; Plasmid stability in recombinant cell cultures; Kinetics of enzyme-catalyzed reactions; Media and air sterilization; Cell cultivation strategies; Novel bioreactor designs; Developments in aeration & agitation in bioreactors; immobilized whole cell and immobilized enzyme reactors; RTD and mixing in bioreactors; Dynamics of mixed cultures; Scale-up and scale down of bioreactors.

Laboratory: Microbial growth and product formation kinetics; enzyme kinetics; Effects of inhibitor on microbial growth; enzyme immobilization techniques; Bioconversion using immobilized enzyme preparation; Bioconversion in batch, fedbatch and continuous bioreactors; Oxygen transfer studies in fermentation; Mixing and agitation in fermenters; RTD studies; Mass transfer in immobilized cell/enzyme reactors.

**BBD851 Major Project Part 1 (BB5)**  
*6 Credits (0-0-12)*

**BBD852 Major Project Part 2 (BB5)**  
*14 Credits (0-0-28)*

**BBD853 Major Project Part 1 (BB5)**  
*4 Credits (0-0-8)*

**BBD854 Major Project Part 2 (BB5)**  
*16 Credits (0-0-32)*

**BBD895 MS Research**  
*36 Credits (0-0-72)*
Department of Chemical Engineering

CLL110 Transport Phenomena
4 Credits (3-1-0)

CLL111 Material and Energy Balances
4 Credits (2-2-0)

CLL113 Numerical Methods in Chemical Engineering
4 Credits (3-0-2)
Overlaps with: MTL107, MTP290, MTL445, CVL734, COL726

CLL121 Chemical Engineering Thermodynamics
4 Credits (3-1-0)
Overlaps with: MCL140, MCL141, MCL142
Review of conservation of energy, mass and introduction to work-energy conversions, and the concept of entropy. Application to closed and open systems, application in analysis of energy and efficiency of equipment. State and properties of pure fluids under different conditions and in flow through equipment. Use of equations of states, graphs, correlations and tables to estimate fluid properties, understanding the relationships between fluid properties and changes in properties. Equilibrium properties of pure materials and mixtures. Understanding the phase behaviour and phase transitions of pure fluids. Thermodynamic analysis of fluids in standard fixtures and equipment (piping fixtures, power plants, engines, refrigerators). Equilibrium behaviour of mixtures of fluids, the nature of interactions between various fluids and how interactions affect their properties and phase transitions. Introduction to separation processes based on difference in equilibrium thermodynamic properties. Introduction to reaction equilibria.

CLL122 Chemical Reaction Engineering I
4 Credits (3-1-0)
Introduction to rate equations, calculation of conversion in single reaction, kinetics of homogeneous reactions. Derivation of reactor design equations, analysis and sizing of reactors, data collection and plotting to determine rate constants. Reactor networks (series/parallel), concepts of selectivity and yield, reaction mechanisms. Temperature and pressure effects on reactions and reactor design, simultaneous material and energy balances, multiple steady-states. Residence time distributions in non ideal reactors.

CLL133 Powder Processing and Technology
3 Credits (3-0-0)

CLL141 Introduction to Materials for Chemical Engineers
3 Credits (3-0-0)

CLL222 Chemical Reaction Engineering II
3 Credits (3-0-0)
Pre-requisites: CLL122

CLL231 Fluid Mechanics for Chemical Engineers
4 Credits (3-1-0)
Overlaps with: APL107, APL106, APL105
Introduction to fluids, Forces on fluids, Fluid statics, Hydrostatic force on submerged bodies, Rigid body motion, Kinematics of flow - Eulerian and Lagrangian descriptions, Flow visualization, Integral analysis - mass and momentum balances, Bernoulli equation, Flow through pipes and ducts, Flow measurement, Flow transportation - pumps, blowers and compressors, Differential analysis of flow, Conservation of mass, linear and angular momentum, Naver-Stokes equation, Unidirectional flows, Viscous flows, Skin friction and form friction, Lubrication approximation, Potential flows, Boundary layer theory, Bliasz equation for flow over a flat plate, Boundary layer separation, Drag and lift force on immersed bodies, Similitude analysis, Turbulent flows.

CLL251 Heat Transfer for Chemical Engineers
4 Credits (3-1-0)
Pre-requisites: CLL110
Overlaps with: MCL242
Modes of heat transfer - conduction, convection, radiation; Heat transfer coefficients in natural and forced convection; Basic conservation equations; Heat transfer with phase change; Design of double pipe heat exchangers, shell and tube heat exchangers and evaporators; Introduction to radiative heat transfer. Unsteady state heat transfer. Two-dimensional heat transfer problems.

CLL252 Mass Transfer I
3 Credits (3-0-0)
Pre-requisites: CLL110
Lattice, Fick's, Stefan-Maxwell, Stokes-Einstein and irreversible thermodynamic approaches to diffusivity of binary and multicomponent system. Film theory and other theories of mass transfer. Analog and
correlation approaches to mass transfer coefficients in interphase mass transfer. Analysis of co-current, counter-current and cross flow stage cascades. Design and operating conditions of differential contact equipment such as packed towers for absorption, adsorption, drying and leaching.

**CLL261 Process Dynamics and Control**  
4 Credits (3-1-0)  
Pre-requisites: MTL100, CLL111  
Overlaps with: MCL212, ELL225, ELL205


**CLL271 Introduction to Industrial Biotechnology**  
3 Credits (3-0-0)  
Pre-requisites: CLL110  
Overlaps with: BEN150, BBL431, BBL731


**CLL296 Nano-engineering of Soft Materials**  
3 Credits (3-0-0)  
Pre-requisites: CLL121  
Overlaps with: PVL421


**CLP301 Chemical Engineering Laboratory I**  
1.5 Credits (0-0-3)  
Pre-requisites: CLL231, CLL251  
Practicals in fluid mechanics and heat transfer.

**CLP302 Chemical Engineering Laboratory II**  
1.5 Credits (0-0-3)  
Pre-requisites: CLL331, CLL252  
Practicals in unit operations, mechanical operations, fluid-particle mechanics and principles of mass transfer.

**CLP303 Chemical Engineering Laboratory III**  
1.5 Credits (0-0-3)  
Pre-requisites: CLL121, CLL122  
Practicals in reaction engineering, thermodynamics and chemical processing.

**CLL331 Fluid-Particle Mechanics**  
4 Credits (3-1-0)  
Pre-requisites: CLL110, CLL231

Introduction to industries dealing with the particles (solid, liquid, gas, soft-materials: colloids, polymer), solid particles: particle size, shape and their distribution, relationship among shape factors and particle dimensions, specific surface area, measurement of surface area and particle size distribution, drag coefficient, packed bed, fluidization. Sedimentation: settling, hindered settling, design of settling tank, filtration, centrifugal separation, cyclone separator, mixing (solid-solid, solid-liquid and liquid-liquid), segregation. Size reduction, size enlargement, flow properties of slurries, behaviour of colloidal particles in dispersed condition.

**CLL352 Mass Transfer II**  
4 Credits (3-1-0)  
Pre-requisites: CLL252


**CLL361 Instrumentation and Automation**  
2.5 Credits (1-0-3)  
Pre-requisites: CLL261


**CLL371 Chemical Process Technology and Economics**  
4 Credits (3-1-0)  
Pre-requisites: CLL252, CLL122


**CLL390 Process Utilities and Pipeline Design**  
3 Credits (3-0-0)  
Pre-requisites: CLL231

CLL402 Process Plant Design
3 Credits (3-0-0)
Pre-requisites: CLL371
Overlaps with: CLL703

CLD411 B. Tech. project
4 Credits (0-0-8)

CLD412 Major Project in Energy and Environment
5 Credits (0-0-10)

CLD413 Major Project in Complex Fluids
5 Credits (0-0-10)

CLD414 Major Project in Process Engineering, Modeling and Optimization
5 Credits (0-0-10)

CLD415 Major Project in Biopharmaceuticals and Fine Chemicals
5 Credits (0-0-10)

CLL475 Safety and Hazards in Process Industries
3 Credits (3-0-0)
Pre-requisites: CLL371

CLL477 Materials of Construction
3 Credits (3-0-0)
Pre-requisites: CLL371

CLL701 Modelling of Transport Processes
2 Credits (2-0-0)
Introduction to methods for solution of algebraic equations, Methods for solution of ODEs, Functions, approximations and regression analysis, Introduction to Design of Experiments.

CLL702 Principles of Thermodynamics, Reaction Kinetics and Reactors
2 Credits (2-0-0)
Introduction to thermodynamics; Notion of equilibrium, states and reversibility; First and Second Laws of Thermodynamics; Equations of state; Equilibrium behaviour of mixtures of fluids; Phase equilibria and VLE; Reaction thermodynamics. Reaction equilibria and chemical kinetics; Ideal reactors; Isothermal reactor design; Temperature and pressure effects in ideal reactors; Heterogeneous catalysis and effectiveness factors; Fluid-solid non-catalytic reactions.

CLL703 Process Engineering
3 Credits (3-0-0)
Process synthesis, material balances and decision making in reactors with recycle streams, input-output structure of flowsheet for batch vs. continuous reactors, hierarchical approach for process engineering design, reactor and separation system selection guidelines, distillation column sequencing, heat exchanger network design, pinch technology, utility selection, grand composite curve, steam and cooling water circuits, integration of heat pumps and heat engines

CLP704 Technical Communication for Chemical Engineers
1 Credit (0-0-2)
Technical paper and report writing, Knowledge of leading Chemical Engineering journals and conferences, carrying out literature search, research methodology, paper referencing and critiquing, ethics and plagiarism, improving presentation and communication skills.

CLL705 Petroleum Reservoir Engineering
3 Credits (3-0-0)
Pre-requisites: CLL110, CLL121
Introduction of static model including porosity, permeability, compressibility and saturations. Crude oil phase behaviour and their measurement techniques for reservoir and laboratory settings. Meaning and calculation of ‘oil in place’ numbers with respect to different recovery mechanisms. Material balance for hydrocarbon reservoirs. Pressure transient analysis. Primary, secondary and tertiary recovery mechanisms, Buckley–Leverett theory (fractional flow curves) for immiscible and miscible displacement. Production forecasting and introduction to reservoir simulation.

CLL706 Petroleum Production Engineering
3 Credits (3-0-0)
Pre-requisites: CLL231, CLL121
Basic concepts: well drilling, well completions, drive mechanisms for different reservoirs, Darcy’s law. Movement of fluids in the well, different artificial lift mechanisms, VLP (vertical lift performance curves), IPR (inflow performance relationships). Well analysis tools (different well performance curves, well logging). Problem identification in wells (examples). Well stimulation techniques.

CLL707 Population Balance Modeling
3 Credits (3-0-0)
Pre-requisites: MTL101, CLL331, CLL352

CLL720 Principles of Electrochemical Engineering
3 Credits (3-0-0)
Volta and Galvani potentials, electrochemical potential, electrochemical

CLL721 Electrochemical Methods
3 Credits (3-0-0)

CLL722 Electrochemical Conversion and Storage Devices
3 Credits (3-0-0)

CLL723 Hydrogen Energy and Fuel Cell Technology
3 Credits (3-0-0)

CLL724 Environmental Engineering and Waste Management
3 Credits (3-0-0)
Overlaps with: CVL100, CVL212, CVL311, CVL312, BBL742

CLL725 Air Pollution Control Engineering
3 Credits (3-0-0)
Pre-requisites: CLL222

CLL726 Molecular Modeling of Catalytic Reactions
3 Credits (3-0-0)
Pre-requisites: CLL222
Sabatier principle. Catalytic cycle, transition state theory. Ensemble effect, defect sites, cluster size effects, metal-support interactions, structural effects, quantum size effects, electron transfer effects. Brönsted-Evans-Polanyi relations. Reactivity of transition-metal surfaces, quantum chemistry of chemical bond, bonding to transition metals, chemisorption.

Kinetics of elementary steps (adsorption, desorption and surface reactions). Reaction on uniform and non-uniform surfaces. Structure-sensitive and non-sensitive reactions on metals.


Catalysis by metals, oxides, sulfides and zeolites. Aqueous phase heterogeneous catalysis and electrocatalysis.

CLL727 Heterogeneous Catalysis and Catalytic Reactors
3 Credits (3-0-0)
Pre-requisites: CLL222

CLL728 Biomass Conversion and Utilization
3 Credits (3-0-0)
Pre-requisites: CLL122
Critical analysis of issues associated with implementing large scale biofuel and biomass energy production. Processes for converting feedstocks to biofuels by thermochemical methods. Biomass conversion catalysis, kinetics and reaction mechanisms, reactor design and scale up issues.

CLL730 Structure, Transport and Reactions in BioNano Systems
3 Credits (3-0-0)
Pre-requisites: CLL110
Overlaps with: SBV882, MCL442
**CLL731 Advanced Transport Phenomena**
3 Credits (3-0-0)
Pre-requisites: CLL110

**CLL732 Advanced Chemical Engineering Thermodynamics**
3 Credits (3-0-0)
Pre-requisites: CLL121

**CLL733 Industrial Multiphase Reactors**
3 Credits (3-0-0)
Pre-requisites: CLL122, CLL222

**CLL734 Process Intensification and Novel Reactors**
3 Credits (3-0-0)
Pre-requisites: CLL122, CLL222

**CLL735 Design of Multicomponent Separation Processes**
3 Credits (3-0-0)
Pre-requisites: CLL352

**CLL736 Experimental Characterization of Multiphase Reactors**
3 Credits (3-0-0)
Pre-requisites: CLL122, CLL222
Analytical techniques: Introduction to various analytical techniques e.g. GC, HPLC, UV Spectroscopy, TGA /DTA, FTIR, MS, GCMS, NMR, TOC, CHONS. Principle of measurement techniques, instruments and procedures. Calibration, data processing, analysis and interpretation. Few working demonstrations.
Catalysis characterization: Introduction to various catalysis preparations and characterization techniques, e.g. porosity, surface area, pore volume and pore size distribution (using BET), XRD, SEM, TEM, NMR, AFM, ESCA. Massbauer spectroscopy, chemisorption, TPD/TPR.
Flow characterization: Introduction to single/multiphase flows/ reactors, role of hydrodynamics. Process parameters of interest, length and time scales, instantaneous vs. time averaged characteristics. Introduction to various advanced intrusive and non-intrusive flow measurement techniques, e.g. mininaturized pressure probes, gamma-ray tomography, densitometry, PIV, RPT, ECT/ERT, high speed photography, tracers and radiotracers.

**CLL742 Experimental Characterization of BioMacromolecules**
3 Credits (3-0-0)
Pre-requisites: CLL141, CLL271
Overlaps with: PTL705
Theory and working principles of analytical instruments including high performance liquid chromatography (HPLC), ultra-high performance liquid chromatography (UPLC), capillary electrophoresis (CE), capillary isoelectric focusing (cIEF), gel electrophoresis, circular dichroism (CD) spectroscopy, Fourier transform infrared spectroscopy (FTIR), mass spectroscopy (MS), atomic force microscopy (AFM), scanning electron microscope (SEM), differential scanning calorimetry (DSC), ultraviolet (UV) spectroscopy, surface plasmon resonance (SPR), 2D gel electrophoresis, fluorescence spectroscopy, Zeta-meter, contact angle goniometer, oscillatory drop module (ODM) of goniometer, and quartz crystal microbalance (QCM). Hands-on experience on characterization of proteins. Case studies in biotech industry.

**CLL743 Petrochemicals Technology**
3 Credits (3-0-0)
Pre-requisites: CLL222

**CLL761 Chemical Engineering Mathematics**
3 Credits (3-0-0)
Pre-requisites: MTL101, CLL110
CLL762 Advanced Computational Techniques in Chemical Engineering
3 Credits (2-0-2)
Pre-requisites: CLL113
Overlaps with: APL703
Introduction to models in Chemical Engineering. Formulation of problems leading to ODEs of initial value types. Stability and stiffness of matrices. Solution of stiff problems like Rober's problem in autocatalytic reactions by Gear's algorithm. Formulation of problems leading to steady state ODEs of boundary value types. Different weighted residual methods to solve BVPs. Orthogonal collocation and Galerkin finite element method. Application to reaction diffusion in porous catalysts pellets under non-isothermal conditions, calculation of effectiveness factor. Moving boundary problems. Transient problems leading to PDEs. Examples in heat and mass transfer and their numerical solution: orthogonal collocation, Monte Carlo method and its applications. Introduction to LBM method to solve fluid flow problems.

CLL766 Interfacial Engineering
3 Credits (3-0-0)
Pre-requisites: CLL110, CLL121
Overlaps with: CML103
Concept and definition of interface. Physical surfaces. Surface chemistry and physics of colloids, thin films, dispersions, emulsions, foams, polyphosphon. Interfacial processes such as crystallization, epitaxy, froth flotation, adsorption, adsorptive bubble separation, catalysis, reaction-injection moulding, microencapsulation. Industrial aspects of interfacial engineering.

CLL767 Structures and Properties of Polymers
3 Credits (3-0-0)
Pre-requisites: CLL141
Overlaps with: PTL703, PTL701, TTL712

CLL768 Fundamentals of Computational Fluid Dynamics
3 Credits (2-0-2)
Pre-requisites: CLL113, CLL110
Overlaps with: AML410, MEL807

CLL769 Applications of Computational Fluid Dynamics
3 Credits (2-0-2)
Pre-requisites: CLL110
Overlaps with: APL410, APL720, MCL813

CLL771 Minor Project
3 Credits (0-0-6)
Literature survey, Writing technical report, Planning and execution of the project work within the stipulated time frame.

CLL771 Introduction to Complex Fluids
3 Credits (3-0-0)

CLL772 Transport Phenomena in Complex Fluids
3 Credits (3-0-0)
Pre-requisites: CLL110

CLL773 Thermodynamics of Complex Fluids
3 Credits (3-0-0)
Overlaps with: PTL202

CLL774 Simulation Techniques for Complex Fluids
3 Credits (3-0-0)
Pre-requisites: CLL113
Overlaps with: MCL315
Simulation techniques: Molecular Dynamics, Brownian Dynamics, Monte-Carlo, Discrete Element Method and Lattice Boltzmann Simulations. Force fields and interactions. Statistical measures and trajectory analysis to determine structure (e.g., radial distribution function) and properties (e.g., self-diffusivity, shear-dependent viscosity) of complex fluids.

CLL775 Polymerization Process Modeling
3 Credits (3-0-0)
Pre-requisites: CLL122
Overlaps with: PTL701
CLL776 Granular Materials
3 Credits (3-0-0)
Pre-requisites: CLL331

CLL777 Complex Fluids Technology
3 Credits (3-0-0)
Pre-requisites: CLL141
An overview of various technologies based on complex fluids and relate them to fundamental principles of thermodynamics and transport phenomena in complex fluids, e.g., how to manipulate micro-structures and their environment to achieve new products with desired properties. Case studies involving assembly, stability and applications of colloids, emulsions, suspensions, polymer melts and granular materials.

CLL778 Interfacial Behaviour and Transport of Biomolecules
3 Credits (3-0-0)
Pre-requisites: CLL110
Overlaps with: CYL669, SBL705, SBV885
Introduction to the cellular structure and function of biomolecules, theory and experimental characterization of commonly-used laboratory techniques in molecular diagnostic protocols. Identification of the important parameters such as sensitivity, specificity, LOD etc. in the design of a quality system for molecular analyses. Highly sensitive reporter technologies and applications, technologies providing highly dense and bioactive solid phases, novel bioaffinity binders, heterogeneous and homogenous assay concepts, and multiplexed bioassays.

CLL779 Molecular Biotechnology and in-vitro Diagnostics
3 Credits (3-0-0)
Introduction to the cellular structure and function of biomolecules, theory and experimental characterization of commonly-used laboratory techniques in molecular diagnostic protocols. Identification of the important parameters such as sensitivity, specificity, LOD etc. in the design of a quality system for molecular analyses. Highly sensitive reporter technologies and applications, technologies providing highly dense and bioactive solid phases, novel bioaffinity binders, heterogeneous and homogenous assay concepts, and multiplexed bioassays.

CLL780 Bioprocessing and Bioseparations
3 Credits (3-0-0)
Pre-requisites: CLL271
Overlaps with: BEL703, BEL820
CLL786 Fine Chemicals Technology
3 Credits (3-0-0)
Pre-requisites: CLL222

CLL791 Chemical Product and Process Integration
3 Credits (3-0-0)
Pre-requisites: CLL371
The course will be a structured project based course with initial exposure to industrial processes of understanding Voice of Customers, identifying design specifications, scoping the technology and product landscape and deciding on the technology strategy. Technical and economic feasibility analysis as well as scale-up and manufacturing concerns will also be discussed. Each group will identify a specific product or process of interest and work through these considerations as well as integrate thermodynamics, transport principles, fluid mechanics and reactor design understanding to design the product or process chosen.

CLL792 Chemical Product Development and Commercialization
3 Credits (3-0-0)
Pre-requisites: CLL110
Overlaps with: MTL766, MAL719, SML802
Design of experiments - factors, responses, main effects, interactions, different kinds of designs - screening vs. high resolution. Statistical data analysis - applied probability, sampling, estimation, hypothesis testing, linear regression, analysis of variance, types of data plots. Technology transfer of processes - need of technology transfer, key attributes, key challenges, solutions to various issues. Intellectual property management - intellectual property rights, IPR laws, patents, trademarks, designs, copyrights, licensing, IP management. Commercialization of technologies - invention, product development, technical and market feasibility analysis, intellectual property acquisition.

CLL793 Membrane Science and Engineering
3 Credits (3-0-0)
Pre-requisites: CLL110, CLL252
Introduction to membrane separation processes, their classification, and applications. General transport theories including theory of irreversible thermodynamics for multicomponent systems. Membrane preparation techniques. Design and analysis and industrial application of various membrane processes such as reverse osmosis, ultra filtration, electrodialysis, dialysis, liquid membrane separation, gas permeation and pervaporation.

CLL794 Petroleum Refinery Engineering
3 Credits (3-0-0)
Pre-requisites: CLL222, CLL352

CLV796 Current Topics in Chemical Engineering
1 Credit (1-0-0)
As per declaration of instructor(s).

CLV797 Recent Advances in Chemical Engineering
2 Credits (2-0-0)
Pre-requisites: To be declared by Instructor
As per declaration of instructor(s).

CLL798 Selected Topics in Chemical Engineering-I
3 Credits (3-0-0)
Pre-requisites: To be declared by Instructor
As per declaration of instructor(s).

CLL799 Selected Topics in Chemical Engineering-II
3 Credits (3-0-0)
Pre-requisites: To be declared by Instructor
As per declaration of instructor(s).

CLD880 Minor Project
4 Credits (0-0-8)

CLD871 Major Project Part-I
6 Credits (0-0-12)

CLD872 Major Project Part-II
14 Credits (0-0-28)

CLD881 Major Project Part-I
8 Credits (0-0-16)

CLD882 Major Project Part-II
12 Credits (0-0-24)

CLD895 MS Research Project
36 Credits (0-0-72)
Department of Chemistry

CML100 Introduction to Chemistry
3 Credits (3-0-0)
Entropy and free energy changes in chemical processes, chemical equilibria, phase transformations, structure and dynamics of microscopic systems, physical basis of atomic and molecular structure, three-dimensional arrangement of atoms in molecules, structure and reactivity of organic, inorganic and organometallic compounds, basic strategies for synthesis of carbon and silicon containing compounds, coordination chemistry, role of inorganic chemistry in living systems.

CML102 Chemical Synthesis of Functional Materials
3 Credits (3-0-0)
Chemical approaches to the synthesis of functional materials – the design of materials targeting important properties by ‘bottom-up’ processes that manipulate primary chemical bonds. Fundamental chemistry principles involved in materials design through synthesis – process methodologies such as self-assembly, sol-gel reactions, synthesis of nanomaterials, etc.

CML103 Applied Chemistry - Chemistry at Interfaces
3 Credits (3-0-0)
Unit processes in organic synthesis. Laboratory vs. industrial synthesis. Role of medium in directing synthetic outcomes, organized media. Natural and synthetic constrained systems (inorganic and organic) for control of reactivity in organic reactions. Phase transfer catalysts, polymer and supported reagents for control of reactions. Green Chemistry. Heterogeneous and homogeneous catalysis, surface chemistry, kinetics of catalyzed reactions. Industrial catalysis.

CML511 Quantum Chemistry
3 Credits (3-0-0)
Basic concepts and postulates of quantum mechanics, Hydrogen atom, Quantization of angular momentum, Many electron atoms, Variation theorem, Perturbation theory, Molecular orbital and valence bond theories, Introductory treatment of semi-empirical and ab initio calculations on molecular systems, Density functional theory.

CML512 Stereochemistry & Organic Reaction Mechanisms
3 Credits (3-0-0)
Stereochemistry of acyclic and cyclic compounds including chiral molecules without a chiral centre, Reaction mechanisms (polar and free radical) with stereochemical considerations, Reactive intermediates: generation, structure, and reactivity.

CML513 Photochemistry & Pericyclic Reactions
3 Credits (3-0-0)

CML514 Main Group Chemistry
3 Credits (3-0-0)
General properties of p block elements, bonding, historical landmarks, and periodic properties, Introduction to group theory, Chemistry of alkali and alkaline earth metals, Chemistry of group 13, 14, 15, and 16 elements, Halogen chemistry, Chemistry of rare gases.

CML515 Instrumental Methods of Analysis
3 Credits (3-0-0)
Measurement basics and data analysis, Introduction to spectrometric methods and components of optical instruments, Atomic absorption, fluorescence, emission, mass, and X-ray spectrometry, Introduction to and applications of uv-vis molecular absorption, luminescence, infrared, Raman, nuclear magnetic resonance, and mass spectroscopy/spectrometry, Introduction to electroanalytical methods: potentiometry, coulometry, and voltammetry, Introduction to chromatographic separation: gas, high-performance liquid, supercritical fluid, and capillary electrophoresis chromatography, Introduction to thermal methods of analysis.

CML521 Molecular Thermodynamics
3 Credits (3-0-0)
Basics concepts, Review of first, second, and third laws of thermodynamics, Gibb’s free energy, Extra work, Chemical potential, Ideal and non ideal solution, Phase rule, Phase diagram, Solutions, Chemical equilibria, Postulates of statistical thermodynamics, Ensembles, Monoatomic and polyatomic ideal gases, Molar heat capacities, Classical statistical mechanics.

CMP521 Laboratory-III
2 Credits (0-0-4)
Basic laboratory techniques to synthesize, purify, and characterize small organic molecules by analytical and spectroscopic methods.

CPR522 Laboratory-IV
2 Credits (0-0-4)
Determination of enzyme activity in biological samples, Protein purification and characterization, Microbial growth experiments, DNA and RNA isolation, Gel electrophoresis.

CML522 Chemical Dynamics & Surface Chemistry
3 Credits (3-0-0)
Kinetics of simple and complex reactions, Transport properties, Theories of reaction rates and dynamics of gas and liquid phase reactions, Experimental techniques to study fast reactions, Photochemical reactions, Surface phenomena and physical methods for studying surfaces, Heterogeneous and homogeneous catalysis.

CML523 Organic Synthesis
3 Credits (3-0-0)
Formation of carbon-carbon bonds including organometallic reactions, Synthetic applications of organoboranes and organosilanes, Reactions at unactivated C-H bonds, Oxidations, Reductions, Newer Reagents, Design of organic synthesis, Retrosynthetic analysis, Selectivity in organic synthesis, Protection and deprotection of functional groups, Multistep synthesis of some representative molecules.

CML524 Transition and Inner Transition Metal Chemistry
3 Credits (3-0-0)
Introduction to coordination chemistry, Crystal field theory, Ligand field theory, Molecular orbital theory, Magnetic and spectral
Chemistry

characteristics of inner transition metal complexes, Substitution, Electron transfer and photochemical reactions of transition metal complexes, Physical, spectroscopic, and electrochemical methods used in the study of transition metal complexes, Metal-metal bonded compounds and transition metal cluster compounds, Uses of lanthanide complexes: as shift reagents, as strong magnets, and in fluorescence, Bioinorganic chemistry: introduction, Bioinorganic chemistry of iron: hemoglobin, myoglobin, cytochromes, Bioinorganic chemistry of zinc, cobalt, and copper.

CML525 Basic Organometallic Chemistry
3 Credits (3-0-0)
Organometallic chemistry of main group, transition, and inner transition metals. Synthesis and applications of BiLi, Grignard, organoaluminum, and organozinc reagents, 18 electron rule, Metal carbonyls: bonding and infrared spectra, phosphines and NHC’s, Alkenes and alkenes, carbenes and carbynes (Fisher and Schrock), Haptol ligands with hapticity from 2-8, Ovadational addition and reductive elimination, 1,1 and 1,2-migratory insertions and beta hydrogen elimination, Mechanism of substitution reactions, Flexibility and hapticity change, Organometallic clusters, C-H activation: astatic and anagostic interactions, Homogeneous catalysis: hydrogenation, hydroformylation, methanol to acetic acid processes, and Wacker oxidation, Introduction to cross coupling and olefin metathesis reactions, Olefin oligomerization and polymerization.

CML526 Structure & Function of Cellular Biomolecules
3 Credits (3-0-0)
Prokaryotic and eukaryotic cells, Structure and function of proteins, carbohydrates, nucleic acids, and lipids. Biological membranes, Enzymes: classification, kinetics, mechanism, and applications. Basic concepts of microbial culture, growth, and physiology.

CMD611 Project Part-I
6 Credits (0-0-12)

CMD621 Project Part-II
10 Credits (0-0-20)

CML631 Molecular Biochemistry
3 Credits (3-0-0)
Central dogma, DNA replication and repair, Transcription, Translation, Recombinant DNA technology, Basic concept of metabolism: glycolysis, TCA cycle, O-oxidation, Amino acid transamination and urea cycle.

CML661 Solid State Chemistry
3 Credits (3-0-0)
Crystal chemistry, Bonding in solids, Defects and non-stoichiometry, A range of synthetic and analytical techniques to prepare and characterize solids, Electronic, magnetic, and superconducting properties, Optical properties which include: luminescence and lasers, nanostructures and low dimensional properties, etc.

CML662 Statistical Mechanics & Molecular Simulation Methods
3 Credits (3-0-0)
Micro- and macroscopic state of a classical system, Phase space, Ergodicity and mixing in phase space, Theory of ensembles, Classical fluids, Phase transitions and relaxation phenomena, Monte Carlo, molecular dynamics, and Brownian dynamics, Computer simulations, Brownian motion, Langevin equation, Elucidation of structural, dynamic, and thermodynamic properties of complex fluids and soft matter.

CML663 Selected Topics in Spectroscopy
3 Credits (3-0-0)
Franck-Condon principle, Fermi Golden rule, Normal mode analysis, Multi-photon spectroscopy, Molecular beam techniques, Non-linear laser spectroscopy, Two-level systems, Precession, Rabi frequency, Notation, Block equations, Multi-dimensional NMR techniques.
methods for homo and hetero-catenated polymers, Characterization methods (spectroscopy, gel permeation chromatography, differential scanning calorimetry)

**CML683 Applied Organometallic Chemistry**  
**3 Credits (3-0-0)**

Introduction to homogeneous catalysis, TON and TOF, Some aspects of commonly used ligands in homogeneous catalysis, such as, CO, amines, phosphines, NHCs, alkenes, alkylnes, carbenes, carbines, etc., Recent developments in hydrogenation and hydroformylation and their asymmetric variations using OM catalysts, Wacker oxidation, Monsanto and Cativa processes, Olefin and alkyne trimerization and oligomerization, Olefin polymerization using Ziegler-Natta, Titanium group metalloccenes, Post metalocene late TM catalysts and FI catalysts, Olefin and alkyne metathesis, Grubbs I, II, and III, Schrock, and Schrock-Hoveyda catalysts, Types of metathesis such as RCM, ROM, ROMP, ADMET, and EM. Applications in industry, Palladium and nickel catalyzed cross coupling reactions such as Suzuki, Heck, Sonogashira, Stille, Negishi, Hiyama, Buchwald-Hartwig, decarboxylative cross coupling, and alpha arielation of carbyuls, Fischer Tropsch Process, C-H activation of alkyls and ariys using transition metal complexes, Organometallic polymers, Bio-organometallic chemistry: Vitamin B-12, Planar chirality of metal sandwich compounds and their applications in industry (e.g. Josiphos catalyst), Ferrocene based drugs, Sustainable catalysis for pharmaceuticals and industry using organometallcics.

**CML684 Bio-Inorganic Chemistry**  
**3 Credits (3-0-0)**

Introduction of bio-inorganic chemistry, General properties of biological molecules, Physical methods in bio-inorganic chemistry, Binding of metal ions and complexes to biomolecule active centers, Synthesis and reactivity of active sites, Atom and group transfer chemistry, Electron transfer in proteins, Frontiers of bio-inorganic chemistry: some topics of current research interest.

**CML691 Microbial Biochemistry**  
**3 Credits (3-0-0)**

Microscopic examination of microorganisms, classification, morphology and fine structure of microbial cells, cultivation, reproduction and growth, pure culture techniques, Basic microbial metabolisms, Concepts of their genetics: transformation, transduction, and conjugation, Important microorganisms and enzymes.

**CML692 Food Chemistry and Biochemistry**  
**3 Credits (3-0-0)**

Carbohydrates: structure and functional properties of mono-oligo-poly saccharides including starch, cellulose, pectic substances, and dietary fibers, Essential amino acids, proteins, and lipids in food and their impact on functional properties, vitamins and minerals, Food flavours: terpenes, esters, ketones, and quinines; Food additives, Bioactive constituents in food: isoflavones, phenol, and glycosides; Enzymes: enzymatic and non-enzymatic browning, enzymes in food processing, oxidative enzymes, Food biochemistry: balanced diet, PER, anti-nutrients and toxins, nutrition deficiency diseases.

**CML695/ CML739 Applied Biocatalysis**  
**3 Credits (3-0-0)**

Introduction to enzymes and enzyme catalysed reactions, Classification and mechanism of reaction, Purification and characterization of enzymes, Michels Menten kinetics, Industrial enzymes, Applications of enzymes in diagnostics, analysis, biosensors, and other industrial processes and bio-transformations, Enzyme structure determination, stability, and stabilisation, Enzyme immobilization and concept of enzyme engineering, Nanoobiocatalysis.

**CML721 Design and Synthesis of Organic Molecules**  
**3 Credits (3-0-0)**

Emphasis will be placed on the above techniques for industrially important materials and the interpretation and evaluation of the results obtained by various methods.

**CML731 Chemical Separation and Electroanalytical Methods**  
3 Credits (3-0-0)  
Theory and applications of equilibrium and nonequilibrium separation techniques. Extraction, countercurrent distribution, gas chromatography, column and plane chromatographic techniques, electrophoresis, ultracentrifugation, and other separation methods, Modern analytical and separation techniques used in biochemical analysis. Principles of electrochemical methods, electrochemical reactions, steady-state and potential step techniques; polarography, cyclic voltammetry, chrono methods, rotating disc and ring disc electrodes, concepts and applications of AC impedance techniques.

**CML733 Chemistry of Industrial Catalysts**  
3 Credits (3-0-0)  
Fundamental aspects of Catalysis - Homogeneous & heterogeneous catalysis - The role of catalytic processes in modern chemical manufacturing - organometallic catalysts - catalysis in organic polymer chemistry - catalysis in petroleum industry - catalysis in environmental control.

**CML734 Chemistry of Nanostructured Materials**  
3 Credits (3-0-0)  
Introduction: fundamentals of nanomaterials science, surface science for nanomaterials, colloidal chemistry; Synthesis, preparation and fabrication: chemical routes, self assembly methods, biomimetic and electrochemical approaches; Size controls properties (optical, electronic and magnetic properties of materials) - Applications (carbon nanotubes and nanoporous zeolites; Quantum Dots, basic ideas of nanodevices).

**CML737 Applied Spectroscopy**  
3 Credits (3-0-0)  
Applications of advanced 1D-NMR techniques such as NOE, 1D 13C-NMR (including APT and DEPT) techniques, multinuclear NMR spectroscopy, 2D NMR techniques (COSY, HETCOR, HSQC, HMBC, NOESY, ROESY etc.) for the structural and stereochemical determination of organic compounds. Introduction to various types of ionizations (such as EI, CI, MALDI, field ionization/desorption, electrospray ionization) and analyzers (such as quadrupole, time of flight, triple quadrupole, QqTOF, ion-trap) in mass spectrometry for MS, MS/MS and MSn applications. Determination of peptide sequencing using mass spectrometric techniques.

**CML738 Applications of P-block Elements and their Compounds**  
3 Credits (3-0-0)  
Introduction, Structure, bonding and recent discussions on d orbital participation. Boranes, carboranes and metallaboranes and their use in BNCT and as control rods in nuclear reactors, modern electron counting methods such as Jemmis rules, chemistry of B(0) and B(1), GaAs, GaN, InSnO3: Synthesis and applications in solar cells, LED and as transparent conducting materials. Fullerenes, nanotubes, graphene, silicones, aluminosilicates, zeolites and their applications. Silicones and their industrial applications. Si(II) and Ge(II) chemistry. NHCs and their use in stabilizing main group compounds. Nitrogen based fertilizers, Ammonia, Haber-Bosch Process, nitrogen based explosives, hydrazines as rocket fuels, applications of azides and pentazenium. Phosphorus based fertilizer processes, phosphorus based pesticides, phosphorus-nitrogen compounds as multidentate ligands, superbases, dendrimer cores and polymers. Phosphines and their industrial uses. Frustrated Lewis acid bases as catalysts. Superacids and their uses. Sulphonamides, industrial applications of sulfur and selenium. Fluorine in pharmaceuticals, fluoropolymers.

**CML739/695 Applied Biocatalysis**  
3 Credits (3-0-0)  

**CML740/675 Chemistry of Heterocyclic Compounds**  
3 Credits (3-0-0)  
Chemistry of heterocyclic compounds containing one, two and three heteroatoms. Total synthesis of representative natural products.

**CML741 Organo and organometallic catalysis**  
3 Credits (3-0-0)  

**CML742 Reagents in Synthetic Transformations**  
3 Credits (3-0-0)  
The course will cover the applications of various oxidation and reduction reactions in organic chemistry with special emphasis on special reagents that are used for selective transformations. Use of organolithium and organoboron compounds in organic synthesis and olefin metathesis will also serve a part of the course.

**CMD799 Minor project**  
3 Credits (0-0-6)

**CML801 Molecular Modelling and Simulations: Concepts and Techniques**  
3 Credits (3-0-0)  
Review of Basic Concepts: Length and Time Scales, Intermolecular Interactions and Potential Energy Surfaces, Evaluation of Long-range interactions Static and Dynamic Properties of Simple and Complex Liquids Molecular Dynamics: Microcanonical and other ensembles; Constrained simulations; non-equilibrium approaches Monte Carlo Methods: Random Numbers and Random Walk, Metropolis Algorithm in various ensembles, Biased Monte Carlo Schemes Free Energy Estimations: Mapping Phase Diagrams, Generating Free Energy Landscapes, Collective Variables Rare Event Simulations and Reaction Dynamics

**VII. Advanced Topics: First principles molecular dynamics, Quantum Monte Carlo methods, Coarse-Graining and Multiscale Simulations for Nanoscale Systems, Quantum mechanics/molecular mechanics (QM/MM) approaches. (To some extent, coverage of advanced topics will depend on research interests of students and faculty since this is a Pre-Ph.D. course).**

**CMD806 Major Project Part-I**  
6 Credits (0-0-12)

**CMD807 Major Project Part-II**  
12 Credits (0-0-24)
Department of Civil Engineering

**CVL100 Environmental Science**
2 Credits (2-0-0)
Pollutant sources and control in air and water, solid waste management, noise pollution and control, cleaner production and life cycle analysis, reuse, recovery, source reduction and raw material substitution, basics of environmental impact assessment, environmental risk assessment and environmental audit, emerging technologies for sustainable environmental management, identification and evaluation of emerging environmental issues with air, water, wastewater and solid wastes.

**CVL111 Elements of Surveying**
4 Credits (3-0-2)

**CVL121 Engineering Geology**
3 Credits (3-0-0)

**CVP121 Engineering Geology Lab**
1 Credit (0-0-2)
Pre-requisites: CVL121 or concurrent with CVL121
Geological Maps, Geological Mapping – contouring, topo sheets, outcrops, apparent and true dips, three point problems, depth and thickness problems, joints, faults; Megascopic and Microscopic identification of Minerals and Rocks, Engineering properties of rocks, refraction and resistivity methods, Guided tour through representative geological formations and structures.

**CVL141 Civil Engineering Materials**
3 Credits (3-0-0)

**CVL212 Environmental Engineering**
4 Credits (3-0-2)
Pre-requisites: CVL100
Water and wastewater treatment overview; Unit processes: systems of water purification processes (sedimentation, coagulation-flocculation, softening, disinfection, adsorption, ion exchange, filtration) and kinetics in unit operation of water purification-theory and design aspects; distribution of water layout systems: design aspects; Wastewater engineering: systems of sanitation, wastewater collection systems design and flows;Characteristics and microbiology of wastewater, BOD kinetics; Unit processes for wastewater treatment (screening, sedimentation; biological aerobic and anaerobic process)-theory and design aspects; Biological processes (Nutrient and phosphorous removal); advanced wastewater treatment-theory and design aspects; Air pollution (health effects, regulatory standards, dispersion, stacks, control systems); Municipal solid waste management; Noise pollution.

**CVL222 Soil Mechanics**
3 Credits (3-0-0)
Origin and Classification of Soils; Phase Relationships; Effective Stress Principle; Effective Stress Under Hydrostatic and 1D flow; Permeability; Flow Through Soils–Laplace equation, flowmets, seepage; Contaminant Transport; Compressibility; Consolidation; Terzaghi's 1D Consolidation Theory; Shear Strength; Drainage Conditions; Pore Water Pressure; Mohr’s Circle; Failure Envelope and Strength Parameters; Factors Affecting Shear Strength; Critical State frame work; Behaviour of soils under cyclic loading, Liquefaction; Compaction; Engineering properties of Natural soils, Compacted Soils and modified soils; Site Investigations; Soil deposits of India.

**CVP222 Soil Mechanics Lab**
1 Credit (0-0-2)
Pre-requisites: CVL222 or concurrent with CVL222
Visual Soil Classification; Water Content; Atterberg Limits; Grain Size Analysis; Specific Gravity; Permeability; standard proctor compaction test, consolidation site, site investigations and introduction to triaxial testing.

**CVL242 Structural Analysis I**
3 Credits (3-0-0)
Pre-requisites: APL108

**CVP242 Structural Analysis Lab**
1 Credit (0-0-2)
Pre-requisites: CVL242 or Concurrent with CVL242
Determination of forces and displacements in statically determinate and indeterminate trusses, Influence Line Diagram for Trusses, Measurement of bending moment and shear forces in beams, Determination of Elastic Properties of Beams, Verification of the Moment Area Theorem, Maxwell Betti Theorem, Influence Line Diagram for Displacement, Support Reaction, Shear Force at an Intermediate Section and Bending Moment, Determination of Carry over Factor, Verification of Carry Over Factor, Determination of displacements in curved members, Analysis of Elastically Coupled Beams, Determination of horizontal reactions in two and three hinged arches, experiment on cable structures.

**CVL243 Reinforced Concrete Design**
3 Credits (3-0-0)
Pre-requisites: CVL141
Design Philosophy: Working stress and limit state design concepts; Design of and detailing of RC beam sections in flexure, shear, torsion and bond; Design for serviceability; Design of RC beams, One way and two way RC slabs, RC short and long columns, RC footings.

**CVP243 Materials and Structures Laboratory Concrete**
1.5 Credits (0-0-3)
Testing of cement, testing of aggregates, mixture design and testing, non-destructive tests, testing of reinforcement, behaviour of reinforced
Concrete beams under flexure and torsion, behaviour of reinforced concrete slabs under uniform and point loads, behaviour of reinforced concrete columns under concentric and eccentric loads.

**CVL244 Construction Practices**
2 Credits (2-0-0)
Pre-requisites: EC35
Introduction and role of technologies, Construction technologies in RC Buildings for Reinforcement, Formwork, and concreting activities, Excavation and Concreting equipment, Formwork material and Design Concepts, Formwork system for Foundations, walls, columns, slab and beams and their design, Flying Formwork such as Table form, tunnel form. Slipform, temporary structures failure, Determining construction loads and ensuring safety of slabs during construction of high rise buildings- shoring, reshoring, preshoring and backshoring technology, Top down construction technology for high rise and underground construction, Bridge construction including segmental construction, incremental construction and push launching techniques, Prefab construction.

**CVL245 Construction Management**
2 Credits (2-0-0)
Pre-requisites: EC35
Introduction to construction projects, stakeholders, phases in a project, Cost estimation from clients perspective, Project selection using time value of money concept, construction contract, cost estimate – contractors perspective, Project planning and network analysis-PERT, CPM, and Precedence Network, Resource scheduling, Time Cost trade off, Time -cost monitoring and control using S-curve and earned value analysis, Construction claims and disputes, and introduction to construction quality and safety.

**CVL261 Introduction to Transportation Engineering**
3 Credits (3-0-0)
Pre-requisites: CVL111
Transportation systems and their classification; Role of transportation with respect to socio-economic conditions; Transportation planning process; Road user and the vehicle; Geometric design of roads: horizontal alignment, vertical alignment, cross-section elements; Relevant geometric design standards; Pavements: flexible and rigid; Characterization of pavement materials; Analysis and design of pavement systems; Pavement design specifications; Pavement construction process; Pavement performance; Traffic engineering; Traffic characteristics; Fundamental relationships; Theories of traffic flow; Intersection design; Design of traffic signs and signals; Highway capacity.

**CVP261 Transportation Engineering Lab**
1 Credit (0-0-2)
Pre-requisites: CVL261 or Concurrent with CVL261
Introduction to material behavior; Characterization of materials used in pavement construction: soil, aggregate, asphalt, asphalt concrete; Introduction to traffic survey methodologies; Traffic surveys: speed studies, intersection study.

**CVL281 Hydraulics**
4 Credits (3-1-0)
Pre-requisites: APL107

Boundary Layer Theory: Navier Stokes Equation, Boundary Layer Equation in 2-dimension, Boundary layer characteristics, Integral Momentum equation, onset of turbulence, properties of turbulent flow, skin friction, application of drag, lift and circulation to hydraulic problems.


Fluvial Hydraulics: Settling velocity, Incipient motion, Resistance to flow and bed forms, Sediment load and transport.

**CVP281 Hydraulics Lab**
1 Credit (0-0-2)
Pre-requisites: CVL281 or Concurrent with CVL281
Experiments on Open Channel Flow Hydraulics, Boundary Layer Theory, Pipe flow, Sediment transport.

**CVL282 Engineering Hydrology**
4 Credits (3-0-2)
Pre-requisites: APL107

Runoff: Hydrograph, Unit Hydrographs; Streamflow measurement.

Flood Routing: Hydrological routing for reservoirs and channels.

Frequency Analysis.

**CVL284 Fundamentals of Geographic Information Systems**
3 Credits (2-0-2)
Pre-requisites: COL100
What is GIS. Geographic concepts for GIS. Spatial relationships, topology, spatial patterns, spatial interpolation. Data storage, data structure, non-spatial database models. Populating GIS, digitizing data exchange, data conversion. Spatial data models, Raster and Vector data structures and algorithms. Digital Elevation Models (DEM) and their application. Triangulated Irregular Network (TIN) model. GIS application areas, Spatial analysis, quantifying relationships, spatial statistics, spatial search. Decision making in GIS context.

**CVL311 Industrial Waste Management**
3 Credits (3-0-0)
Pre-requisites: CVL212
Industrial waste types and characteristics; levels of environmental pollution due to industrial wastes; health issues due to industrial wastes; ecological and human health risk assessment due to industrial wastes; waste characterization methods; treatment methods-conventional and recent trends (for air, water, soil media); Prevention versus control of industrial pollution; hierarchy of priorities for industrial waste management; comparison of real-life industrial waste management practices (ex: superfund remedial sites, etc.); economics of industrial waste management and sustainability issues; environmental rules and regulations; clean up goals/disposal/reuse of treated wastes; Source reduction and control of industrial water and air pollution; Minimization of industrial solid and hazardous waste; Waste management case studies from various industries.

**CVL312 Environmental Assessment Methodologies**
3 Credits (3-0-0)
Pre-requisites: CVL212
Environmental issues related to developmental activities: Nature and characteristics of environmental impacts of urban and industrial developments.

Linkages between technology, environmental quality, economic gain, and societal goals.

Environmental indices and indicators for describing affected environment. Methodologies and environmental systems modeling tools for prediction and assessment of impacts on environmental quality (surface water, ground water, air, soil).


Environmental health and safety: Basic concepts of environmental risk and definitions; Hazard identification procedures; Consequence analysis and modeling (discharge models, dispersion models, fire and explosion models, effect models etc.).
Emerging tools for environmental management: Environmental Management Systems, Environmentally sound technology transfer, emission trading, international resource sharing issues, climate change, international environmental treaties and protocols. Case studies.

**CVL313 Air and Noise Pollution**  
3 Credits (3-0-0)  
**Pre-requisites:** CVL212  
Definitions, source and types of air and noise pollution, physical and chemical properties of air pollutants, secondary pollutants formation, instrument design and industrial application, gas phase adsorption and biofiltration, carbon Credit, global warming potential, case studies, data analysis, interpretation.

**CVL321 Geotechnical Engineering**  
4 Credits (3-1-0)  
**Pre-requisites:** CVL222  
Foundations: types, selection and design considerations; Bearing capacity of shallow foundations: Terzaghi theory, factors affecting; Bearing capacity of deep foundations: single pile analysis, pile tests, pile driving formula, group capacity, introduction to laterally loaded piles; Settlement of shallow and deep foundations: stress distribution, immediate and consolidation settlements; Slope stability analysis: infinite slopes, method of slices, Swedish circle method; Earth dams: types and design aspects; Earth pressure analysis: Rankine and Coulomb methods; Earth retaining structures: types, design aspects, underground structures; Earthquake geotechnics: evaluation of liquefaction potential, seismic slope stability, seismic bearing capacity; Machine foundations: types, analysis, design procedure; Ground improvement techniques: types, deep stabilization, anchorage, grouting; Geosynthetics: types, functions, properties; reinforced soil walls; Geoenvironment: Landfills - types, liner, cover, stability; Ash ponds - stage raising, design aspects.

**CVP321 Geotechnical Engineering Lab**  
1 Credit (0-0-2)  
**Pre-requisites:** CVL321 or Concurrent with CVL321  
Vane shear test, Direct shear test, Specimen preparation, Unconfined compression test, Unconsolidated undrained test, Consolidated drained test, Consolidated undrained test with pore water pressure measurement.

**CVL341 Structural Analysis II**  
3 Credits (3-0-0)  
**Pre-requisites:** CVL242  
Determinacy and stability; Method of consistent deformations-Matrix formulation, Application to beams, trusses and frames; Slope-deflection method and Moment-distribution method- Beams and frames with uneven loading, support settlements, dealing with symmetry and anti-symmetry, Non-sway and sway frames; Matrix stiffness method; Matrix flexibility method; Energy methods; Approximate methods of analysis; Direct stiffness method for computer applications including computational aspects and MATLAB Assignments.

**CVL342 Design of Steel Structures**  
3 Credits (3-0-0)  
**Pre-requisites:** CVL242  
Structural steel and properties, Design philosophy-Working stress and limit state; Connection types- Riveted, bolted and welded; Design of tension, compression and flexural members; Design of members subjected to combined loadings-Axial and bending, Torsion, Biaxial bending; Column bases, Gantry and plate girders; Roof trusses; Plastic design; Introduction to stability concepts, Design of shed-type structures.

**CVP342 Materials and Structures Laboratory-Steel**  
1 Credit (0-0-2)  
Basic properties of structural steel; Tensile stress-strain behaviour; Buckling of slender columns, Flexural testing of beams; Torsional behaviour of beams, Unsymmetrical bending; Lateral-torsional buckling; Flexural-torsional buckling; Connection behaviour; Tension-field action in plate girders.

**CVL344 Construction Project Management**  
3 Credits (3-0-0)  
**Pre-requisites:** CVL245  
Additional network analysis- Ladder Network, LoB,etc., Time constrained Resource allocation and resource constrained problems, Time Cost trade off, project updating and control using EVM, Construction contracts and its types, tendering procedure, estimation and fixing of markup, bidding models, claims compensation and disputes, dispute resolution models, FIDIC contracts, Linear programming, Problems in construction, Formulation, Graphical solution, Simplex method, Dual problem, sensitivity analysis and their application to Civil engineering, Transportation Assignment problems and their applications.

**CVL361 Introduction to Railway Engineering**  
3 Credits (3-0-0)  
**Pre-requisites:** CVL261  
History: Indian railways, international perspective; Railway track gauge: factors affecting gauge choice, multi gauge; New project planning and surveys; Alignment of railway track; Structure of railway track: rails, sleepers, ballast, subgrade, track fitting; Structural design of railway track: stresses, creep; Geometric design of rail track: gradients, curves, superelevation; Locomotives and rolling stock: resistance and tractive power; Points and crossings; Railway stations and yards; Traffic control; Signalling and interlocking; Public rail transportation in metros.

**CVL381 Design of Hydraulic Structures**  
4 Credits (3-0-2)  
**Pre-requisites:** CVL281 and CVL282  
**Input studies.**  
CVL385 Frequency Analysis in Hydrology
2 Credits (2-0-0)
Pre-requisites: CVL282
Concepts of probability in Hydrology, Random events, Random variables; moments and expectations; Common probabilistic distributions; goodness of fit tests; Stochastic processes.

CVL386 Fundamentals of Remote Sensing
3 Credits (2-0-2)
Pre-requisites: EC 75
What is Remote Sensing? Historical development of remote sensing, Remote sensing components, Data collection and transmission, Sensors and satellite imageries, Electromagnetic energy and spectrum, Wavebands, Interactions of electromagnetic energy with atmosphere and earth's surface, radiometric quantities, Photogrammetry and aerial photography, Vertical and tilted photographs, Photographic materials, Photo-processes, Stereoscopic viewing, fly view, Aerial mosaics, Various satellite systems and monitoring programs, Data Products, Satellite data, Data formats, Data acquisition for natural resources management and weather forecast, Random errors and least square adjustment, Coordinate transformation, Photographic interpretation, Image processing, Potential applications of remote sensing in diverse areas and decision making, Integrated use of remote sensing and GIS, Case studies.

CVD411 B.tech. Project Part-I
4 Credits (0-0-8)

CVD412 B.tech. Project Part-II
6 Credits (0-0-12)

CVL421 Ground Engineering
3 Credits (3-0-0)
Pre-requisites: CVL321

CVL422 Rock Engineering
3 Credits (3-0-0)
Pre-requisites: CVL321
Geological classification, rock and rock mass classification, strength and deformation behaviour of rocks, pore pressures, failure criteria, laboratory and field testing, measurement of in-situ stresses and strains, stability of rock slopes and foundations, design of underground structures, improvement of in situ properties of rock masses and support measures.

CVL423 Soil Dynamics
3 Credits (3-0-0)
Pre-requisites: CVL321
Engineering problems involving soil dynamics; Role of inertia; Theory of Vibrations: Single and two-degree freedom systems; Wave propagation in elastic media; Soil behaviour under cyclic/dynamic loading; Small and large strain dynamic properties of soils; Design criteria for machine foundations; Elastic homogeneous half space and lumped parameter solutions; Vibration isolation; Coadal provisions; Causes of Earthquakes; Strong Ground Motion: Measurement, characterization and estimation; Amplification theory and ground response analysis; Liquefaction of soil and its remediation; Seismic slope stability; Seismic bearing capacity and earth pressures.

CVL424 Environmental Geotechniques & Geosynthetics
3 Credits (3-0-0)
Pre-requisites: CVL321
Causes and effects of subsurface contamination; Waste disposal on land; Characteristics of solid wastes; Waste Containment Principles; Types of landfills; Planning of landfills; Design of liners and covers for landfills; Environmental Monitoring around landfills; Detection, control and remediation of subsurface contamination; Geotechnical re-use of solid waste materials.

Types of geosynthetics; Manufacturing; Functions; Testing and evaluation; Designing with geotextiles, geogrids, geonets and geomembranes.

CVL431 Design of Foundations & Retaining Structures
3 Credits (3-0-0)
Pre-requisites: CVL321
Earth Retaining Structures: Types, Earth pressures, Design of rigid, flexible and reinforced soil retaining walls, braced excavations, and ground anchors for retaining walls. Introduction to design of foundation for dynamic loads.

CVL432 Stability of Slopes
2 Credits (2-0-0)
Pre-requisites: CVL321
Slope Stability: Short term and long term stabilities; Limit equilibrium methods; Infinite slopes; Finite height slopes - Swedish method, Bishop's simplified method, Stability charts; Conditions of analysis - steady state, end of construction, sudden draw down conditions; Factor of safety; Coadal provisions; Earthquake effects. Seepage Analysis: Types of flow; Laplace equation; Flownet in isotropic, anisotropic and layered media; Entrance-exit conditions; Theoretical solutions; Determination of phreatic line. Earth Dams: Introduction; factors influencing design; Design of components; Instrumentation; Reinforced Slopes: Steep slopes; Embankments on soft soils; Reinforcement design.

CVL433 FEM in Geotechnical Engineering
3 Credits (3-0-0)
Pre-requisites: CVL321

CVP434 Geotechnical Design Studio
2 Credits (0-0-4)
Pre-requisites: CVL321
Seepage analysis through an earth dam. Slope stability analysis of a dam. Settlement analysis of shallow and deep foundations; Analysis and design of retaining structures; Analysing the structural forces in a tunnel lining.
CVL435 Underground Structures
2 Credits (2-0-0)
Pre-requisites: CVL321
Overlaps with: CVL713
Types and classification of underground structures, Functional aspects, Sizes and shapes, Support systems, Design methodology.
Stresses-deformation analysis of openings (circular, elliptical, spherical, ellipsoidal) using analytical and numerical methods.
Design of underground structures using analytical methods, empirical methods and observational methods, Rock support interaction analysis, NATM Hydraulic tunnels, Shafts, Tunnel portals, Metro tunnels.

CVL441 Structural Design
3 Credits (3-0-0)
Pre-requisites: CVL241, CVL243, CVL342
Design of Reinforced Cement concrete (RCC) Structures — Building frames Liquid retaining structures, Earth Retaining walls.
Design of Steel Structures — Plate girders, gantry girders and steel bridge components.

CVP441 Structural Design & Detailing
1.5 Credits (0-0-3)
Pre-requisites: CVL243, CVL342
Part-I Concrete Structures
Computer-aided analysis and design of real-life reinforced concrete (RC) structure. Dimensioning of concrete elements based on modular formworks available in construction industry. Detailing of concrete elements in terms of reinforcement, curtailment, lapping, splicing of reinforcements and connection with adjoining elements in the structure; member drawings. Joint detailing from ductility view point, Indian standard (IS) code recommendations and practical intricacies involved in casting and handling of the RC members, its sequence of construction and constructability.
Part-II Steel Structures
Computer-aided analysis and design of real-life steel structure. Steel member details as per shop/field activities for welding/bolting; i.e. fabrication (shop) drawings. Connection details, gusset plate design and detailing from ductility view point, Indian standard (IS) code recommendations and practical intricacies involved in fabrication and handling of the steel members, its sequence of erection and constructability.

CVL442 Structural Analysis-III
3 Credits (3-0-0)
Pre-requisites: CVL341
Introduction to FEM for structural analysis with review of energy methods-2D plane stress and plane strain elements, beam element, 2D bending element, example problems, elements of structural dynamics-free and forced vibration of SDOF system, treatment of impact and arbitrary loading, frequency and time domain analysis; free vibration mode shapes and frequencies of MDOF systems; normal mode theory for forced vibration analysis of MDOF system; example problems. Elements of plastic analysis; upper and lower bound theorems; methods of collapse mechanism; application to beams and multistory frames; example problems.

CVL443 Prestressed Concrete & Industrial Structures
3 Credits (3-0-0)
Pre-requisites: CVL241, CVL243, CVL341
Industrial Structures—Analysis and design of Cylindrical shell structures, Folded plates, Chimneys, Silos, Bunkers.

CVL461 Logistics and Freight Transport
3 Credits (3-0-0)
Overlaps with: SML843
Pre-requisites: CVL261 or Instructor’s permission
Evolution of freight and logistics; Interrelationships between society, environment and freight transport; Survey methodologies to understand freight movement; Cost measurement: Production, Holding, Transportation, Handling; Effect of internal and external variables on cost; Demand forecasting; Inventory planning and management; Transportation and distribution network: Design, Development, Management; Ware house operations; Pricing: Perishable, seasonal demand, uncertainty issues; Vehicle routing: One-to-one distribution, One-to-many distribution, Shortest path algorithm, Quickest time algorithm; Logistics information system; Designing and planning transportation networks; Multi-modal transportation issues.

CVL462 Introduction to Intelligent Transportation Systems
3 Credits (3-0-0)
Pre-requisites: CVL261
Introduction to Intelligent Transportation Systems (ITS); ITS Organizational Issues, the fundamental concepts of Intelligent Transportation Systems (ITS) to students with interest in engineering, transportation systems, communication systems, vehicle technologies, transportation planning, transportation policy, and urban planning. ITS in transportation infrastructure and vehicles, that improve transportation safety, productivity, environment, and travel reliability. Mobile device applications of ITS such as trip planners.

CVL481 Water Resources Management
3 Credits (3-0-0)
Pre-requisites: CVL282 and EC 100
Scope of water resources management, Global trends in water utilization, Crop water requirements and irrigation, Planning and desing of various irrigation methods, Soil salinity and water logging, Hydropower systems management, Strom water system management, Economic analysis of water resources projects, Flood Control studies.

CVL482 Water Power Engineering
3 Credits (2-0-2)
Pre-requisites: CVL281 and EC 100
Basic principle of hydropower generation, Hydropower Project Planning, Site selection, Hydropower development schemes, Reservoir storage, Assessment of power potential, Hydrologic analysis: Flow duration and load duration curves, Dependable flow, Design flood, Reservoir operation; Hydraulic design of various components of hydropower plants: intakes, hydraulic turbines, conduits and water conveyance, penstock; Performance characteristics of turbines, Specific unit quantities, Hydraulic power design, Power house design, Water hammer and surge analysis, Surge tanks, Small and micro hydro power development, tidal plants, Current scenarios in hydropower development, Project feasibility, Impact of hydropower development on water sources systems, environment, socioeconomic conditions and national economy.

CVL483 Groundwater & Surface-water Pollution
2 Credits (2-0-0)
Pre-requisites: CVL282 and EC 100
Groundwater contamination; River and Lake pollution; Pollution sources, Geogenic and anthropogenic pollution; Soil Pollution; Contaminant transport mechanisms; Pollution control, remediation technologies and role of wetlands. Environmental impact assessments, Hydrological impacts, Vulnerability, Case studies.

CVP484 Computational Aspects in Water Resources
3 Credits (1-0-4)
Pre-requisites: CVL281 and EC 100
Numerical Interpolation and Integration and application to water resources problems; Numerical solution of differential equations in Water Resources such as groundwater flow, pipe flows, open channel flows.

**CVL485 River Mechanics**  
3 Credits (2-0-2)  
Pre-requisites: CVL281 and EC 100  
Introduction, river morphology, drainage patterns, stream order. Properties of mixture of sediment and water. Incipient motion and quantitative approach to incipient motion, channel degradation and armoring. Bed forms and resistance to flow, various approaches for bed load transport, suspended load profile and suspended load equations, total load transport including total load transport equations. Comparison and evaluation of sediment transport equations. Stable channel design with critical tractive force theory.

**CVL486 Geo-informatics**  
3 Credits (2-0-2)  
Pre-requisites: EC 100  
Geospatial and temporal data, Data acquisition, Global positioning system, Global Navigational Satellite System, GPS survey, Aerial and laser scanning surveys, Data acquisition using remote sensing techniques, Sensors and satellite imageries, Stereoscopic 3D viewing, Fly view, Satellite data formats and specifications, Data acquisition for natural resources management and weather forecast, Image processing and interpretation, GIS concepts and Spatial data models, Introduction to microwave remote sensing & LiDAR, Geospatial analysis, DEM/DTM generation & 3D modelling, Inferential statistics, Spatial interpolation, Integrated use of geospatial technologies, Applications and case studies.

**CVD700 Minor Project**  
3 Credits (0-0-6)

**CVL700 Engineering Behaviour of Soils**  
3 Credits (3-0-0)  

**CVP700 Soil Engineering Lab**  
3 Credits (0-0-6)  
Laboratory Tests: Preparation of samples - Sand and Clay, Consolidation test, Direct shear test, Vane shear test, Unconfined compression test, Unconsolidated undrained triaxial test, Consolidated drained triaxial test, Consolidated undrained triaxial test with pore water pressure measurement, Free swell index test, Swelling pressure test.

Field Investigations and field tests: Drilling of bore hole, standard penetration test, undisturbed and representative sampling, SCP Test, Electrical resistivity, Plate load test, Pile load test.

**CVL701 Site Investigation and Foundation Design**  
3 Credits (3-0-0)  

**CVL702 Ground Improvement and Geosynthetics**  
3 Credits (3-0-0)  

**CVL703 Geo-environmental Engineering**  
3 Credits (3-0-0)  
Subsurface Contamination and Contaminant Transport; Waste disposal on Land and containment, Landfills and Slurry ponds, Monitoring of subsurface contamination, Control and Remediation. Engineering Properties of waste and geotechnical reuse, erosion control, sustainability, energy geotechnics.

**CVL704 Finite Element Method in Geotechnical Engineering**  
3 Credits (3-0-0)  

**CVL705 Slopes and Retaining Structures**  
3 Credits (3-0-0)  

**CVL706 Soil Dynamics and Earthquake Geotechnical Engineering**  
3 Credits (3-0-0)  
Engineering problems involving soil dynamics; Role of inertia; Theory

**CVL707 Soil-Structure Interaction Analysis**
3 Credits (3-0-0)

**CVL708 Geotechnology of Waste Disposal Facilities**
3 Credits (3-0-0)
Integrated waste management, Detailed design of MSW Landfills and HW Landfills including individual components, Closure of Old landfills, Expansion of old landfills, Ashpands and Tailings Ponds, Seismic Stability; Disposal of Nuclear Waste.

**CVL709 Offshore Geotechnical Engineering**
3 Credits (3-0-0)

**CVD710 Minor Project (CEU)**
3 Credits (0-0-6)

**CVL710 Engineering Properties of Rocks and Rock Masses**
3 Credits (3-0-0)

**CVP710 Rock Mechanics Laboratory 1**
3 Credits (0-0-6)
Tests and test procedures, Rock samples, Specimen preparation, Coring, cutting and lapping. Tolerance limits.


**CVL711 Structural Geology**
3 Credits (3-0-0)

**CVL712 Slopes and Foundations**
3 Credits (3-0-0)

**CVL713 Analysis and Design of Underground Structures**
3 Credits (3-0-0)

**CVL714 Field Exploration and Geotechnical Processes**
3 Credits (3-0-0)
Surface and sub surface exploration methods. Aerial and remote sensing techniques, Geophysical methods, electrical resistivity, seismic refraction, applications. Rock drilling, Core samplers, Core boxes, Core orientations.


Ground improvement techniques. Compaction, Grouting, Types of grouts, technique, Rheological models. Viscous and viscoplastic flows. Spherical and radial flows, Shotcrete, Ground anchors, Rock bolts.
CVL715 Excavation Methods and Underground Space Technology
3 Credits (3-0-0)


CVL716 Environmental Rock Engineering
3 Credits (3-0-0)
Theory: Stress-strain behaviour of rocks and rock masses: Elastic, elasto-plastic, and brittle, Crack phenomena and mechanisms of rock fracture.
Temperature, pressure and water related, problems, Effect of temperature on rock behaviour. Fluid flow through intact and fissured rocks. Time dependent behaviour of rocks: Creep, Viscoelasticity and Viscoplasticity
Continuum and discontinuum theories: Equivalent material, Block and Distinct element.

CVD720 Major thesis part1
6 Credits (0-0-12)

CVS720 Independent Study
3 Credits (0-3-0)
Specific to the context of the problem decided by the supervisor.

CVL720 Air Pollution and Control
3 Credits (3-0-0)
Air-pollution; Air Pollution Effect on Plants; Air Pollution effect on Human health; Air quality monitoring; Air Pollution Meteorology; Gaussian Plume model; Urban Air Pollution; Air Pollution from Industries; Air Pollution control; Air pollution indices; standards; norms; rules and regulations; Indoor Air Pollution.

CVD721 Major Thesis Part-II
12 Credits (0-0-24)

CVL721 Solid Waste Engineering
3 Credits (3-0-0)

CVL722 Water Engineering
3 Credits (3-0-0)
Water quality parameters-conventional contaminants and emerging contaminants; Sedimentation; Coagulation and flocculation; Filtration-mechanisms and interpretations; Ion exchange and adsorption; Disinfection; Reverse osmosis, electrodialysis, desalination.

CVL723 Wastewater Engineering
3 Credits (3-0-0)
Wastewater quality parameters, Biological processes; Microbial growth kinetics; Modeling of suspended growth systems; concepts and principles of carbon oxidation, nitrification, denitrification, methanogenesis. Biological nutrient removal; Anaerobic treatment; Attached growth reactors; decentralised wastewater treatment systems; constructed wetlands; Design of pretreatment, secondary treatment, and tertiary disposal systems. Sludge stabilization, treatment, sludge thickening, sludge drying, aerobic and anaerobic digestion of sludges; reliability and cost effectiveness of wastewater systems; Emerging contaminants in wastewater-treatment issues.

CVL724 Environmental Systems Analysis
3 Credits (3-0-0)
Introduction to natural and man-made systems. Systems modeling as applied to environmental systems. Nature of environmental systems, the model building process addressing to specific environmental problems. Strategies for analyzing and using environmental systems models. Fate and transport models for contaminants in air, water, and soil. Optimization methods (search techniques, linear programming, non-linear programming, dynamic programming) to evaluate alternatives for solid-waste management and water and air pollution control. Optimization over time. Integrated environmental management strategies addressing multi-objective and multi-stakeholder planning.

CVL725 Environmental Chemistry and Microbiology
3 Credits (1-0-4)
Chemical equilibria and kinetics fundamentals; Acids and bases; Titrations; Acidity; Alkalinity; Buffers and buffer intensity; Chemical equilibrium calculations; pC-pH diagram; Langiger index; Solubility diagram; Oxidation and reduction reactions; Cell structure; Types of microorganisms in environment;metabolic classification of organisms; laboratory procedure for determining chemical and microbial parameters, Introduction to advanced instruments.

CVD726 Minor Project
3 Credits (0-0-6)

CVL727 Environmental Risk Assessment
3 Credits (3-0-0)
Basic concepts of environmental risk and definitions; Human health risk and ecological risk assessment framework;Hazard identification procedures and hazard prioritization; Environmental risk zonation; Consequence analysis and modelling (discharge models, dispersion models, fire and explosion models, effect models etc.). Estimation of incident frequencies from historical data, frequency modelling techniques e.g., Fault tree analysis (FTA) and Event tree analysis (ETA), Reliability block diagram. Human factors in risk analysis; Risk management & communication. Rules, regulations and conventions.

CVL728 Environmental Quality Modeling
3 Credits (3-0-0)
Plume Rise Models; Introduction to Air Quality Modelling;Turbulence fundamentals;Basic diffusion equation; ficks law; deterministic; numerical and statistical modeling approach; Fundamentals of Receptor modelling; Dispersion and receptor models; Fundamentals
of indoor air quality modelling techniques; Fundamentals of water quality modelling: surface water and ground water models; Fate and transport of conservative and non-conservative pollutants. Modelling as a tool for strategising pollution prevention and control.

**CVL729 Environmental Statistics and Experimental Design**  
3 Credits (2-0-2)  
Introduction on environmental data, environmental statistics estimation (concentration, frequency of detection, minimum detection limit, sample size), frequency and probability distributions, inferences concerning mean and variance, confidence Interval estimation, hypotheses test, ANOVA, regression, goodness of fit, factorial experimentation, exceedence factor, intervention model, Case studies.

**CVL730 Hydrologic Processes and Modeling**  
3 Credits (3-0-0)  

**CVP730 Simulation Laboratory-I**  
1.5 Credits (0-0-3)  
Basic of Fortran 90, Fortran 95 and computing, Numerical solution of different types of partial differential equations: parabolic equation, elliptical equation, hyperbolic equation, Backwater curve analysis; Groundwater flow problems, Pipe network analysis, Unsteady channel flow.

**CVS730 Minor Project (CEW)**  
3 Credits (0-0-6)

**CVL731 Optimization Techniques in Water Resources**  
3 Credits (3-0-0)  
Optimization techniques commonly used in water resources planning & management, water infrastructures, and irrigation and hydropower projects; Linear programming and duality, Network flow algorithms, Dynamic programming, Nonlinear programming, Geometric and Goal programming, Introduction to modern heuristic methods like genetic algorithm and simulated annealing, Multiobjective optimization, Applications and case studies in water resources, agriculture, environment and other areas of science & engineering.

**CVP731 Simulation Laboratory-II**  
1.5 Credits (0-0-3)  
Simulate hydraulic, hydrologic, pipe flow, water hammer using various softwares such as Visual Mod Flow, SWAT, HYDRUS, Hytran, MIKE, Bentley Software, Fluent, HMS, SAMS.

**CVL732 Groundwater Hydrology**  
3 Credits (3-0-0)  

**CVL733 Stochastic Hydrology**  
3 Credits (2-0-2)  
Concepts of probability and Random variables; moments and expectations; Common probabilistic distributions and estimation of parameters; goodness of fit tests; Modelling of Hydrologic High and Low Extremes, Regional Frequency Analysis, Stochastic processes and modelling of stochastic time series; Markov Chains and Probabilistic Theory of Reservoir Storages.

**CVL734 Advanced Hydraulics**  
3 Credits (3-0-0)  

**CVL735 Finite Element in Water Resources**  
3 Credits (3-0-0)  
Introduction to finite element method, Mathematical concepts and weighted residual techniques, Spatial discretization, Shape functions, Isoparametric elements, Explicit and implicit time marching schemes, Equation assembly and solution techniques, Application: Navier-Stokes equations, dispersion of pollutants into ground and surface water, Flow through earthen dams, seepage beneath a hydraulic structure, Groundwater flow in confined and unconfined aquifers.

**CVL736 Soft Computing Techniques in Water Resources**  
3 Credits (2-0-2)  
Artificial Intelligence; Expert Systems; Artificial Neural Networks: Introduction, Training, Applications in Hydrology; Genetic Algorithms; Fuzzy Logic Systems, Fuzzy Set Theory, Predictive and Descriptive Data Mining; Classification Methods: Decision trees, NN, Bayesian, ANN, SVM, Applications; Association Analysis: Cluster Analysis - K-means, Fuzzy, Self-Organising maps; Anomaly detection; Applications in Water Resources - Forecasting, Regionalization.

**CVL737 Environmental Dynamics and Management**  
3 Credits (3-0-0)  
Environmental property and processes, Environmental simulation models, Elements of environmental impact analysis, Impact assessment methodologies, Framework of environmental assessment, Environmental impact of water resources projects, Assessment of hydrological hazards, Environmental management, Case studies.

**CVL738 Economic Aspects of Water Resources Development**  
3 Credits (3-0-0)  
Economics of water and development, Basic economic concepts, Financial analysis of a project, Pricing concepts, Benefit-cost-sensitivity analysis, Capital budgeting and cost allocation, Economics of natural resources management, Hydro economic model, Hydro-economic Risk assessment, Economics of river restoration, Economics of trans-boundary water resources management.

**CVL740 Pavement Materials and Design of Pavements**  
4 Credits (3-0-2)  
Pre-requisites: M.Tech: Nil; B.Tech: Instructor's permission  
Components of pavement structure and its requirements; Materials used in pavement construction: aggregate, Portland cement, asphalt, Portland cement concrete, asphalt concrete; Aggregates; production, properties, testing procedures, gradation and blending; Portland cement based materials: mixture design, production, properties, testing, construction; Asphalt binder: refining process, properties, testing procedures, grading systems; Asphalt concrete mixture design; fundamentals of mix design procedure, mixture volumetrics, current mix design procedures; Production and construction practices; Stresses and strains in pavement system: traffic, environment considerations; Design of pavements: new, overlay; Pavement performance; Drainage consideration.

**CVL741 Urban and Regional Transportation Planning**  
4 Credits (3-0-2)  
Pre-requisites: M.Tech: Nil; B.Tech: Instructor's permission  
Fundamentals of transportation planning. Components of transportation system and their interaction. Historical development and current status of techniques used in travel demand forecasting; Economic Theory of travel demand forecasting; trip generation, trip distribution, mode choice, traffic assignment models. Integration of landuse transport
models. Comparison and evaluation of various models. Simultaneous travel demand models: Parameter Estimation and Validation. Travel Data collection and use of surveys. The role of transportation planning in the overall regional system. Methodology and models for regional transportation system, planning, implementation framework and case studies. Applications to passenger and freight movement in urban area. Implications for policy formulations and analysis.

**CVL742 Traffic Engineering**  
4 Credits (3-0-2)  
Pre-requisites: M.Tech: Nil; B.Tech: Instructor's permission  

**CVL743 Airport Planning and Design**  
3 Credits (3-0-0)  
Pre-requisites: M.Tech: Nil; B.Tech: Instructor's permission  
Overview of air transport; Forecasting demand-passenger, freight; Aircraft characteristics; Airport planning-requirements site selection, layout plan, Geometric design of runway, taxiway and aprons; Airport capacity-airside, landside; Passenger terminal-functions, passenger and baggage flow; Airport pavement design and drainage; Parking and apron design; Air cargo facilities; Air traffic control lighting and signage; Airport safety; Environmental impact of airports; Airport financing and economic analysis.

**CVL744 Transportation Infrastructure Design**  
3 Credits (2-0-2)  
Pre-requisites: M.Tech: Nil; B.Tech: Instructor's permission  
Transportation infrastructure: components, structural and functional requirements, capacity, level of service; Highway infrastructure: grade intersections, rotaries, interchanges; Railway infrastructure: trackbed design, grade-crossing design, embankment, retaining walls; Drainage infrastructure: culverts, bridges; Pedestrian infrastructure: pedestrian sidewalks, foot bridges; Miscellaneous: bus and truck terminals, parking facilities, guard rails, tunnels, underpasses;

**CVL745 Modeling of Pavement Materials**  
3 Credits (2-0-2)  
Pre-requisites: M.Tech: Nil; B.Tech: Instructor's permission  
Role of constitutive modeling; Laboratory testing in relation to constitutive modeling: elastic modulus, resilient modulus, complex modulus, creep, rheological tests; Introduction to continuum mechanics: strain tensor, stress tensor, isotropy, anisotropy, constitutive relationships; Factors affecting material behavior: temperature, rate, time, confining pressure; Unbound materials: soil, aggregate; Bound materials: binding using asphalt, water, lime, polymer, fly ash, cement; Constitutive models: unbound materials, bound materials; Field performance of pavement materials: fatigue, rutting, temperature issues, moisture damage, permeability; Transfer functions to relate laboratory performance with field performance.

**CVL746 Public Transportation Systems**  
3 Credits (3-0-0)  
Pre-requisites: M.Tech: Nil; B.Tech: Instructor's permission  
This course discusses the role of urban public transportation modes, focusing on bus and rail systems. Operational and Technological characteristics are described, along with their impacts on capacity, service quality, and cost. Current practice and methods for data collection and analysis, performance evaluation, route and network design, frequency determination, and vehicle and crew scheduling are covered. Main topics include: Transit System; Estimation of Transit Demand; Route planning techniques; Bus Scheduling; Transit Corridor identification and planning; Mass Transport Management Measures; Integration of Public Transportation Modes. Public transport Infrastructure; Case Studies. Multimodal Transportation Systems.

**CVL747 Transportation Safety and Environment**  
3 Credits (3-0-0)  
Pre-requisites: M.Tech: Nil; B.Tech: Instructor's permission  
Scientific management techniques in planning, implementing, and evaluating highway safety programs, strategies to integrate and amplify safety in transportation planning processes., multidisciplinary relationships necessary to support effective traffic safety initiatives. Traffic Safety as public health problem, Injury indices and costing , emergency care, pollution inventory in urban areas, environment and safety standards.

**CVL750 Intelligent Transportation Systems**  
3 Credits (3-0-0)  
Pre-requisites: M.Tech: Nil; B.Tech: Instructor's permission  
Introduction to Intelligent Transportation Systems (ITS); ITS Organizational Issues, the fundamental concepts of Intelligent Transportation Systems (ITS) to students with interest in engineering, transportation systems, communication systems, vehicle technologies, transportation planning, transportation policy, and urban planning. ITS in transportation infrastructure and vehicles, that improve transportation safety, productivity, environment, and travel reliability. Mobile device applications of ITS such as trip planners, ETA s of public transit vehicles.

**CVD753 Minor Project in Transportation Engineering**  
3 Credits (0-0-6)  
Pre-requisites: M.Tech: Nil  
CVD754 Independent Study  
3 Credits (0-0-6)  
Pre-requisites: Instructor's permission  
CVD756 Minor Project in Structural Engineering  
3 Credits (0-0-6)  
The course content will be decided by the concerned faculty member (supervisor) who will be assigning the research project to the students registered for this course.

**CVL756 Advanced Structural Analysis**  
3 Credits (3-0-0)  

**CVP756 Structural Engineering Laboratory**  
3 Credits (0-0-6)  
Concrete: Concrete mix-design Evaluation of stress-strain response of plain, self-compacting and high-performance concrete; Behaviour of RC members under axial, flexure, shear torsion, and interaction; Behavior of slabs, Non-destructing testing. Response of structures and its elements against extreme loading events. Model testing: Models of plates, shells, and frames; Free and forced vibrations; Evaluation of dynamic modulus; Beam vibrations; Vibration isolation; Shear wall building model; Time and frequency-domain study. Smart materials; Photogrammetry for Displacement Measurement; Vibration Characteristics of RC Beams using Piezoelectric Sensors etc.

**CVS756 Independent Study (CES)**  
3 Credits (0-0-6)  
Course content will be decided by the concerned faculty member of structural engineering.
CVD757 Major Project Part-I (CES)
9 Credits (0-0-18)
Pre-requisites: programme core Credits+minimum 24 credits

CVL757 Finite Element Methods in Structural Engineering
3 Credits (2-0-2)

CVD758 Major Project Part-II (CES)
9 Credits (0-0-18)
Pre-requisites: CVD757 must be passed

CVL758 Solid Mechanics in Structural Engineering
3 Credits (3-0-0)
Pre-requisites: UG/Dual- 120 credits
Introduction; Historical developments; Theory of stress; Kinematics; Isotropic/ anisotropic linear elastic solids; Axioms of constitutive equations; Finite isotropic elasticity; Hypo/ hyperelasticity; Hardening plasticity; Viscoelasticity; Boundary Value Problems (BVPs); Plane elasticity; Polar coordinates; Torsion and bending of prismatic bars with general section; Elastic wave propagation; Current trends.

CVL759 Structural Dynamics
3 Credits (3-0-0)

CVL760 Theory of Concrete Structures
3 Credits (3-0-0)
Introduction: Historical developments, Material properties; Cracked concrete members under flexural moment and axial force; Deformations and collapse; M-P interaction. Beams without stirrups under flexural and torsional shear; Morsch and Regan theories; Skew-bending theory. Beams with stirrups under flexural and torsional shear: Plane and space truss analogies, Modified compression field theory, Unified theory, P-M-V-T interaction; Strut and tie model; Cracking: Bond slip, Development length, Tension softening, Durability detailing; Serviceability: Elastic, creep and shrinkage deformations; Elastic analysis: Redistribution of moments; Plastic analysis: Inelastic and hysteretic behaviour; Limit design, Confined concrete: Ductility detailing requirements; Buckling of columns; Concrete slabs: Yield line theory, Strip Theory; Reliability and safety: Limit state design method, Target reliability; Current trends: Constitutive modelling, Capacity design, Finite element analysis.

CVL761 Theory of Steel Structures
3 Credits (3-0-0)
Structural steel: Classifications, Grades, Behavioural characteristics, Plasticity and hardening; Material models: Simple, Rigid, Power function; Smooth hysteresic; Design methodology: Allowable, Limit state, Ultimate; Methods of analysis including second-order effects; Plastic design: Plate instabilities, Local buckling, Section classifications; Structural stability: Global buckling, Member and frames under axial and combined loading; Sway and non-sway frames; Design of members under combined bending, shear and torsion; Connections: Simple, Semi-rigid, Rigid; Plates girders: Simple post-critical theory, Tension-field theory, Section design, Stiffener requirements; Gantry girder; Grillage foundation; Earthquake-resistant design and detailing; Fire-resistant design; Fatigue-resistant design.

CVL762 Earthquake Analysis and Design
3 Credits (3-0-0)
Seismology; Seismic Risk and Hazard; Soil Dynamics and Seismic Inputs to Structures; Response Spectrum Analysis (RSA); Special Analysis; Nonlinear and Push-Over Analysis; Dynamic Soil-Structure Interaction (SSI); Earthquake Resistant Design Philosophy; Performance Based Earthquake Engineering; Code Provisions for Seismic Design of Structures; Retrofitting and Strengthening of Structures; Concept of Base Isolation Design and Structural Vibration Control; Advanced Topics in Earthquake Engineering.

CVL763 Analytical and Numerical Methods for Structural Engineering
3 Credits (3-0-0)

CVL764 Blast Resistant Design of Structures
3 Credits (2-0-2)
Blast Engineering: Explosion Phenomena, Shock Front, Fragmentation, Waves, Ground Shock, and Interaction with Structures; Structural Analysis for Impulsive Loading; Pressure-Impulse (PI) Diagrams; Material Behaviour under High Strain-Rate of Loadings; Blast Resistant Design of Structures; Performance-Based Blast Design; Progressive Collapse; Anti-Terrorism Planning and Design of Facilities; Blast Retrofitting; Indian/ International Standards and Codes of Practice; Numerical Analysis Tools for Blast Analysis using Finite Element (FE) Software and Hydrocodes.

CVL765 Concrete Mechanics
3 Credits (3-0-0)
Introduction; Rheological modelling of fresh concrete; Flowing concrete; Mechanics of hardened concrete: Failure criteria; Constitutive equations; Elasto-plasticity, visco-elasticity, fatigue, damage mechanics and fracture; Mechanics of hydrating concretes, Durability Mechanics, Transport processes; Drying shrinkage; Micromechanics , Numerical and analytical homogenisation, poromechanics , Crystalline growths and internal microstresses.

CVL766 Design of Bridge Structures
3 Credits (3-0-0)
Introduction, historical/ magnificent bridges; Site Selection, Planning, and Type of Bridges; Loads and Forces; Code Provisions for Design of Steel and Concrete Bridges; Analysis Methods, Grillage Analog; Theories of Lateral Load Distribution and Design of Superstructure: Slab Type, Beam-Slab, and Box Type; Distribution of Externally Applied and Self-Induced Horizontal Forces among Bridge Supports in Straight, Curved, and Skewed Decks; Continuous Type and Balanced Cantilever Type Superstructure; Temperature Stresses in Concrete...
Bridge Deck; Different Types of Foundations: Open, Pile, and Well Foundations; Choice of Foundation for Abutments and Piers; Design of Abutments, Piers, Pile/ Pier Caps; Effect of Differential Settlement of Supports; Bridge Bearings; Expansion Joints for Bridge Decks; Vibration of Bridge Decks; Parapet and Railings for Highway Bridges; Construction Methods; Segmental Construction of Bridges; Inspection and Maintenance of Bridges; Health Monitoring and Evaluation of Existing Bridges; Bridge Failure: Case Studies.

**CVL767 Design of Fiber Reinforced Composite Structures**
*3 Credits (3-0-0)*
Introduction; Types of structural fibers: matrix, fiber and interface; Fiber reinforced concrete (FRC): High-performance concrete; Stress transfer, Bond, Pull-out, Toughening mechanism; Fracture mechanics; Modeling of tensile and flexural behaviours; Behaviour under compression; Shear failure theory; Behaviour under seismic loading; Composite structural design: Design spirals, Selection Criteria configurations; Laminate design; Mathematical analysis of laminates; Design of single skin panels, Design of composite stiffeners.

**CVL768 Design of Masonry Structures**
*3 Credits (3-0-0)*
Introduction and Historical Perspective; Masonry Materials; Masonry Design Approaches; Overview of Load Conditions; Compression Behavior of Masonry; Masonry Wall Configurations; Distribution of Lateral Forces; Flexural Strength of Reinforced Masonry Members: In-plane and Out-of-plane Loading, Interactions; Structural Wall; Columns and Pilasters; Retaining Wall; Pier and Foundation; Shear and Ductility of Reinforced Masonry Members; Prestressed Masonry; Stability of Walls; Coupling of Masonry Walls, Openings, Columns, Beams; Elastic and inelastic analysis; Modelling Techniques; Static Push-Over Analysis and use of Capacity Design Spectra.

**CVL769 Design of Tall Buildings**
*3 Credits (3-0-0)*
Structural systems and general concepts of tall buildings; Various methods of structural analysis; Gravity systems for steel, concrete, and composite buildings; Lateral systems for steel, concrete, and composite buildings; Interaction of frames and shear walls; Simultaneous and sequential loading; Differential shortening of columns; P-Δ effects; Effect of openings; Foundations and foundation-superstructure interaction; Wind/ earthquake effects and design for ductility; Damping systems; Asymmetric structures and twisting of frames.

**CVL770 Prestressed and Composite Structures**
*3 Credits (2-0-2)*
Introduction; Need, Advantages, and Disadvantages; High Strength Materials; Pretensioning and Post-Tensioning Methods; Prestressing Methods; Prestressing Systems and Devices; Camber, Deflections, and Cable Profiles/ Layouts; Load-Balancing; Codes and Standards; Prestressed Concrete Members - Flexure, Shear, Torsion Behaviors; Design Methods and Code Provisions; Strain Compatibility Method; Pressure/ Thrust Line; Pre-Tensioning; Grouted/ Bonded and Ungrouted/ Unbonded Post-Tensioning; Partial Prestressing; Bursting Stresses; Anchorage Zone (End Block Design); Transmission and Transfer Length; De-Bonding and Draping of Prestressing Tendons; Camber, Deflection, and Ductility; External Prestressing; Decompression; Losses in Prestress; Bearing and Bond Stresses; Case Studies of Prestressed Concrete Bridge Design and Practices.

**CVL771 Construction Technology Laboratory**
*1.5 Credits (0-0-3)*
Tests related to quality control at site, in-situ tests, tests related to damage and deterioration assessment, performance monitoring of structures.

**CVS771 Independent Study (CEC)**
*3 Credits (0-0-6)*

**CVC772 Seminar in Construction Technology and Management-I**
*0 Credits (0-0-2)/Compulsory Audit*

**CVD772 Major Project Part-I (CEC)**
*9 Credits (0-0-18)*

**CVL772 Construction Project Management**
*3 Credits (3-0-0)*

**CVPD772 Computational Laboratory for Construction Management**
*1.5 Credits (0-0-3)*
Introduction to construction project models - analytical and numerical. Application software for project planning, scheduling & control. Programming exercises for estimation, network planning and control, LP in construction. MATLAB Programming in linear and non-linear programming.

**CVD773 Major Project Part-II (CEC)**
*12 Credits (0-0-24)*

**CVL773 Quantitative Methods in Construction Management**
*3 Credits (3-0-0)*
Introduction and concepts of probability and statistics, Linear programming, Transportation and assignment problems. Dynamic programming, Queueing theory, Decision theory, Games theory. Simulations applied to construction, Modifications and improvement on CPM/PERT techniques.

**CVL774 Construction Contract Management**
*3 Credits (3-0-0)*

**CVL775 Construction Economics and Finance**
*3 Credits (3-0-0)*
Engineering economics, Time value of money, discounted cash flow, NPV, ROR, PI. Basis of comparison, Incremental rate of return, Benefit-cost analysis, Replacement analysis, Break even analysis. Depreciation and amortization. Taxation and inflation, Evaluation of profit before and after tax. Risks and uncertainties and management decision in capital budgeting. Working capital management, financial plan and multiple...

**CVD776 Minor Project (CET)**
3 Credits (0-0-6)

**CVL776 Construction Practices and Equipment**
3 Credits (3-0-0)
Formwork design and scaffolding, slipform and other moving forms, Shoring, Resthousing, and Backshoring in multistoreyed Building construction. Prestressing, Steel and composites construction methods: Fabrication and erection of structures including heavy structures, Prefab construction, Industrialized construction, Modular coordination. Special construction methods: High rise construction, Bridge construction including segmental construction, incremental construction and push launching techniques. Factors affecting selection of equipment - technical and economic, Analysis of production outputs and costs, Characteristics and performances of equipment for major civil engineering activities such as Earth moving, erection, material transport, pile driving, Dewatering, and Concreting.

**CVS776 Independent Study (CET)**
3 Credits (0-0-6)

**CVD777 Major Project Part-I (CET)**
9 Credits (0-0-18)

**CVL777 Building Science**
3 Credits (3-0-0)

**CVD778 Major Project Part-II (CET)**
12 Credits (0-0-24)

**CVL778 Building Services and Maintenance Management**
3 Credits (3-0-0)
Concepts of functional design of building for fire protection, design of lift systems for optimum service. Building service system design. Control and intelligent buildings, HVAC, hot and cold water services, waste water handling system, electrical services, building maintenance management.

**CVL779 Formwork for Concrete Structures**
3 Credits (3-0-0)
Requirements and selection for Formwork, Formwork Materials, such as Timber, Plywood, Steel, Aluminum Form, Plastic Forms, and Accessories, Horizontal and Vertical Formwork Supports; Formwork Design Concepts, Illustration of Formwork system for Foundations, walls, columns, slab and beams and their design, Formwork for Shells, Domes, Folded Plates, Overhead Water Tanks, Natural Draft Cooling Tower. Formwork for Bridge Structures, Flying Formwork such as Table form, Tunnel form. Slipform, Formwork for Precast Concrete, Formwork Management Issues pre award and post award, Formwork failures-causes and Case Studies in Formwork Failure, Formwork issues in multi-story building construction.

**CVD800 Major Project Part-I**
6 Credits (0-0-12)

**CVL800 Emerging Topics in Geotechnical Engineering**
3 Credits (3-0-0)

A course which will vary from year to year to study new and exciting developments in the broad spectrum of Geotechnical and Geoenvironmental Engineering. The course will also focus on new offshoots of Geotechnical and Geoenvironmental Engineering.

**CVP800 Geoenvironmental and Geotechnical Engg. Lab**
3 Credits (0-0-6)

**CVS800 Independent Study**
3 Credits (0-0-6)

**CVD801 Major Project Part-II**
12 Credits (0-0-24)

**CVL801 Constitutive Modelling in Geotechnics**
3 Credits (3-0-0)

**CVD810 Major Project Part-I (CEU)**
6 Credits (0-0-12)

**CVL810 Emerging Topics in Rock Engineering and Underground Structures**
3 Credits (3-0-0)
Advanced and state-of-the-art rock engineering topics.

**CVP810 Rock Mechanics Laboratory-II**
3 Credits (0-0-6)
Pre-requisites: Rock Mechanics Lab-I CVP710
Project planning, Schedule and cost assessment, DPR and GD for Major projects, Field visit, Sample collection, Scanline survey and seismic survey, Rock characterization, Determination of physical and mechanical properties of rocks, Analysis of slopes using GEOSLOPE and Analysis of tunnels using Phase2, both using the material properties determined through laboratory tests. Design of slopes and tunnels.

**CVS810 Independent Study (CEU)**
3 Credits (0-0-6)

**CVD811 Major Project Part-II (CEU)**
12 Credits (0-0-24)

**CVL811 Numerical and Computer Methods in Geomechanics**
3 Credits (2-0-2)
Pre-requisites: CVL704 or Equivalent

Integration of stress-strain equations, Concepts of verification and validation, Selection of model input parameters, Integration of load-displacement relations, Integration of seepage, consolidation and heat
conduction equations, Sturm–Liouville problem, Solution of seepage, consolidation, heat conduction and Sturm-Liouville equations using finite difference and finite element programming methods, Comparison with commercially available software results.

**CVL817 Structural Safety and Reliability (PG)**
**3 Credits (3-0-0)**
Fundamentals of set theory and probability, probability distribution, regression analysis, hypothesis testing. Stochastic process and its moments and distributions, concepts of safety factors, Safety, reliability and risk analysis, first order and second order reliability methods, simulation based methods, confidence limits and bayesian revision of reliability, reliability based design, examples of reliability analysis of structures.

**CVL818 Design of Plates and Shells (PG)**
**3 Credits (2-1-0)**

**CVL819 Concrete Mechanics (PG)**
**3 Credits (3-0-0)**
Introduction; Rheological modelling of fresh concrete; Constitutive equations; Nonlinear elasticity, plasticity, visco-elasticity and fracture mechanics of hardened concrete; Confinement and ductility; Moisture diffusion; Drying shrinkage; Solid and structural mechanics of reinforced concrete, Skew bending, modified compression field and unified theories of R.C. beams under bending, shear and torsion; Bond-slip and phenomenon of cracking in reinforced concrete; Statical and dynamical analysis of R.C. Structures; Trends.

**CVL820 Environmental impact assessment**
**3 Credits (3-0-0)**

**CVVP820 Advanced Air Pollution Laboratory**
**3 Credits (1-0-4)**
Monitoring of TSP using HVS, Monitoring of PM2.5 using cyclone based sampler, Size segregated particle collection and data analysis using histogram, inversion program, Personal exposure assessment, determination of count and geometric mean diameter, determination of chemical species in air samples, Determination of emission factors of particle and gases for combustion sources, Determination of TVOC; Determination of indoor air quality parameters, determination of Bioaerosol; Monitoring and analysis of meteorological parameters.

**CVL821 Industrial Waste Management and Audit**
**3 Credits (3-0-0)**

**CVVP821 Advanced Water and Wastewater Laboratory**
**3 Credits (1-0-4)**

**CVL822 Emerging Technologies for Environmental Management**
**3 Credits (3-0-0)**
Contemporary micro and macro environmental issues of importance, global environmental and resource sharing issues, international treaties and protocols. Emerging contaminants and emerging technologies for waste management, Case studies of environmental pollution and innovative management strategies. Environmental technology transfer, Non-conventional Energy, Emission trading, Adaptation to climate change.

**CVL823 Thermal Techniques for Waste Management**
**3 Credits (3-0-0)**

**CVL824 Life Cycle Analysis and Design for Environment**
**3 Credits (3-0-0)**

**CVL825 Fundamental of Aerosol: Health and Climate Change**
**3 Credits (3-0-0)**
This course will introduce the students with fundamentals of aerosols, Difference in gas and particle motion in the air, physio-chemical and optical properties of individual and mixed particles, behaviour of non-spherical particles, thermodynamic properties of aerosol, particle formation, application of aerosol fundamentals and properties in research and industries, impact of aerosol properties on indoor/outdoor air quality, health and climate.

**CVL826 Quantitative microbial risk assessment**
**1 Credit (1-0-0)**

**CVL827 Environmental Implications of Engineered Nanomaterials**
**2 Credits (2-0-0)**
Engineered nanomaterials, Occurrence of nanomaterials in environment, Fate of nanomaterials in environment, Exposure pathways-model development and parameter estimation, Dose-response effects of nanomaterials to humans and aquatic species; dose-response modeling and risk estimation of nanomaterials exposures; Risk management of nanomaterials pollution; Prioritization of nanomaterials for monitoring; Regulatory guidelines for implications assessment and pollution regulations; Emerging challenges for long-term management of nanomaterials exposure.
Civil Engineering

CVL828 Water Distribution and Sewerage Network Design
3 Credits (3-0-0)

CVL830 Groundwater Flow and Pollution Modeling
3 Credits (3-0-0)
Subsurface processes and concepts for groundwater resources evaluation. Unsaturated zone properties: Soil moisture levels, Retention curves, Flow through unsaturated porous media, Multiphase flows, infiltration and wetting front, Groundwater contamination, Sources and causes of groundwater pollution, Pollution dynamics, Hydrodynamics dispersion, Adsorption, Biodegradation, Radioactive decay, Reactive processes, Multiphase contamination, NAPLs, VOCs, Site specific groundwater quality problems in Indian context. Numerical models, Finite difference methods, Numerical modeling of steady and transient flows in saturated and unsaturated domain, Contaminant transport modeling, Application of FEM and BIEM in groundwater modeling. Regional aquifer simulation, Contaminated groundwater systems and their rehabilitation, Development and optimization based management of aquifer systems, Stochastic models, Random field concepts in groundwater models; Application of emerging techniques to groundwater management.

CVS830 Independent Study (CEW)
3 Credits (0-3-0)

CVD831 Major Project Part-I
6 Credits (0-0-12)

CVL831 Surface Water Quality Modeling and Control
3 Credits (3-0-0)

CVD832 Major Project Part-II
12 Credits (0-0-24)

CVL832 Hydroelectric Engineering
3 Credits (3-0-0)
Hydropower development schemes and their various configurations, Planning for firm Capacities, Peak Load and Base Load configurations, Role of and Regulation of Hydropower development in a mixed hydro-steam system, Governing of Hydropower systems; study of hydraulic transients in Penstocks, Surge analysis and dynamics of Surge tanks. Micro hydrow power developments.

CVL833 Water Resources Systems
3 Credits (3-0-0)

CVL834 Urban Water Infrastructure
3 Credits (3-0-0)
Urban water cycle, Urban water infrastructures - water supply, storm water drainage, sanitation, sewerage and wastewater conveyance infrastructures, Water supply and sewerage network hydraulics, SCADA systems, Sustainable urban designs, Methodologies for assessing sustainability of urban water infrastructures, Emerging sustainable materials and design procedures for water supply and sewerage pipelines, Hydraulic performance and structural strength, chemical resistance and resilience characteristics of emerging materials based water and sewer pipelines, Rehabilitation and augmentation technologies for water supply and sewerage networks, Analytic hierarchy process and optimization techniques for arriving at the best appropriate rehabilitation/augmentation technology, Urban water management, Rain water harvesting, Managed aquifer recharge, Constructed/engineered wetlands, Sprinkler and drip irrigation, Water use efficiencies, Effect of water management practices on urban water infrastructure, hydrology and groundwater regime, Surface and subsurface mapping of water supply and sewerage networks, Structural safety and mitigating plans against natural and human caused threats.

CVL835 Eco-hydraulics and Hydrology
3 Credits (3-0-0)
Classification of Hydro environmental systems, governing equations for open surface flow doms, pollutant transport equations in hydro-environmental flow systems, computational methods and solution techniques. Study of ecological descriptors, numerical ecology, multi-objective definitions of environmental flows, Hydrologic indices for e-flows and river health assessment. Riverine habitat characterization and habitat simulation models. Anthropogenic triggers for changes in riverine habitat.

CVL836 Advanced Hydrologic Land Surface Processes
3 Credits (3-0-0)
Introduction: Eco-hydro-climatology; Climate System; Climate, weather and Climate Change; Water, Energy and Carbon Cycle; Overview of Earth’s Atmosphere: Heat-Balance of Earth Atmosphere System; Temporal Variation of Air temperature; Introduction to Atmospheric Thermodynamics: First and second law of thermodynamics, Adiabatic process and adiabatic lapse rate, Entropy, Clausius-Clapeyron Theory, Introduction to cloud microphysics and cloud droplet formation process, Cloud liquid water content, entrainment, warm and cold cloud. Hydrologic Cycle: Global water balance; Precipitation and Weather, Forms of Precipitation; Atmospheric Stability; Monsoon; Global Wind Circulation; Indian Summer Monsoon Rainfall. Climate Variability: Floods, Droughts, Climate Extremes. Climate Change: Introduction; Causes and Modeling of Climate Change, Climate Models, Downscaling; IPCC Scenarios; Commonly used Statistical Methods in Hydro-climatology: Trend Analysis; EOF, PCA; Canonical Correlation; Statistical Downscaling; Ecological Climatology: Leaf energy fluxes and leaf photosynthesis; Ecosystem and vegetation dynamics; Coupled climate vegetation dynamics, Carbon cycle climate feedbacks.

CVL837 Mechanics of Sediment Transport
3 Credits (2-0-2)
Introduction; Equations of Particle Movement particle in a moving fluid, collision with the bed, diffusion of turbulence; Macroscopic View of Sediment Transport – bedload, suspended load; Threshold Condition for Sediment Movement – Critical stress for flow over a granular bed, Shields diagram; Mechanics of Bedload Transport: Bagnold hypothesis of bedload transport, bedload transport relations; Mechanics of Suspended Sediment Transport; Total load transport; Descriptive Analysis of Bedforms – introduction of bedform mechanics, dunes, antidunes, ripples, bars; Stability Analysis of Bedforms; Mechanism of transportation of materials by fluid flow through pipeline; Rheology and classification of complex mixtures; Fundamentals of two-phase flow; Phase separation and settling behaviour; Flow of non-Newtonian fluids through pipes: Turbulent flows of Complex mixtures, Slurry pipeline transportation, Design methods.
CVL839 Hydrologic Applications of Remote Sensing
3 Credits (2-0-2)
Principles of remote sensing, Remote sensing platforms and data acquisition systems, Wavebands, Radiometric quantities, Spectral reflectance and spectral signature, Interaction of electromagnetic radiation with land surface features, hydrosphere and atmosphere, Data capture for simulation of land surface processes, Photographic and image interpretation, Satellite image processing, Earth surface features inventory, Geomorphology, Landuse classification, Landuse planning and landcover mapping, Flood plain mapping and flood plain zoning, Remote sensing applications in water resources, agriculture, geology and environmental monitoring, Applications in snow and glacier studies, Snow line, Ice cover, Snow-pack properties, Integrated use of remote sensing and GIS. Data preparation and Decision support analysis, Estimation of damages due to hydrologic extremes and preparation of contingency plans, Case studies.

CVL840 Planning and Design of Sustainable Transport Systems
3 Credits (3-0-0)
Pre-requisites: M.Tech: CVL741; B.Tech: Instructor’s permission
Sustainable Transportation Planning and Design including: Consideration of bicycles, pedestrian, mass transit modes, and private vehicles like cars and two wheelers as well as how these modes interrelate. Applicability at varying scales, from a downtown street to a neighborhood to a regional network Case studies are discussed from different parts of the world. Various indicators for measuring sustainability index of transport system including public health, resource consumption, local and global pollution and equity considerations are discussed.

CVL841 Advanced Transportation Modelling
3 Credits (2-0-2)
Pre-requisites: M.Tech: CVL741; B.Tech: Instructor’s permission

CVL842 Geometric Design of Roads
3 Credits (2-0-2)
Pre-requisites: M.Tech: CVL741, CVL742; B.Tech: CVL261 and one TE elective
Introduction to basic road geometric design elements and methodology - design philosophy and design techniques; Design controls - human, vehicle and speed related factors. Road vehicle performance - road vehicle dynamics - tractive and resisting forces. Braking forces. Theoretical and practical stopping distances. Elements of geometric design - cross section elements; Horizontal Alignment - tangents, curves, transitions, superelevation; Vertical Alignment - grades and curves; Coordination of Horizontal and Vertical Alignment. Design of Intersections at-grade- design principles, channelization, roundabouts, Interchanges- types, warrants, lane balancing; Road side safety- hazards and clear zone concept, traffic safety barriers, impact attenuation.

CVL844 Transportation Infrastructure Management
3 Credits (3-0-0)
Pre-requisites: M.Tech: CVL740; B.Tech: Instructor’s permission
Transportation infrastructure components; Deterioration phenomena; Effect of external factors like environment, traffic loading, material properties on deterioration mechanisms; Evaluation techniques to evaluate damage: destructive, nondestructive; Performance models: development, calibration; Infrastructure management systems; Serviceability of condition and safety; Decision making and optimization techniques applied to infrastructure management; Life cycle cost analysis techniques.

CVL845 Viscoelastic Behavior of Bituminous Materials
3 Credits (3-0-0)
Pre-requisites: M.Tech: CVL740; B.Tech: Instructor’s permission
Overview of material behavior-elastic, plastic, viscoelastic, Viscoplastic response; Aging; Issues in representative volume element; Mechanical analogs for viscoelastic response; Fundamental viscoelastic response-creep compliance, relaxation, complex modulus; Interconversion techniques to obtain fundamental viscoelastic responses; Time-temperature superposition; linear viscoelastic constitutive equations; Elastic-viscoelastic correspondence principle; Predicting material behavior-undamaged, damaged state conditions, Introduction to nonlinear viscoelasticity, Viscoelasticplastic behaviour, fracture mechanics.

CVL846 Transportation System Management
3 Credits (3-0-0)
Pre-requisites: M.Tech: CVL741 and CVL742; B.Tech: Instructor’s permission
Transportation systems - resource management, approaches to funding. Asset and demand management - Integrated network design, changing travel behaviour, optimising asset management, role of technology; Optimizing the investment outcomes - movement of freight and passenger, traffic. Land use planning and urban growth management - land use and its effect on infrastructure and efficient network operations. Congestion, systemic congestion improvement and system-wide efficiency, Transit oriented development, safety considerations; evaluation of strategies; case studies.

CVL847 Transportation Economics
3 Credits (3-0-0)
Pre-requisites: M.Tech: CVL741; B.Tech: Instructor’s permission
Overview of Transportation Economics; Transportation Investments and economic Development. Basics of Engineering economics, marginal analysis, opportunity cost, shadow price, money value of time, discounted cash flow, NPV, ROR, benefit-cost analysis. Road User Costs; Public transportation economics; Social Cost of Transportation; Cost of congestion, pollution, traffic accidents. Taxation, regulations, financing Transport Systems; Legal framework for transportation sector, case studies.

CVL848 Traffic Flow Modelling
3 Credits (3-0-0)
Pre-requisites: CVL742
Descriptors of traffic flow: Macroscopic and Microscopic, time, space and generalized measurement regions. Cumulative plots. Traffic Flow models - General classification and typology. Macroscopic Flow Models - continuity equation, LWR model, higher order models, numerical schema, Mesoscopic Flow Models - gas kinetic theory, Microscopic and Submicroscopic Flow Models - car following and lane changing; Pipes and forbes models; General motors-Gazis-Herman-Rothery (GHR) models, Stability analysis, macro-micro bridge. Modelling at Juctions/Intersections; Un-signalized and Signalized; Roundabouts; Pedestrian Modelling - normal and panic movements; variations across infrastructure; Simulation - simple and complex traffic conditions.

CVL850 Transportation Logistics
3 Credits (3-0-0)
Pre-requisites: M.Tech: CVL742 else Instructor’s permission (including B.Tech)
Evolution of freight and logistics; Interrelationships between transportation and Public Transport systems. Analysis of Ranked and Rated data, Demand models for Nonmotorised transportation and Public Transportation systems.

CVL870 Geotechnical Engineering
3 Credits (3-0-0)
Pre-requisites: M.Tech: CVL740; B.Tech: Instructor’s permission
Evolution of freight and logistics; Interrelationships between transportation and Public Transport systems. Analysis of Ranked and Rated data, Demand models for Nonmotorised transportation and Public Transportation systems.
society, environment and freight transport; Survey methodologies to understand freight movement; Cost measurement: Production, Holding, Transportation, Handling; Effect of internal and external variables on cost; Demand forecasting; Inventory planning and management; Transportation and distribution network: Design, Reverse Logistics. Development, Management; Ware house operations; Pricing: Perishable, seasonal demand, uncertainty issues; Vehicle routing: One-to-one distribution, One-to-many distribution, Shortest path algorithm, Quickest time algorithm; Logistics information system; Designing and planning transportation networks; City logistics.

**CVL851 Special Topics in Transportation Engineering**  
3 Credits (3-0-0)  
Pre-requisites: CVL740 or CVL741 or CVL742 or Instructor’s permission  
Course details shall be announced by the instructor at the time of offering of the course. The lectures will be supplemented by reading materials. The assessment will be based on a combination of assignments, quizzes, and term papers and tests.

**CVS852 Advanced Topics in Transportation Engineering**  
3 Credits (3-0-0)  
Pre-requisites: CVL740, CVL741, CVL742  
This is an advanced course for M.Tech. Transportation engineering program where students will study a specialized topic within transportation engineering (including but not limited to transportation planning, traffic engineering and pavement engineering). The topic shall be announced by instructor at the beginning. The performance of student in this course will be evaluated through presentation(s) and report(s) made by student during the registered term.

**CVD853 Major Project Part-I**  
9 Credits (0-0-18)  
Pre-requisites: CVL740, CVL741, CVL742  

**CVD854 Major Project Part-II**  
12 Credits (0-0-24)  
Pre-requisites: CVL740, CVL741, CVL742  

**CVL856 Strengthening and Retrofitting of Structures**  
3 Credits (3-0-0)  
Structural assessment, damage under accidental and cyclic loads, cracking in structures, evaluation of damage, analysis of existing structures, compression, flexural and shear strengthening, strengthening using laminates, strengthening using prestressing, bracing and stiffening of structures, maintenance of retrofitting, design codes for retrofitting of structures, retrofitting of steel structures, retrofitting of masonry structures.

**CVL857 Structural Safety and Reliability**  
3 Credits (3-0-0)  
Fundamentals of Set Theory and Probability; Probability Distribution, Regression Analysis, Hypothesis Testing, Stochastic Process and Its Moments; Probability Distributions; Concepts of Safety Factors, Safety, Reliability and Risk Analysis; First Order and Second Order Reliability Methods; Simulation Based Methods; Confidence Limits and Bayesian Revision of Reliability; Reliability Based Design; System Reliability; Examples of Reliability Analysis of Structures.

**CVL858 Theory of Plates and Shells**  
3 Credits (3-0-0)  

**CVL859 Theory of Structural Stability**  
3 Credits (3-0-0)  

**CVL860 Advanced Finite Element Method and Programming**  
3 Credits (2-0-2)  
Pre-requisites: CVL757  
Finite element method (FEM) to solve complex structural engineering problems. Various types of finite elements (FE) considering nonlinear material models; constitutive laws; hybrid elements. Strong and weak form representation and solutions. FEM for dynamic problems: consistent mass matrix, vibration of bars, beams, and plate elements. FEM for buckling problems: geometric matrix, buckling of struts, and plate elements. FE modeling and analysis of complex structures: 3-D frames, shear walls, bridges, cooling towers, continua etc. Computational aspects: meshing, convergence, singularity, etc. Interpretation of results. Comparison with other methods.

**CVL861 Analysis and Design of Machine Foundations**  
3 Credits (2-0-2)  
General design requirements, general dynamics of machine foundations for rotating and reciprocating machines, determination of soil properties, modelling, analysis and design of block/frame type foundations, specific details for machines applying impulsive loads, compressors and turbo-generators, detailed dynamic analysis and modes of vibration for frame type foundations, techniques for vibration isolation, practical case studies, codal requirements, construction aspects of machine foundations. Laboratory : Instrumentation aspects in terms of sensors and data acquisition systems, measurement of dynamic soil parameters, measurement of vibration related parameters, vibration isolation, computational aspects related to frame type foundations including dynamic analysis.

**CVL862 Design of Offshore Structures**  
3 Credits (3-0-0)  

**CVL863 General Continuum Mechanics**  
3 Credits (3-0-0)  
Introduction: Field and particle theories in physics. Historical development of continuum mechanics-A basic engineering science. Classical theories: Stress and kinematics. Elasticity, Viscoelasticity and Elastoplasticity; Newtonian fluids. Continuum thermomechanics; Classius-Duhem Inequality; Thermodynamics with internal variables. Constitutive equations; Axioms for simple materials; Frame indifference; Finite elasticity; Hyper/hypoelasticity; Non-Newtonian fluids.
Polar and nonlocal materials; Materials of differential/gradient type; Configurational mechanics; Biomechanics; Nanomechanics. Theories of conduction and diffusion; Electromagnetism. Coupled fields: Thermoelasticity and electromagnetoelasticity; MHD; Chemomechanics. Intermediate problems; Statistical continuum theories; Relativistic continuum mechanics; Materials models for luminiferous Aether.

Rational methodology and realism; Current trends.

**CVL864 Structural Health Monitoring**
3 Credits (2-0-2)
Concept of structural health monitoring, sensor systems and hardware requirements, global and local techniques, computational aspects of global dynamic techniques, experimental mode shapes, damage localization and quantification, piezoelectric materials and other smart materials, electro-mechanical impedance (EMI) technique, adaptations of EMI technique.

Laboratory: Sensor installation and diagnostics, mode shape extraction, location and quantification of damage using global dynamic techniques, damage detection using electro-mechanical impedance technique, remote monitoring.

**CVL865 Structural Vibration Control**
3 Credits (3-0-0)
Pre-requisites: CVL759
Introduction; Types and classifications; Control theories; Optimal stiffness distributions for building type structures; Role of damping in controlling motion; Active and semi-active systems; Tuned mass dampers - single/ multiple; Quasi-static active control; Passive control: viscous, visco-elastic, friction, hysteretic dampers, base isolation; Nonlinear modeling; Dynamic feedback control; Neural network based control systems; Design for buildings, bridges, power plants, and other structures; Current trends and performance-based design.

**CVL866 Wind Resistant Design of Structures**
3 Credits (3-0-0)
Pre-requisites: CVL759

**CVL871 Durability and Repair of Concrete Structures**
3 Credits (3-0-0)
Chemical composition of concrete, permeability and transport processes, corrosion of reinforcement and prestressing steel in concrete, carbonation, chloride attack, alkali-silica reaction, freeze-thaw attack, sulphate attack, acid attack, effect of fire and high temperatures and seawater attack, cracking, weathering, biological processes, non-destructive testing, repairs, protection and retrofitting, durability based design of structures.

**CVL872 Infrastructure Development and Management**
3 Credits (3-0-0)
Introduction to Indian Infrastructure. Govt. initiatives through various five year plans. Overview of various sectors of infrastructure and SEZ.

Infrastructure procurement through Public-Private-Partnership. Sector-wise differences in policies, Concession agreement, Selection procedure of concessionaires, Issues in financial closure, Stakeholder management.

**CVL873 Fire Engineering and Design**
3 Credits (3-0-0)
(A) Fire engineering: fundamentals of fire science, fire dynamics, hazard mitigation, and safety; codes, standards, rules and fire safety regulations; thermodynamics, thermofluids, heat and mass transfer; human behavior in fire and urban planning; fire testing methods for materials; large-scale fire testing. "Fire protection" - current methods in fire safety engineering; mechanics of repair; mitigation of fire damage by due design, and construction; industrial fire safety. Passive fire protection: analyzing the thermal effects of fires on buildings and designing structural members. Introduction to active fire protection.

(B) Structural fire engineering: fire behavior and scenarios, heat transfer to the structure, structural response and stability under thermo-mechanical loads; fire safety design; mechanical properties of structural materials at elevated temperatures; fire response of steel, concrete, fiber reinforced polymers, high-performance materials etc.; computational procedures to predict structural behavior under fire conditions; structural fire resistance based on theoretical/empirical relationships; performance-based fire engineering; strengthening/repair of structures.

**CVL874 Quality and Safety in Construction**
3 Credits (3-0-0)


**CVL875 Sustainable Materials and Green Buildings**
3 Credits (3-0-0)

**CVD895 MS Research Project**
36 Credits (0-0-72)
Department of Computer Science and Engineering

COL100 Introduction to Computer Science
4 Credits (3-0-2)

COL106 Data Structures & Algorithms
5 Credits (3-0-4)
Pre-requisites: COL100

COL202 Discrete Mathematical Structures
4 Credits (3-1-0)
Overlaps with: MTL180
Propositional logic, Predicate Calculus and Quantifiers; Proof Methods; Sets, functions, relations, Cardinality, Infinity and Diagonization; Induction and Recursion; Modular Arithmetic, Euclid's Algorithm, primes, Public Key Cryptography; Polynomials, finite fields and Secret Sharing; Coding Theory: Error correcting codes, Hamming codes, Hamming bound; Basic Counting - Pigeon hole principle; Advanced Counting - recurrence relations, generating functions, inclusion-exclusion; basic information theory, entropy, Kraft's inequality, mutual information, lower bounds; Probability - sample space, conditional probability, expectation, linearity of expectation, variance, Markov, Chebychev, probabilistic methods; Graph Theory - Eulerian, Hamiltonian & planar graphs, edge and vertex coloring.

COL215 Digital Logic & System Design
5 Credits (3-0-4)
Pre-requisites: COL100, ELL100
Overlaps with: ELL201
The course contents can be broadly divided into two parts. First part deals with the basics of circuit design and includes topics like circuit minimization, sequential circuit design and design of and using RTL building blocks. The second part is focused on ASIC style system design and introduces VHDL, FPGA as implementation technology, synthesis steps as well as testing techniques. Course ends with introducing the challenges of embedded design where software is becoming integral to all devices. The laboratory assignments are a key component of this course and requires students to design and implement circuits and sub-systems on FPGA kits covering almost all the topics covered in the lectures.

COL226 Programming Languages
5 Credits (3-0-4)
Pre-requisites: COL106
Value and state oriented paradigms. Translation. Notions of syntax and semantics of programming languages; introduction to operational/natural semantics of functional and imperative languages. Data abstractions and control constructs; block-structure and scope, principles of abstraction, qualification and correspondence; parameter passing mechanisms; runtime structure and operating environment; practical and implementation issues in run-time systems and environment; abstract machines; features of functional and imperative languages; the un-typed and simply-typed Lambda calculus, type systems for programming languages including simple types and polymorphism; objects; classes and inheritance in object-oriented languages. Interactive programming and interfaces. The laboratory activities will involve building a variety of small interpreters for core languages in various paradigms. Tools such as lex and yacc will be introduced for front-end analysis.

COP290 Design Practices
3 Credits (0-0-6)
Pre-requisites: COL 106
The contents may differ each year depending on the instructor. The course should involve 2-3 large programming projects done in groups of 2-4.

COD300 Design Project
2 Credits (0-0-4)
Basic design methodology – introduction to the steps involved, Familiarization with software practices, tools and techniques, software project involving conceptualization, design analysis, implementation and testing using the tools and techniques learnt.

COD310 Mini Project
3 Credits (0-0-6)
Design/fabrication/implementation work under the guidance of a faculty member. Prior to registration, a detailed plan of work should be submitted by the student to the Head of the Department for approval.

COR310 Professional Practices (CS)
2 Credits (1-0-2)
EC - 60
The course would consist of talks by working professionals from industry, government and research organizations. It may also include site visits to various organizations.

COS310 Independent Study (CS)
3 Credits (0-3-0)
EC - 60
Research oriented activities or study of subjects outside regular course offerings under the guidance of a faculty member. Prior to registration, a detailed plan of work should be submitted by the student to the Head of the Department for approval.

COP315 Embedded System Design Project
4 Credits (0-1-6)
Pre-requisites: COL215, COL216 or equivalent courses
Students working in small groups of four to six are expected to deliver in one semester on an innovative solution for problems/challenges that are typical to India and perhaps other developing countries. The students would have to go through the full cycle of specification, design and prototyping/building a concept demonstrator. Key component of the assessment would be through a public demonstration of their solution. Learning to work in groups as well as planning and delivering a large task are other expected learnings.
COL331 Operating Systems
5 Credits (3-0-4)
Pre-requisites: COL106 COP290
Overlaps with: ELL405
Primary UNIX abstractions: threads, address spaces, file system, devices, inter process communication; Introduction to hardware support for OS (e.g., discuss x86 architecture); Processes and Memory; Address Translation; Interrupts and Exceptions; Context Switching; Scheduling; Multiprocessors and Locking; Condition Variables, Semaphores, Barriers, Message Passing, etc.; File system semantics, design and implementation; File system Durability and Crash recovery; Security and Access Control.

COL333 Principles of Artificial Intelligence
4 Credits (3-0-2)
Pre-requisites: COL106
Overlaps with: COL671, COL770, ELL789
Philosophy of artificial intelligence, problem solving, search techniques, constraint satisfaction, game playing (minimax, expectiminimax), automated planning, knowledge representation and reasoning through logic, knowledge representation and reasoning through fuzzy logic and Bayesian networks, Markov decision processes, machine learning, neural networks, reinforcement learning, soft computing, introduction to natural language processing.

COL334 Computer Networks
4 Credits (3-0-2)
Pre-requisites: COL106, COL216
Overlaps with: ELL402
Students will be exposed to common network algorithms and protocols, including physical layer modulation (analog AM/FM, digital ASK/PSK/PSK), encoding (NRZ, Manchester, 4B/5B), link layer framing, error control, medium access control (TDMA, FDMA, CSMA/CA, CSMA/CD), bridging, SDN, addressing (IPv4/IPv6), name resolution (DNS), routing (DV, LS protocols RIP, OSPF, BGP), transport protocols (TCP), congestion avoidance (window based AIMD), and application design models (client-server, P2P, functioning of HTTP, SMTP, IMAP). Programming assignments will be designed to test network application design concepts, protocol design towards developing error detection and correction methods, efficient network utilization, and familiarization with basic tools such as ping, trace route, wires hark.

COL341 Fundamentals of Machine Learning
4 Credits (3-0-2)
Pre-requisites: COL106, MTL106
Overlaps with: ELL409, ELL784

COL351 Analysis and Design of Algorithms
4 Credits (3-1-0)
Pre-requisites: COL106
Overlaps with: MTL342, COL702
Checking 2-edge, 2-node and strong connectivity using DFS, Strongly connected components. Greedy algorithms, minimum spanning trees (Prim/Kruskal), Union-find data structure. Matroids. Divide and conquer algorithms. Polynomial multiplication, DFT and FFT. Dynamic Programming, All pairs shortest paths (Bellman-Ford, Floyd Warshall), s-t flows, Ford-Fulkerson, Edmonds-Karp, applications of maxflow Intractability, NP-completeness, Polynomial time reductions. String matching, KMP and Rabin-Karp. Universal hashing and applications. Geometric algorithms like convex hulls, multidimensional data structures, plane sweep paradigm.

COL352 Introduction to Automata & Theory of Computation
3 Credits (3-0-0)
Pre-requisites: COL202
Overlaps with: MTL383
Regular Languages, Finite Automata, equivalence, minimization, Myhill-Nerode Theorem, introduction to non-determinism, Context free grammars, Pushdown automata, equivalence and applications. Turing machines, Recursive and Recursively enumerable sets, non-determinism, RAMs and equivalence, Universal Turing Machines, undecidability, Rice’s theorems for RE sets, Post machines, Basics of Recursive function theory. Equivalence, Church’s thesis, computational complexity, space and time complexity of Turing Machines, Relationships, Savage’s theorem, Complexity classes, Complete problems, NP-completeness, Cook-Levin theorem.

COL362 Introduction to Database Management Systems
4 Credits (3-0-2)
Pre-requisites: COL106
Overlaps with: MTL710
Data models (ER, relational models, constraints, normalization), declarative querying (relational algebra, datalog, SQL), query processing/optimization (basics of indexes, logical/physical query plans, views) and transaction management (introduction to concurrency control and recovery). Overview of XML data management, text management, distributed data management. Course project to build a web-based database application.

COL380 Introduction to Parallel & Distributed Programming
3 Credits (2-0-2)
Pre-requisites: COL106, COL351, COL331
Overlaps with: COL730, MTL765

COD490 B.Tech. Project
6 Credits (0-0-12)
Pre-requisites: EC 100
Overlaps with: COD492
This course is designed for CSE B.Tech. students who do not seek departmental specialization. The course is done, usually in groups, under the supervision of one or more faculty members of the computer science department.

COD492 B.Tech. Project Part-I
6 Credits (0-0-12)
Pre-requisites: EC 100
Overlaps with: COD490
This course is part-1 of a large project and is designed for CSE B.Tech. students seeking department specialization. This project is done individually, or sometimes in small groups, under the supervision of one or more faculty member of the computer science department. This project spans also the course COD494. Hence it is expected that the problem specification and the milestones to be achieved in solving the problem are clearly specified. Students not seeking specialization may take this course of if they are interested in the COD490-COD492 sequence.
COD494 B.Tech. Project Part-II
8 Credits (0-0-16)
Pre-requisites: COD492, EC 100
The student(s) who work on a project are expected to work towards the goals and milestones set in COD492. At the end there would be a demonstration of the solution and possible future work on the same problem. A dissertation outlining the entire problem, including a survey of literature and the various results obtained along with their solutions is expected to be produced.

COL632: Introduction to Database Systems
4 Credits (3-0-2)
Pre-requisites: COL106 OR Equivalent
Overlap with: COL362, MTL710
Data models (ER, relational models, constraints, normalization), declarative querying (relational algebra, datalog, SQL), query processing/optimization (basics of indexes, logical/physical query plans, views) and transaction management (introduction to concurrency control and recovery). Overview of XML data management, text management, distributed data management. Course project to build a web-based database application.

COL633: Resource Management in Computer Systems
4 Credits (3-0-2)
Pre-requisites: COL106 OR Equivalent
Overlap with: COL331 EEL405, MTL358
Primary UNIX abstractions: threads, address spaces, filesystem, devices, interprocess communication; Introduction to hardware support for OS (e.g., discuss x86 architecture); Processes and Memory; Address Translation; Interrupts and Exceptions; Context Switching; Scheduling; Multiprocessors and Locking; Condition Variables, Semaphores, Barriers, Message Passing, etc.; FILEsystem semantics, design and implementation; FILEsystem Durability and Crash recovery; Security and Access Control

COL 671: Principles of Artificial Intelligence:
4 Credits (3-0-2)
Pre-requisites: COL106 OR Equivalent
Overlap with: COL333, COL770, ELL789

COL 672: Computer Networks
4 Credits (3-0-2)
Pre-requisites: COL106 OR Equivalent
Overlap with: COL334, ELL789
Students will be exposed to common network algorithms and protocols, including physical layer modulation (analog AM/FM, digital ASK/FSK/PSK), encoding (NRZ, Manchester, 4B/5B), link layer framing, error control, medium access control (TDMA, FDMA, CSMA/CA, CSMA/CD), bridging, SDN, addressing (IPv4/v6), name resolution (DNS), routing (DV, LS, protocols RIP, OSPF, BGP), transport protocols (TCP), congestion avoidance (window based AIMD), and application design models (clientserver,P2P, functioning of HTTP, SMTP, IMAP). Programming assignments will be designed to test network application design concepts, protocol design towards developing error detection and correction methods, efficient network utilization, and familiarization with basic tools such as ping, traceroute, wireshark.

COP701 Software Systems Laboratory
3 Credits (0-0-6)
The contents may differ each year depending on the instructor. The course should involve 2-3 large programming projects done in groups of 2-4. A set of three project oriented assignments which will be announced at the start of each semester with definite submission deadlines. The set of assignments will be designed to develop skills and familiarity with a majority of the following: make, configuration management tools, installation of software, archiving and creation of libraries, version control systems, documentation and literate programming systems, GUI creation, distributed state maintenance over a network, programming in different environments like desktop and handhelds, program parsing and compilation including usage of standard libraries like pthreads, numerical packages, XML and semi-structured data, program environments, testing and validation tools.

COL 702 Advanced Data Structures and Algorithms
4 Credits (3-0-2)
Pre-requisites: COL106 OR Equivalent
Overlap with: COL351

COL 703 Logic for Computer Science
4 Credits (3-0-2)
Pre-requisites: COL106 OR Equivalent
Overlap with: MTL747
Review of the principle of mathematical induction; the principle of structural induction; review of Boolean algebras; Syntax of propositional formulas; Truth and the semantics of propositional logic; Notions of satisfiability, validity, inconsistency; Deduction systems for propositional logic; Completeness of deduction systems; First order logic (FOL); Proof theory for FOL; introduction to model theory; completeness and compactness theorems; First order theories. Programming exercises will include representation and evaluation; conversion to normal-forms; tautology checking; proof normalization; resolution; unification; Skolemization, conversion to Horn-clauses; binary-decision diagrams. Decidability, undecidability and complexity results. Introduction to formal methods, temporal/modal logics.

COL 718 Architecture of High Performance Computers
4 Credits (3-0-2)
Pre-requisites: COL216 OR Equivalent
Classification of parallel computing structures; Instruction level parallelism - static and dynamic pipelining, improving branch performance, superscalar and VLIW processors; High performance memory system; Shared memory multiprocessors and cache coherence; Multiprocessor interconnection networks; Performance modelling; Issues in programming multiprocessors; Data parallel architectures

COL 719 Synthesis of Digital Systems
4 Credits (3-0-2)
Pre-requisites: COL215 OR Equivalent
After a basic overview of the VLSI design flow, hardware modelling principles and hardware description using the VHDL language are covered. This is followed by a study of the major steps involved in behavioural synthesis: scheduling, allocation, and binding. This is followed by register-transfer level synthesis, which includes retiming
and Finite State Machine encoding. Logic synthesis, consisting of combinational logic optimisation and technology mapping, is covered next. Popular chip architectures - standard cells and FPGA are introduced. The course concludes with a brief overview of layout synthesis topics: placement and routing.

**COL722 Introduction to Compressed Sensing**  
*3 Credits (3-0-0)*  
**Pre-requisites: COL106 OR Equivalent**

Sparsity, L1 minimization, Sparse regression, deterministic and probabilistic approaches to compressed sensing, restricted isometry property and its application in sparse recovery, robustness in the presence of noise, algorithms for compressed sensing. Applications in magnetic resonance imaging (MRI), applications in analog-to-digital conversion, low-rank matrix recovery, applications in image reconstruction.

**COL724 Advanced Computer Networks**  
*4 Credits (3-0-2)*  
**Pre-requisites: COL334 OR Equivalent**

Review of the Internet architecture, layering; wired and wireless MAC; intra- and inter-domain Internet routing, BGP, MPLS, MANETs; error control and reliable delivery, ARQ, FEC, TCP; congestion and flow control; QoS, scheduling; mobility, mobile IP, TCP and MAC interactions, session persistence; multicast; Internet topology, economic models of ISPs/CDNs/content providers; future directions.

**COL726 Numerical Algorithms**  
*4 Credits (3-0-2)*  
**Pre-requisites: COL106 OR Equivalent**

Overlaps with: MTL704  
Number representation, fundamentals of error analysis, conditioning, stability, polynomials and root finding, interpolation, singular value decomposition and its applications, QR factorization, condition number, least squares and regression, Gaussian elimination, eigenvalue computations and applications, iterative methods, linear programming, elements of convex optimization including steepest descent, conjugate gradient, Newton's method.

**COL728 Compiler Design**  
*4.5 Credits (3-0-3)*  
**Pre-requisites: COL 216, COL 226 OR Equivalent**

Compilers and translators; lexical and syntactic analysis, top-down and bottom-up parsing techniques; internal form of source programs; semantic analysis, symbol tables, error detection and recovery, code generation and optimization, Type checking and static analysis. Static analysis formulated as fixpoint of simultaneous semantic equations. Data flow. Abstract interpretation. Correctness issues in code optimizations. Algorithms and implementation techniques for type-checking, code generation and optimization. Students will design and implement translators, static analysis, type-checking and optimization. This is a praxis-based course. Students will use a variety of software tools and techniques in implementing a complete compiler.

**COL729 Compiler Optimization**  
*4.5 Credits (3-0-3)*  
**Pre-requisites: COL 216, COL 226 OR Equivalent**

Overlaps with: COL728  
Program representation – symbol table, abstract syntax tree; Control flow analysis; Data flow analysis; Static single assignment; Def-use and Use-def chains; Early optimizations – constant folding, algebraic simplifications, value numbering, copy propagation, constant propagation; Redundancy Elimination – dead code elimination, loop invariant code motion, common sub-expression elimination; Register Allocation; Scheduling – branch delay slot scheduling, list scheduling, trace scheduling, software pipelining; Optimizing for memory hierarchy – code placement, scalar replacement of arrays, register pipelining; Loop transformations – loop fission, loop fusion, loop permutation, loop unrolling, loop tiling; Function inlining and tail recursion; Dependence analysis; Just-in-time compilation; Garbage collection. Laboratory component would involve getting familiar with internal representations of compilers; profiling and performance evaluation; and the design and implementation of novel compiler optimizations.

**COL730 Parallel Programming**  
*4 Credits (3-0-2)*  
**Pre-requisites: COL106, COL313**

Parallel computer organization, Parallel performance analysis, Scalability, High level Parallel programming models and framework, Load distribution and scheduling, Throughput, Latency, Memory and Data Organizations, Inter-process communication and synchronization, Shared memory architecture, Memory consistency, Interconnection network and routing, Distributed memory architecture, Distributed shared memory, Parallel IO, Parallel graph algorithms, Parallel algorithm techniques: Searching, Sorting, Prefix operations, Pointer Jumping, Divide-and-Conquer, Partitioning, Pipelining, Accelerated Cascading, Symmetry Breaking, Synchronization (Locked/Lock-free).

**COL732 Virtualization and Cloud Computing**  
*4 Credits (3-0-2)*  
**Pre-requisites: COL331**

Introduction to Virtualization and Cloud Computing; Binary Translation; Hardware Virtualization; Memory Resource Management in Virtual Machine Monitor; Application of Virtualization; Cloud-scale Data Management and Processing; I/O Virtualization.

**COL733 Cloud Computing Technology Fundamentals**  
*4 Credits (3-0-2)*  
**Pre-requisites: COL331**

Overview of Cloud Computing, Virtualisation of CPU, Memory and I/O Devices; Storage Virtualisation and Software Defined Storage (SDS), Software Defined Networks (SDN) and Network Virtualisation, Data Centre Design and interconnection Networks, Cloud Architectures, Public Cloud Platforms (Google App Engine, AWS, Azure), Cloud Security and Trust Management, Open Source Clouds (Baalad, Open Stack, Cloud Stack), Cloud Programming and Software Environments (Hadoop, GFS, Map Reduce, NoSQL systems, Big Table, HBase, Libvirt, OpenVswitch), Amazon (IaaS), Azure(PaaS), GAE (PaaS)

**COL740 Software Engineering**  
*4 Credits (3-0-2)*  
**Pre-requisites: COL106, COL226**


**COD745 Minor Project**  
*3 Credits (0-0-6)*  
**Pre-requisites: EC 75**

Research and development projects based on problems of practical and theoretical interest. Evaluation will be based on periodic presentations, student seminars, written reports, and evaluation of the developed system (if applicable).

**COP745 Digital System Design Laboratory**  
*3 Credits (0-0-6)*  
**Pre-requisites: COL215 OR Equivalent**

Being primarily a laboratory course, it would consist of a series of assignments that would increase in complexity in terms of designs to be carried out. Each assignment would involve learning to translate starting from natural language specifications to HDL...
design representation. The students would use modern synthesis techniques to realize these designs on FPGA boards before testing them for functionality as well as performance. Students would also be required to specify and implement a project (small system design) as part of the course.

COL750 Foundations of Automatic Verification
4 Credits (3-0-2)
Pre-requisites: COL226, COL352 OR Equivalent
A selection from the following topics, and experiments with the mentioned tools: Review of first-order logic, syntax and semantics. Resolution theorem proving. Binary Decision Diagrams (BDDs) and their use in representing systems. (Programming exercises coding and using logic programming frameworks). Transition systems, automata and transducers. Buchi and other automata on infinite words; Linear Time Temporal Logic (LTL), and specifying properties of systems in LTL; the relationship between temporal logic and automata on infinite words, LTL Model checking (exercises using Spin or similar tools); Computational Tree Logic (CTL and CTL*); CTL model checking (exercises); Process calculi such as CSP and CCS. Notions of program equivalence -- traces, bisimulation and other notions. Hennessy-Milner Logic (HML) and Mu calculus (exercises using tools such as CWB -- Concurrency Work Bench). Symbolic model checking, exercises using tools such as SMV. Sat-based model checking and Davis-Putnam procedure; (exercises using tools such as nuSMV). Possible additional topics include: equational logic frameworks, real-time frameworks, reactive frameworks, pi-calculus (exercises using tools such as the Mobility Workbench), Tree automata and Weak Second-order Logic with k successors (WSkS), (exercises using Mona or similar tools).

COL751 Algorithmic Graph Theory
3 Credits (3-0-0)
Pre-requisites: COL351 OR Equivalent
Overlaps with: MTL468

COL752 Geometric Algorithms
4 Credits (3-0-2)
Pre-requisites: COL351 OR Equivalent
Geometric Fundamentals: Models of computation, lower bound techniques, geometric primitives, geometric transforms Convex hulls: Planar convex hulls, higher dimensional convex hulls, randomized, output sensitive, and dynamic algorithms, applications of convex hull, Intersection detection: segment intersection, line sweep, map overlay, halfspace intersection, polyhedral intersection, Geometric searching: segment, interval, and priority-search trees, point location, persistent data structure, fractional cascading, range searching, nearest-neighbor searching Proximity problems: closest pair, Voronoi diagram, Delaunay triangulation and their subgraphs, spanners, well separated pair decomposition Arrangements: Arrangements of lines and hyperplanes, sweep-line and incremental algorithms, lower envelopes, levels, and zones, applications of arrangements Triangulations: monotone and simple polygon triangulations, point-set triangulations, optimization criteria, Steiner triangulation, Delaunay refinement Geometric sampling: random sampling and ε-nets, ε-approximation and discrepancy, cuttings, coresetsGeometric optimization: linear programming, LP-type problems, parametric searching, approximation techniques. Implementation Issues: robust computing, perturbation techniques, floating-point filters, rounding techniques.

COL753 Complexity Theory
3 Credits (3-0-0)
Pre-requisites: COL352, COL705 OR Equivalent
Modeling computation (Finite state machines, Non-determinism, Turing machines, class P etc.), NP and NP-completeness, Diagonalization (Time hierarchy and Ladner's theorem), Space complexity (PSPACE, NL, Savitch's theorem, Immerman-Szelepcsényi theorem etc.), Polynomial hierarchy, Boolean circuits (P/poly), Randomized classes (RP, BPP, ZPP, Adleman's Theorem, Gács-Sipser-Lautemann Theorem), Interactive proofs (Arthur-Merlin, IP=PSPACE), Cryptography (one-way functions, pseudorandom generators, zero knowledge), PCP theorem and hardness of approximation, Circuit lower bounds (Hastad's switching lemma), Other topics (#P, Todà's theorem, Average-case complexity, derandomization, pseudorandom construction)

COL754 Approximation Algorithms
3 Credits (3-0-0)
Pre-requisites: COL351 OR Equivalent

COL756 Mathematical Programming
3 Credits (3-0-0)
Pre-requisites: COL351 OR Equivalent
Overlaps with: MTL103, MTL704

COL757 Model Centric Algorithm Design
4 Credits (3-0-2)
Pre-requisites: COL351 OR Equivalent
The RAM model and its limitations, Introduction to alternate algorithmic models Parallel models like PRAM and Interconnection networks; Basic problems like Sorting, Merging, Routing, Parallel Prefix and applications, graph algorithms like BFS, Matching Memory hierarchy models; Caching, Sorting, Merging, FFT, Permutation, Lower bounds Data Structures - searching, Priority queues Streaming Data models: Distinct items, frequent items, frequency moments, estimating norms, clustering On line algorithms: competitive ratio, list accessing, paging, k-server, load-balancing, lower-bounds.
COL758 Advanced Algorithms
4 Credits (3-0-2)
Pre-requisites: COL351 OR Equivalent

COL759 Cryptography & Computer Security
3 Credits (3-0-0)
Pre-requisites: COL351, MTL106 OR Equivalent
Overlaps with: MTL730
Part 1: Foundations: Perfect secrecy and its limitations, computational security, pseudorandom generators and one time encryption, pseudorandom functions, one way permutations, message authentication and cryptographic hash functions.
Part 2: Basic Constructions and proofs: Some number theory, symmetric key encryption, public key encryption, CPA and CCA security, digital signatures, oblivious transfer, secure multiparty computation.

COL760 Advanced Data Management
4 Credits (3-0-2)
Pre-requisites: COL362 OR Equivalent
Storage and file structures, advanced query processing and optimization for single server databases, distributed data management (including distributed data storage, query processing and transaction management), web-data management (including managing the web-graph and implementation of web-search), big data systems.

COL762 Database Implementation
4 Credits (3-0-2)
Pre-requisites: COL362 OR Equivalent
Review of Relational Model, Algebra and SQL, File structures, Constraints and Triggers, System Aspects of SQL, Data Storage, Representing Data Elements, Index, Multi dimensional and Bit-map Indexes, Hashing, Query Execution, Query Compiler.

COL765 Intro. To Logic and Functional Programming
4 Credits (3-0-2)
Pre-requisites: COL106 OR Equivalent
Introduction to declarative programming paradigms. The functional style of programming, paradigms of developments of functional programs, use of higher order functionals and pattern-matching. Introduction to lambda calculus. Interpreters for functional languages and abstract machines for lazy and eager lambda calculi, Types, type-checking and their relationship to logic. Logic as a system for declarative programming. The use of resolution and theorem-proving techniques in logic programming. The relationship between logic programming and functional programming.

COL768 Wireless Networks
4 Credits (3-0-2)
Pre-requisites: COL334 OR Equivalent
Radio signal propagation, advanced modulation and coding, medium access techniques, self-configurable networks, mesh networks, cognitive radio and dynamic spectrum access networks, TCP over wireless, wireless security, emerging applications.

COL770 Advanced Artificial Intelligence
4 Credits (3-0-2)
Pre-requisites: COL106 OR Equivalent
Overlap with: COL333, COL770, ELL789
Philosophy of artificial intelligence, fundamental and advanced search techniques (A*, local search, suboptimal heuristic search, search in AND/OR graphs), constraint optimization, temporal reasoning, knowledge representation and reasoning through propositional and first order logic, modern game playing (UCT), planning under uncertainty (Topological value iteration, LAO*, LRTDP), reinforcement learning, introduction to robotics, introduction to probabilistic graphical models (Bayesian networks, Hidden Markov models, Conditional random fields), machine learning, introduction to information systems (information retrieval, information extraction).

COL772 Natural Language Processing
4 Credits (3-0-2)
Pre-requisites: COL106 OR Equivalent
Overlaps with: MTL785
NLP concepts: Tokenization, lemmatization, part of speech tagging, named entity recognition, co-reference resolution, parsing, information extraction, sentiment analysis, question answering, text classification, document clustering, document summarization, discourse, machine translation.

COL774 Machine Learning
4 Credits (3-0-2)
Pre-requisites: MTL106 OR Equivalent
Overlaps with: COL341 ELL784, ELL888

COL776 Learning Probabilistic Graphical Models
4 Credits (3-0-2)
Pre-requisites: MTL106 OR Equivalent
Overlaps with: COL341 ELL784, ELL888

COL778 Computer Vision
4 Credits (3-0-2)
Pre-requisites: EC 80
Overlaps with: ELL793
COL781 Computer Graphics
4.5 Credits (3-0-3)
Pre-requisites: COL106 OR Equivalent
Overlaps with: ELL792
Graphics pipeline; Graphics hardware: Display devices, Input devices; Raster Graphics: line and circle drawing algorithms; Windowing and 2D/3D clipping; Cohen and Sutherland line clipping, Cyrus Beck clipping method; 2D and 3D Geometrical Transformations: scaling, translation, rotation, reflection; Viewing Transformations: parallel and perspective projection; Curves and Surfaces: cubic splines, Bezier curves, B-splines, Parametric surfaces, Surface of revolution, Sweep surfaces, Fractal curves and surfaces; Hidden line/surface removal methods; illuminations model; shading: Gouraud, Phong; Introduction to Ray-tracing; Animation; Programming practices with standard graphics libraries like openGL.

COL783 Digital Image Analysis
4.5 Credits (3-0-3)
Pre-requisites: COL106, ELL205 OR Equivalent
Overlap with: ELL715
Digital Image Fundamentals; Image Enhancement in Spatial Domain: Gray Level Transformation, Histogram Processing, Spatial Filters; Image Transforms: Fourier Transform and their properties, Fast Fourier Transform, Other Transforms; Image Enhancement in Frequency Domain; Color Image Processing; Image Warping and Restoration; Image Compression; Image Segmentation: edge detection, Hough transform, region based segmentation; Morphological operators; Representation and Description; Features based matching and Bayes classification; Introduction to some computer vision techniques: Imaging geometry, shape from shading, optical flow; Laboratory exercises will emphasize development and evaluation of image processing methods.

COL786 Advanced Functional Brain Imaging
4 Credits (3-0-2)
Pre-requisites: COL781
Introduction to human Neuro-anatomy, Hodgkin Huxely model, overview of brain imaging methods, introduction to magnetic resonance imaging, detailed fMRI, fMRI data analysis methods, general linear model, network analysis, machine learning based methods of analysis.

COL788 Advanced Topics in Embedded Computing
3 Credits (3-0-0)
Pre-requisites: COL216, COL331 OR Equivalent
Overlaps with: ELL782
Embedded Platforms, Embedded processor architectures, System initialization, Embedded operating systems (linux), DSP and graphics acceleration, Interfaces, Device Drivers, Network, Security, Debug support, Performance tuning.

The course would involve substantial programming assignments on embedded platforms.

COS799 Independent Study
3 Credits (0-3-0)
The student will be tasked with certain reading assignments and related problem solving in a appropriate area of research in Computer Science under the overall guidance of a CSE Faculty member. The work will be evaluated through term paper.

COL812 System Level Design and Modelling
3 Credits (3-0-0)
Pre-requisites: COL719
Embedded systems and system-level design, models of computation, specification languages, hardware/software co-design, system partitioning, application specific processors and memory, low power design.

COL818 Principles of Multiprocessor Systems
4 Credits (3-0-2)
Pre-requisites: COL216, COL351, COL331 OR Equivalent
Mutual Exclusion, Coherence and Consistency, Register Constructions, Power of Synchronization Operations, Locks and Monitors, Concurrent queues, Futures and Work-Stealing, Barriers, Basics of Transactional Memory (TM), Regular Hardware TMs, Unbounded Hardware TMs, Software TMs.

COL819 Advanced Distributed Systems
4 Credits (3-0-2)
Pre-requisites: COL331, COL334, COL380 OR Equivalent
Epidemic/Gossip based algorithms, Peer to peer networks, Distributed hash tables, Synchronization, Mutual exclusion, Leader election, Distributed fault tolerance, Large scale storage systems, Distributed file systems, Design of social networking systems.

COL821 Reconfigurable Computing
3 Credits (3-0-0)
Pre-requisites: COL719
FPGA architectures, CAD for FPGAs: overview, LUT mapping, timing analysis, placement and routing, Reconfigurable devices - from fine-grained to coarse-grained devices, Reconfiguration modes and multi-context devices, Dynamic reconfiguration, Compilation from high level languages, System level design for reconfigurable systems: heuristic temporal partitioning and ILP-based temporal partitioning, Behavioral synthesis, Reconfigurable example systems' tool chains.

COL829 Advanced Computer Graphics
4 Credits (3-0-2)
Pre-requisites: COL781
Rendering: Ray tracing, Radiosity methods, Global illumination models, Shadow generation, Mapping, Anti-aliasing, Volume rendering, Geometrical Modeling: Parametric surfaces, Implicit surfaces, Meshes, Animation: spline driven, quaternions, articulated structures (forward and inverse kinematics), deformation purely geometric, physically-based, Other advanced topics selected from research papers.

COL830 Distributed Computing
3 Credits (3-0-0)
Pre-requisites: COL226 OR Equivalent

COL831 Semantics of Programming Languages
3 Credits (3-0-0)
Pre-requisites: COL226, COL352
Study of operational, axiomatic and denotational semantics of procedural languages; semantics issues in the design of functional and logic programming languages, study of abstract data types.

COL832 Proofs and Types
3 Credits (3-0-0)
Pre-requisites: COL226, COL352
COL851 Special Topics in Operating Systems
3 Credits (3-0-0)
Pre-requisites: COL331 Or Equivalent
To provide insight into current research problems in the area of operating systems. Topics may include, but are not limited to, OS design, web servers, Networking stack, Virtualization, Cloud Computing, Distributed Computing, Parallel Computing, Heterogeneous Computing, etc.

COL852 Special Topics in COMPILER DESIGN
3 Credits (3-0-0)
Pre-requisites: COL728/COL729
Special topic that focuses on state of the art and research problems of importance in this area.

COL859 Advanced Computer Graphics
4 Credits (3-0-2)
Rendering: Ray tracing, Radiosity methods, Global illumination models, Shadow generation, Mapping, Anti-aliasing, Volume rendering, Geometrical Modeling: Parametric surfaces, Implicit surfaces, Meshes, Animation: spline driven, quaternions, articulated structures (forward and inverse kinematics), deformation — purely geometric, physically based, Other advanced topics selected from research papers.

COL860 Special Topics in Parallel Computation
3 Credits (3-0-0)
The course will focus on research issues in areas like parallel computation models, parallel algorithms, Parallel Computer architectures and interconnection networks, Shared memory parallel architectures and programming with OpenMP and Pthreads, Distributed memory message-passing parallel architectures and programming, portable parallel message-passing programming using MPI. This will also include design and implementation of parallel numerical and non-numerical algorithms for scientific and engineering, and commercial applications. Performance evaluation and benchmarking high-performance computers.

COL861 Special Topics in Hardware Systems
3 Credits (3-0-0)
Under this topic one of the following areas will be covered: Fault Detection and Diagnosability. Special Architectures. Design Automation Issues. Computer Arithmetic, VLSI.

COL862 Special Topics in Software Systems
3 Credits (3-0-0)
Special topic that focuses on state of the art and research problems of importance in this area.

COL863 Special Topics in Theoretical Computer Science
3 Credits (3-0-0)
Pre-requisites: COL351
Under this topic one of the following areas will be covered: Design and Analysis of Sequential and Parallel Algorithms. Complexity issues, Trends in Computer Science Logic, Quantum Computing and Bioinformatics, Theory of computability. Formal Languages. Semantics and Verification issues.

COL864 Special Topics in Artificial Intelligence
3 Credits (3-0-0)
Pre-requisites: COL333/COL671/Equivalent
Potential topics or themes which may be covered (one topic per offering) include: information extraction, industrial applications of AI, advanced logic-based AI, Markov Decision Processes, statistical relational learning, etc.

COL865 Special Topics in Computer Applications
3 Credits (3-0-0)
Pre-requisites: Permission of the Instructor
Special topic that focuses on special topics and research problems of importance in this area.

COL866 Special Topics in Algorithms
3 Credits (3-0-0)
Pre-requisites: COL 351 OR Equivalent
The course will focus on specialized topics in areas like Computational Topology, Manufacturing processes, Quantum Computing, Computational Biology, Randomized algorithms and other research intensive topics.

COL867 Special Topics in High Speed Networks
3 Credits (3-0-0)
Pre-requisites: COL334 OR COL672
The course will be delivered through a mix of lectures and paper reading seminars on advanced topics in Computer Networks. Hands-on projects will be conceptualized to challenge students to take up current research problems in areas such as software defined networking, content distribution, advanced TCP methodologies, delay tolerant networking, data center networking, home networking, green networking, clean state architecture for the Internet, Internet of things, etc.

COL868 Special Topics in Database Systems
3 Credits (3-0-0)
Pre-requisites: COL334/COL672/Equivalent
The contents would include specific advanced topics in Database Management Systems in which research is currently going on in the department. These would be announced every time the course is offered.

COL869 Special topics in Concurrency
3 Credits (3-0-0)
The course will focus on research issues in concurrent, distributed and mobile computations. Models of Concurrent, Distributed and Mobile computation. Process calculi, Event Structures, Petri Nets an labeled transition systems. Implementations of concurrent and mobile, distributed programming languages. Logics and specification models for concurrent and mobile systems. Verification techniques and algorithms for model checking. Type systems for concurrent/ mobile programming languages. Applications of the above models and techniques.

COL870 Special Topics in Machine Learning
3 Credits (3-0-0)
Pre-requisites: COL341 OR Equivalent
Contents may vary based on the instructor's expertise and interests within the broader area of Machine Learning. Example topics include (but not limiting to) Statistical Relational Learning, Markov Logic, Multiple Kernel Learning, Multi-agent Systems, Multi-Class Multi-label Learning, Deep Learning, Sum-Product Networks, Active and Semi-supervised Learning, Reinforcement Learning, Dealing with Very High-Dimensional Data, Learning with Streaming Data, Learning under Distributed Architecture.

COL871 Special Topics in programming languages & Compilers
3 Credits (3-0-0)
Pre-requisites: COL728/COL729/Equivalent
Contents may vary based on the instructor’s interests within the broader area of Programming Languages and Compilers.

COL872 Special Topics in Cryptography
3 Credits (3-0-0)
Pre-requisites: COL759 OR Equivalent
Contents may vary based on the instructor’s interests within the broader area of Cryptography. Examples include CCA secure encryption, multiparty computation, leakage resilient cryptography,
broadcast encryption, fully homomorphic encryption, obfuscation, functional encryption, zero knowledge, private information retrieval, byzantine agreement, cryptography against extreme attacks etc.

**COV876 Special Module on Automated Reasoning Methods for Program Analysis**

Course Categories: DE for CSI, PE for CS5, PE(SS) for MCS.

1 Credit (1-0-0)

Pre-requisites: EC100 for UG

Through the course students will (1) get exposure to fundamental concepts in building automated reasoning tools to support deployment of formal methods for software and cyber physical systems, (2) get an overview of the advanced state of the art approaches towards building automated reasoning tools, (3) learn about foundational aspects so as to prepare them to pursue these topics and related literature independently for research and use in system design and other applications and (4) become aware of exciting new directions in research on software and system analysis, particularly techniques for automatically generating invariant properties.

**COV877 Special Module on Visual Computing**

1 Credit (1-0-0)

The course will be a seminar-based course where the instructor would present topics in a selected theme in the area of visual computing through research papers. Students will also be expected to participate in the seminar.

**COV878 Special Module in Machine Learning**

1 Credit (1-0-0)

Contents may vary based on the instructor’s expertise and interests within the broader area of Machine Learning. Example topics include (but not limiting to) Statistical Relational Learning, Markov Logic, Multiple Kernel Learning, Multi-agent Systems, Multi-Class Multi-label Learning, Deep Learning, Sum-Product Networks, Active and Semi-supervised Learning, Reinforcement Learning, Dealing with Very High-Dimensional Data, Learning with Streaming Data, Learning under Distributed Architecture.

**COV879 Special Module in Financial Algorithms**

1 Credit (1-0-0)

Pre-requisites: MTL106 OR Equivalent

Overlap with: MTL 732 & MTL 733

Special module that focuses on special topics and research problems of importance in this area.

**COV880 Special Module in Parallel Computation**

1 Credit (1-0-0)

Pre-requisites: Permission of Instructor

Special module that focuses on special topics and research problems of importance in this area.

**COV881 Special Module in Hardware Systems**

1 Credit (1-0-0)

Pre-requisites: Permission of Instructor

Special module that focuses on special topics and research problems of importance in this area.

**COV882 Special Module in Software Systems**

1 Credit (1-0-0)

Special module that focuses on special topics and research problems of importance in this area.

**COV883 Special Module in Theoretical Computer Science**

1 Credit (1-0-0)

Pre-requisites: COL 351 OR equivalent

Special module that focuses on special topics and research problems of importance in this area.

**COV884 Special Module in Artificial Intelligence**

1 Credit (1-0-0)

Pre-requisites: COL333/COL671/Equivalent

Special module that focuses on special topics and research problems of importance in this area.

**COV885 Special Module in Computer Applications**

1 Credit (1-0-0)

Special module that focuses on special topics and research problems of importance in this area.

**COV886 Special Module in Algorithms**

1 Credit (1-0-0)

Pre-requisites: COL351 OR Equivalent

Special module that focuses on special topics and research problems of importance in this area.

**COV887 Special Module in High Speed Networks**

1 Credit (1-0-0)

Pre-requisites: COL334 OR COL672

The course will be delivered through a mix of lectures and paper reading seminars on advanced topics in Computer Networks. Students will be introduced to topics such as software defined networking, content distribution, advanced TCP methodologies, delay tolerant networking, data center networking, home networking, green networking, clean state architecture for the Internet, Internet of things, etc.

**COV888 Special Module in Database Systems**

1 Credit (1-0-0)

Pre-requisites: COL362 OR COL632 OR Equivalent

Potential topics or themes which may be covered (one topic per offering) include: data mining, big data management, information retrieval and database systems, semantic web data management, etc.

**COV889 Special Module in Concurrency**

1 Credit (1-0-0)

Pre-requisites: MTL106 OR Equivalent

Special module that focuses on special topics and research problems of importance in this area.

**COD891 M.Tech. Minor Project**

3 Credits (0-0-6)

Research and development oriented projects based on problems of practical and theoretical interest. Evaluation done based on periodic presentations, student seminars, written reports, and evaluation of the developed system (if applicable). Students are generally expected to work towards the goals and milestone set for Minor Project COP 891.

**COD892 M.Tech. Project Part-I**

7 Credits (0-0-14)

It is expected that the problem specification and milestones to be achieved in solving the problem are clearly specified. Survey of the related area should be completed. This project spans also the course COP892. Hence it is expected that the problem specification and the milestones to be achieved in solving the problem are clearly specified.

**COD893 M.Tech. Project Part-II**

14 Credits (0-0-28)

Pre-requisites: COD 892

The student(s) who work on a project are expected to work towards the goals and milestones set in COP893. At the end there would be a demonstration of the solution and possible future work on the same problem. A dissertation outlining the entire project, including a survey of literature and the various results obtained along with their solutions is expected to be produced by each student.

**COD895 MS Research Project**

36 Credits (0-0-72)
**Department of Electrical Engineering**

**ELL100 Introduction to Electrical Engineering**
4 Credits (3-0-2)


**ELL201 Digital Electronics**
4.5 Credits (3-0-3)

Pre-requisites: EEL 100


**ELL202 Circuit Theory**
4 Credits (3-1-0)

Pre-requisites: ELL100


Electro-mechanical energy conversion principles: Force and EMF production in a rotating machine.

DC machines: Types, construction, working principle, characteristics and applications.

3-phase induction machines: Types, construction, Introduction to windings and winding factor, production of revolving magnetic field, working principle on 3-phase induction machine, equivalent circuit, characteristics, phasor diagram and applications.

3-phase synchronous machines: Types, construction, working principle, equivalent circuit, characteristics, phasor diagram and applications. Fractional-HP and Special Machines.
ELP225 Control Engineering Laboratory
1.5 Credits (0-0-3)
Pre-requisites: ELL225
Basics of Sensors and Actuators, Study of AC and DC Motors, Linear Systems, Analog and Digital Motors, Synchros, Temperature Control.

ELL231 Power Electronics and Energy Devices
3 Credits (3-0-0)
Pre-requisites: ELL100
Introduction to semiconductor basics and PN Junctions. Short introduction to power device technology, PIN diodes, Schottky diodes, Power BJTs, Power MOSFETs, IGBTs, Thyristors, Wide bandgap power semiconductor devices, Packaging and Reliability of Power devices, Destructive mechanisms in power devices, Power device induced oscillations and Electromagnetic disturbances, Selection of power devices in power electronic systems, Smart power integrated circuits.

ELL301 Electrical and Electronics Instrumentation
3 Credits (3-0-0)
Pre-requisites: ELL100

ELL302 Power Electronics
3 Credits (3-0-0)
Pre-requisites: ELL231 (EE3)/ELL211 (EE1)

ELP302 Power Electronics Laboratory
1.5 Credits (0-0-3)
Pre-requisites: ELL302
Power flow analysis. Fault analysis in power systems. Power system stability studies. Transients in power system and travelling waves. Introduction to power system relaying and brief idea of over current, differentia and impedance based protection. Basic concepts of Power system operation and control. Introduction to HVDC and FACTS.

ELP303 Power Engineering Laboratory
1.5 Credits (0-0-3)
Pre-requisites: ELP303
Experiments will be conducted on 3-phase alternators and transformers for measuring their sequence impedance. Directional, overcurrent and differential protection relays will be studied. Computer simulation for power flow, short circuit and stability studies of interconnected power systems. Numerical relays and synchrophasors will be introduced. FACTS devices will be experimented.

ELL304 Analog Electronics
5.5 Credits (3-1-3)
Pre-requisites: ELL100, ELL202, ELL211, ELL231
Review of working of BJT and MOSFET, large signal and small signal models, biasing schemes, analysis and design of various single stage amplifier configuration, low and high frequency analysis of single stage amplifiers, frequency compensation, current mirrors, multistage amplifiers; differential and operational amplifiers, negative and positive feedback, oscillators and power amplifiers.

ELL305 Computer Architecture
3 Credits (3-0-0)
Pre-requisites: ELL201
Overlaps with: CSL211
Introduction: Performance measurement, Instruction Set Architecture, Computer Arithmetic, Processor: ALU design, Control design, Pipelining, Memory Hierarchy, I/O management, Multicores, Multiprocessors, Clusters, GPU.

ELP305 Design and System Laboratory
1.5 Credits (0-0-3)

ELL311 Communication Engineering
4 Credits (3-1-0)
Pre-requisites: ELL205

ELP311 Communication Engineering Laboratory
1 Credit (0-0-2)
Pre-requisites: ELL311
Laboratory experiments on analog, pulse, and basic digital modulation and demodulation techniques.

ELL312 Semiconductor process technology
3 Credits (3-0-0)
Pre-requisites: ELL211
Overlaps with: ELL784
Semiconductor materials (inorganic and organic), history of semiconductor IC devices, crystal structure, defects, vacancies
and interstitials, semiconductor crystal growth, bulk doping methods, purification methods, wafer manufacture, diffusion, surface doping, oxidation, dopant redistribution, ion implantation and annealing, rapid thermal processes, photolithography, masks, photoreists, exposure, electron beam lithography, vacuum systems, gas flow, plasma processes, pumping theory, leaks, vacuum gauges, wet etching, plasma etching, process gas chemistry and polymerization, ion milling, reactive ion etching, lift-off, vapor pressure of materials, evaporation, sputtering, deposition rate and step coverage, co-depositions, film growth mechanisms and stress, chemical vapor deposition, metal-organic chemical vapor deposition, atomic layer deposition, molecular beam epitaxy, planarization processes, interconnects, yield and device integration.

**ELL313 Antennas and Propagation**
3 Credits (3-0-0)
Prerequisites: ELL212
Starting from the principle of radiation different types of antenna; wire, slot, planar and their arrays with feeds. Antenna synthesis and design and measurements. Characteristics of propagation of radio waves in different atmospheric layers and study of the losses, fading and scattering of microwave and millimeter waves in the atmosphere.

**ELL315 Introduction to Analog Integrated Circuits**
3 Credits (3-0-0)
Prerequisites: ELL204, ELL202

**ELL316 Introduction to VLSI Design**
3 Credits (3-0-0)
Prerequisites: ELL211
Basic MOS characteristics; Deep sub-micron; velocity saturation; Dynamic MOS characteristics; parasitics; leakage; sizing; propagation delay; Logical effort, path delay, optimization; Ratio-ed logic, Pass transistor logic and parasitics; Dynamic logic, pulsed sequential logic; Logical synthesis, physical design, layout; Introduction to design of VLSI memories.

**ELL318 Digital Hardware Design**
3 Credits (3-0-0)
Prerequisites: ELL305
Overlaps with: CSL316
Technology basics and digital logic families such as static CMOS, pass transistor, transmission gate, dynamic and domino logic. Advanced sequential logic elements with latch-based design and timing and clocking concepts. Design flows and paradigms. Data path, control and advanced pipeline implementations. Advanced digital arithmetic. Performance evaluation.

**ELL319 Digital Signal Processing**
4 Credits (3-0-2)
Prerequisites: ELL205

**ELL330 Independent Study (EE3)**
3 Credits (0-3-0)

**ELL332 Electric Drives**
3 Credits (3-0-2)
Prerequisites: ELL203
Basic Concepts: Characteristics and operating modes of drive motors. Starting, braking and speed control of motors. 4 quadrant drives. Types of loads. Torque and associated controls used in process industries.
DC Motor Drives: Characteristics, Starting Methods, Braking Methods, Speed Control Using Converters and Choppers.
Three phase Induction Motor Drives: Characteristics and Equivalent Circuits, Starting Methods, Braking Methods, Speed Control of Cage Rotor Induction Machines using as AC voltage controllers, Voltage-Source and Current-Source Inverters. V-by-F Control and other Control Techniques. Speed Control of Wound-Rotor Induction Machines using Rotor Resistance Variation; Slip-Power Recovery Scheme.
Three phase Synchronous Motor Drives: Characteristics and Equivalent Circuits, Starting Methods, Braking Methods, Speed Control in True Synchronous and Self Control Modes.

**ELP332 Electric Drives Laboratory**
1.5 Credits (0-0-3)
Prerequisites: ELL332

**ELL333 Multivariable Control**
3 Credits (3-0-0)
Prerequisites: ELL225
Overlaps with: ELL721

**ELL334 DSP based Control of Drives**
4 Credits (3-0-2)
Prerequisites: ELL203, ELL332

**ELL335 CAD of Electric Machines**
4 Credits (3-0-2)
Prerequisites: ELL103
ELL363 Power Engineering-II
3 Credits (3-0-0)
Pre-requisites: ELL303

ELL365 Embedded Systems
3 Credits (3-0-0)
Overview of Embedded Systems; Embedded System Architecture: processor exampleARM, PIC, etc.; features of digital signal processor; SOC, memory subsystem, busstructure (PC104, I2C, SPI etc.), interfacing protocols (USB, IrDA etc), testing and debugging, power management; Embedded System Software: Program Optimization, Concurrent Programming, Realtime Scheduling and I/O management; Networked Embedded Systems: special networking protocols (CAN, Bluetooth); Applications.

ELL400 Power Systems Protection
3 Credits (3-0-0)
Pre-requisites: ELL303
Fundamentals of Power system protection, philosophy of protective relays, Different types of relays, Introduction to protection elements like CT, PT, CB, Isolator etc. (includes CT and PT class, CB transients, CB rating and testing, Arc extinction in CB), Over current relays: Principle, operation and setting, Directional relays: needs and operating principle, Power system components protected using over current relays, Differential relays: Principle, operation and setting, Protection of three phase transformer, bus bar and generator using differential relays, Distance relays: Principle, operation and setting, Simple impedance relay, reactance relay, Mho relay and angle impedance relays, Quadrilateral relays, Transmission line protection using distance relays, Static relays: principle, amplitude comparator and phase comparator, Phase comparator realization using positive coincidence period, Distance relay realization using comparators, Generator protection, Overview of Numerical relaying and few algorithms, Phasor extraction, Introduction to PMU and its use, Fault location.

ELL401 Advanced Electromechanics
3 Credits (3-0-0)
Pre-requisites: ELL203
Introduction to Advancement in Electromechanics, Permanent Magnet Brushless DC Machines, Permanent Magnet Synchronous Motors, Switched Reluctance Motors, Single-Phase Machines, Axial Field Machines and other Advanced Electrical Machines, Introduction to Control of Advanced Electrical Machines, Applications in Industry, Domestic Appliances, Electric Mobility, etc., Computer Aided Simulation and Design of Advanced Electrical Machines, Case Studies.

ELL402 Computer Communication
3 Credits (3-0-0)
Pre-requisites: MEL250
Overlaps with: ELL785, CSL374, ELL473
(i) Introduction, network structure: Basic networking concepts, Motivations for layered network concepts, Network examples; (ii) OSI reference model: Layering concepts, Overview of different layer functionalities; (iii) TCP/IP: Layering concepts, Layered functionalities, packet formats, fragmentation, Different layer protocols and examples: ARP, ICMP, etc., Congestion and error control; (iv) Network examples and functionalities: Ethernet, hub, bridge, switch, WANS, MANs, LANs, PANs, BANS; (v) Basic network protocol analysis: Performance metrics, Queueing models; (vi) Multiaccess protocols: Need for multiaccess protocols, Contention-free access schemes, Contention-based protocols: ALOHA, CSMA; (vii) Routing in data networks: Basic graph theoretic concepts, spanning tree, Shortest path routing, distance vector routing, link state routing, RIP, OSPF; (viii) Cross-layer protocol optimization concepts: Distributed control, cost and energy efficiencies.

ELL405 Operating Systems
3 Credits (3-0-0)
Pre-requisites: ELL305
Overlaps with: ELL602, CSL373, MAL358, ELL358
Introduction to OS; Process and Thread management; Scheduling; Concurrent threads and processes: mutual exclusion, synchronization, inter-process communication; Memory management: Cache and Virtual Memory management; Resource management: deadlock and its prevention; File management; I/O management; Introduction to real time systems; Elements distributed operating systems.

ELL406 Robotics and Automation
3 Credits (3-0-0)
Pre-requisites: ELL225

ELL408 Low power circuit design
3 Credits (3-0-0)
Pre-requisites: ELL211

ELL409 Machine Intelligence and Learning
4 Credits (3-0-2)
Pre-requisites: MTL106, COL106
Overlaps with: ELL784, ELL789, CSL333/CSL671, CSL341/ COL774, MAL803
Introduction to machine intelligence and intelligent agents; problem solving; knowledge representation and reasoning (logical and probabilistic); need for learning; basics of machine learning; Decision Trees; Rule-based models; linear learning models; Support Vector Machines; Artificial Neural Networks; Deep Learning; Probabilistic Modelling; Naive Bayes; Reinforcement Learning; Clustering; Feature Selection; Principal Component Analysis; Combining models; Philosophical issues in intelligence and learning. Substantive implementation assignments or a term project involving design of an intelligent learning-based system.

ELL410 Multicore Systems
3 Credits (3-0-0)
Motivation for multicores; Multithreading; Flynn’s taxonomy; Stream processing (vecTLIIV, GPU). Message passing; Shared memory; Cache coherence in multiprocessor Synchronisation; Interconnection networks; Benchmarks and advanced topics; Project.

ELD411 B.Tech. Project-I
3 Credits (0-0-6)
Pre-requisites: ELL311
Overlaps with: ELL762
PSK. Comparison of Digital Modulation Schemes, Bandwidth Efficiency, Pseudo-Noise Sequences and Spread Spectrum, Trellis coded modulation, Digital signaling over fading multipath channels, OFDM communications systems.

**ELP411 Digital Communications Laboratory**
1 Credit (0-0-2)
Pre-requisites: ELP311

**EPLL417 Renewable Energy Systems**
3 Credits (3-0-0)
Pre-requisites: ELL303
Modeling of wind resource, aerodynamic characteristics, wind energy generators — steady-state and dynamic modeling, electrical and pitch controller design, effect of induction generators on grid operation, solar Photovoltaic systems — steady state and dynamic modeling, MPPT operation, power electronic systems for solar PV, fuel cells.

**ELD431 B.Tech. Project-I**
3 Credits (0-0-6)

**EPLL431 Power System Optimization**
3 Credits (3-0-0)
Pre-requisites: ELL303

**EPLL433 CAD of Power Electronics Systems**
4 Credits (3-0-2)
Pre-requisites: ELP302
Introduction to Power Electronic systems, Mathematical modeling of power electronic systems, State-space modeling, Average model, Circuit averaging model, Canonical circuit model, small-signal models and circuit transfer functions. Introduction to power electronics simulators, system oriented simulators, circuit simulators, merits and limitations. Introduction to magnetic design, high frequency inductor and transformer design. Hands-on exercise problems on power electronic circuits simulation using PSPICE/ SIMULINK/PSIM simulators.

**ELD436 Digital control**
3 Credits (3-0-0)
Pre-requisites: ELL225

**ELD437 Switched Mode Power Conversion**
3 Credits (3-0-0)
Pre-requisites: ELL231
To give an introduction about the power switching devices such as thyristors, GTO, MOSFETS, BJT, IGBT and MCTS. Basic concept of gate drivers (Trigger techniques, optical isolators, protection circuits, and isolation transformers), snubber design and protection schemes of power devices are to be discussed. Basic circuit configurations, design and analysis of choppers (step-up, step-down, step-up/down and multi-phase choppers), DC-DC converters (non-isolated and isolated), inverters (voltage and current source configurations) are discussed. This is followed by improved power quality converters (non-isolated and isolated) for reduction of harmonics at AC mains.

**ELD440 Power Systems Protection**
Fundamentals of Power system protection, philosophy of protective relays, Different types of relays, Implementation to protection elements like CT, PT, CB, Isolator etc, (includes CT and PT class, CB transients, CB rating and testing, Arc extinction in CB).
Over current relays: Principle, operation and setting, Directional relays: needs and operating principle, Power system components protected using over current relays.

Distance relays: Principle, operation and setting, Simple impedance relay, reactance relay, Mho relay and angle impedance relays, Quadrilateral relays, Transmission line protection using distance relays.
Static relays: principle, amplitude comparator and phase comparator, Phase comparator realization using positive coincidence period, Distance relay realization using comparators.
Generator protection.
Overview of Numerical relaying and few algorithms, Phasor extraction, Introduction to PMU and its use, Fault location.

**ELD450 BTP Part-II**
8 Credits (0-0-16)

**ELD453 Power System Dynamics and Control**
3 Credits (3-0-0)

**ELD454 BTP Part-II**
8 Credits (0-0-16)

**ELD456 Special Topics in NE&PS–I**
3 Credits (3-0-0)
Pre-requisites: to be decided by the instructor
ELL457 Special Topics in C&IS—I
3 Credits (3-0-0)

ELL458 BTP Part-II
8 Credits (0-0-16)

ELL458 Special Topics in CS&N—I
3 Credits (3-0-0)

ELL459 BTP Part-II
8 Credits (0-0-16)
Pre-requisites: ELD411, ELD431

ELL459 Special Topics in IP—I
3 Credits (3-0-0)
Pre-requisites: to be decided by the instructor

ELL460 Special Topics in IP—II
3 Credits (3-0-0)
Pre-requisites: to be decided by the instructor

ELL700 Linear Systems Theory
3 Credits (3-0-0)
Pre-requisites: ELL225 or equivalent

ELV700 Special Module in Systems and Control
1 Credit (1-0-0)
Pre-requisites: to be decided by the instructor
To provide exposure in specialized topics in systems and control.

ELL701 Mathematical Methods in Control
3 Credits (3-0-0)

ELL702 Nonlinear Systems
3 Credits (3-0-0)
Pre-requisites: ELL225 or equivalent

ELL703 Optimal Control Theory
3 Credits (3-0-0)
Pre-requisites: ELL700 or ELL333
Maximization of functionals of a single and several functions using calculus of variations, Constrained extremals, Euler-Lagrange Equation, Necessary conditions for optimal control, Pontryagin's minimum principle and state inequality constraints, Minimum time problems, Minimum control effort problems, Linear quadratic regulator problems, Riccati Equation, Singular intervals in optimal control problems, The principle of optimality, Application of the principle of optimality to decision making, Dynamic programming applied to routing problems, Solving optimal control problems using dynamic programming, Discrete linear regulator problem, Hamilton-Jacobi-Bellman Equation, Numerical Techniques to determine optimal trajectories.

ELL704 Advanced Robotics
3 Credits (3-0-0)
Pre-requisites: ELL225

ELL705 Stochastic Filtering and Identification
3 Credits (3-0-0)
Pre-requisites: ELL701 or ELL333

ELL706 Systems Biology
3 Credits (3-0-0)
Pre-requisites: ELL225
MODELS : Variables and parameters, Law of mass action, Representations : Deterministic vs stochastic, Spatial aspects, Examples of core processes: Gene expression, Protein degradation, Phosphorylation.


ELL706 Selected Topics in Systems and Control
3 Credits (3-0-0)
Pre-requisites: to be decided by the instructor
To be decided by the Instructor when floating this course: It can be anything that is related to systems and control engineering, but is not covered in any of the established courses.

ELL709 Design Aspects in Control
3 Credits (3-0-0)

ELL710 Coding Theory
3 Credits (3-0-0)
Measure of information, Source Communication, Channel models, Channel Capacity and coding, Linear Block codes, Low Density Parity Check (LDPC) Codes, Bounds on minimum distance, Cyclic codes, BCH codes, Reed Solomon Codes, Convolutional codes, Treills coded Modulation, Viterbi decoding, Turbo codes, Introduction to Space-Time Codes and Introduction to Cryptography. If time permits, LDPC/Turbo codes in the wireless standards. There are no laboratory or design activities involved with this course.

ELV710 Special Module in Cyber Security
1 Credit (1-0-0)
Overview of cyber security, computer security and the associated threat, attack, adversary models, access control, intrusion detection, basic network security, security of cyber physical systems and a brief introduction to cryptography.

ELL711 Signal Theory
3 Credits (3-0-0)
Pre-requisites: ELL105, ELL311
Discrete random variables (Bernoulli, binomial, Poisson, geometric, negative binomial, etc.) and their properties like PDF, CDF, MGF. Continuous random variables: Gaussian, multivariate Gaussian; whitening of the Gaussian random vector; complex Gaussian random vector, circularity; Rayleigh and Rician; exponential; chi-squared; gamma. Signal spaces: convergence and continuity; linear spaces, inner product spaces; basis, Gram-Smidt orthogonalization. Stochastic convergence, law of large numbers, central limit theorem. Random processes: stationarity; mean, correlation, and covariance functions, WSS random process; autocorrelation and cross-correlation functions; transmission of a random process through a linear filter; power spectral density; white random process; Gaussian process; Poisson process.

ELL712 Digital Communications
3 Credits (3-0-0)
Review of random variables and random process, signal space concepts, Common modulated signals and their power spectral densities, Optimum receivers for Gaussian channels, Coherent and non-coherent receivers and their performance (evaluating BER performance through software tools), Basics of Information theory, source and channel coding, capacity of channels, band-limited channels and ISI, multicarrier and spread-spectrum signaling, multiple access techniques.

ELL713 Microwave Theory and Techniques
3 Credits (3-0-0)
Pre-requisites: ELL212
Overlaps with: CRL711

ELL714 Basic Information Theory
3 Credits (3-0-0)
Pre-requisites: ELL105
Introduction to entropy, relative entropy, mutual information, fundamental inequalities like Jensen's inequality and log sum inequality. Proof of asymptotic equipartition property and its usage in data compression. Study of entropy rates of the stochastic process following Markov chains. Study of data compression: Kraft inequality and optimal source coding. Channel capacity: symmetric channels; channel coding theorem, Fano's inequality, feedback capacity. Differential entropy. The Gaussian channel: bandlimited channels, channels with colored noise, Gaussian channels with feedback. Detailed study of the rate-distortion theory: rate distortion function, strongly typical sequences, computation of channel capacity. Joint source channel coding/separation theorem. There are no laboratory or design activities involved with this course.

ELL715 Digital Image Processing
4 Credits (3-0-2)

ELL716 Telecommunication Switching and Transmission
3 Credits (3-0-0)
Wireline access circuits, long haul circuits, signaling, switching exchanges, analysis of telecom switching networks, teletraffic engineering, management protocols, multi-service telecom protocols and networks.

ELL717 Optical Communication Systems
3 Credits (3-0-0)
Pre-requisites: ELL769
The fiber channel with its linear and nonlinear characteristics, LED and Laser diode transmitter design, PIN and APD receiver design, Modulation schemes, Source and line coding in optical systems. Optical Link design with dispersion and power budgeting. Design of digital and analog communication systems. Optical amplifiers, WDM system design. Hybrid fiber co-axial/microwave links.

ELL718 Statistical Signal Processing
3 Credits (3-0-0)
Pre-requisites: ELL711
Review of random variables, GS orthogonalization, geometric concepts, notions of projection, random processes, WSS processes, properties of autocorrelation and power spectral densities, properties of autocorrelation matrices, Cholesky decomposition, eigenv-analysis, optimum Linear filtering, LMS and its performance, variants, Least-squares, QR decomposition and SVD, RLS and its performance, square-root RLS, Kalman Filters, spectrum modelling.

ELP718 Telecommunication Software Laboratory
3 Credits (0-1-4)
Contents: CASE tools, object-oriented program development, use of telecom network simulator, implementation using C/C++/Java, network management software design, V5 test and simulation.

ELL719 Detection and Estimation Theory
3 Credits (3-0-0)
Pre-requisites: ELL711
Overview of the course, Classical Decision Theory: Binary hypothesis testing: Bayes criterion, Neyman-Pearson criterion, min-max test,
M-ary hypothesis testing: General rule, minimum probability of error decision rule, Gaussian case and associated geometric concepts, Erasure decision problem, Random parameter estimation. Non-random parameter estimation: CRLB for nonrandom parameters. ML estimation rule, asymptotic properties of ML estimates. Linear minimum variance estimation, Least squares methods CRLB for random parameter estimation, condition for statistical efficiency. Multiple parameter estimation, Composite and non-parametric hypothesis testing, Applications, Detection of signals,

Mathematical preliminaries: K-L expansion and its application to Detection of known and unknown (i.e. with unknown, parameters) signals in AWGN, Detection of signals in colored noise. Linear estimation, Wiener filters and solution of Wiener Hopf Equations, Kalman-Bucy filters, Miscellaneous estimation techniques.

**ELP719 Microwaves Laboratory**
3 Credits (0-1-4)
Design, fabrication and testing of simple linear microwave circuits using microstrip technology.

**ELP720 Advanced Digital Signal Processing**
3 Credits (3-0-0)
*Pre-requisites: ELL205*
Review of Signals and Systems, Sampling and data reconstruction processes.
Z transforms. Discrete linear systems.
Frequency domain design of digital filters.
Quantization effects in digital filters.
Discrete Fourier transform and FFT algorithms.
High speed convolution and its application to digital filtering.
Introduction to Multirate signal processing, Multirate filtering and Filterbanks: including Polyphase decomposition and perfect reconstruction, Cyclicstationarity and LPTV filters, Introduction to Wavelet Transform.
The self-study component will consist of design problems in the above to be implemented on MATLAB.

**ELP720 Telecommunication Networks Laboratory**
3 Credits (0-1-4)
Contents: Development of network elements such as routers, SNMP nodes. Use of laboratory and telecom field test instruments such as: oscilloscopes, oscillators, RMS meters, transmission impairment measuring systems, return loss meters, etc. Enables students to study voice and data switching functions and to measure transmission and traffic characteristics on models of the major business communication systems and carrier transmission facilities (controlled LAN environments, Ethernet, E1, T1/T3 lines). Experimental procedures include the use of frequency and time division multiplex systems and the modulation techniques employed by in such systems and the observation of noise and distortion effects.

**ELV720 Special Module in Communication Systems and Networking-I**
1 Credit (1-0-0)

**ELV721 Introduction to Telecommunication Systems**
3 Credits (3-0-0)
*Pre-requisites: Only for MBA students of Bharti School, Audit for others*
Fundamentals of signals, signal transmission and media, modulation techniques, equalization, amplification, crosstalk, attenuation, switching principles, telephony, signaling, transmission systems-DSL, optical, radio.

**ELP721 Embedded Telecommunication Systems Laboratory**
3 Credits (0-1-4)

**ELP722 Antenna Theory and Techniques**
3 Credits (3-0-0)
Review of electromagnetism and vector calculus, history and context of antenna theory, operation of various antenna types, such as dipole, linear, loop, and resonant type, characterization of antenna performance metrics, and introduction to numerical techniques for visualizing antenna radiation patterns.

**ELP723 Broadband Communication Systems**
3 Credits (3-0-0)
Multiple Access Techniques – CSMA, Spread Spectrum (SS), Direct Spread SS, Frequency Hopping SS and CDMA, Timing Synchronization, Delay Lock Loop, ISDN Physical Layer, ISDN Data Link Layer, Signaling System Number 7.  Multi-User Gaussian Broadcast channel, OFDM, OFDMA, ATM Switch and Protocols, CLOS Network Switch, OFDM Concept, OFDMA System, Multi-Carrier CDMA, WiMAX.

**ELP724 Computational Electromagnetics**
3 Credits (3-0-0)
Capacity region of the multi-user Gaussian MAC channel. Capacity region of the multi-user Gaussian Broadcast channel (BC) with single-antenna terminals. Capacity of state dependent channels with non-causal side information (Gelfand-Pinsker coding). Dirty paper coding to pre-cancel known interference. MAC-BC duality. Capacity region of the multi-user Gaussian Broadcast channel with multi-antenna terminals (Dirty paper coding achieves the capacity region). Capacity region of the Interference channel. There are no laboratory or design activities involved in this course.

**ELP725 Wireless Communications**
3 Credits (3-0-0)
*Pre-requisites: ELL712*
The wireless channel (physical modeling, linear time-varying system, discrete-time baseband model, time and frequency coherence), point-to-point communication (detection, diversity, spatial multiplexing), cellular systems (multiple access and interference management), capacity of point-to-point wireless channels (single and multi-antenna), capacity of single-antenna multuser channels, point-to-point multi-antenna (MIMO) channels and spatial multiplexing, point-to-point MIMO capacity and multiplexing architectures.

**ELP725 Wireless Communication Laboratory**
3 Credits (0-1-4)

**ELP726 Nano-Photonics and Plasmonics**
3 Credits (3-0-0)

**ELP727 Digital Communication and Information Systems**
3 Credits (3-0-0)
Review of Fourier Transforms, Sampling Theorem, Quantization, Pulse Code Modulation, Digital Modulation Schemes – BPSK, QPSK,
Pre-requisites: to be decided by the instructor

ELL728 Optoelectronic Instrumentation
3 Credits (3-0-0)
Introduction to test and measuring instruments, instrumentation amplifier, chopper stabilized amplifier, analog signal processing: active filter, A/D, D/A converters, integrated, transimpedance and low impedance pre-amplifiers design, sample & hold circuits, multiplexer, peak detector, zero crossing detector etc., digital design: PALs, FPGA, signal analyzer: superheterodyne spectrum analyzer, DFT and FFT analyzer, digital filters and computer interface, microcontrollers: introduction to microcontroller and applications such as 8031, optical post, in-line and pre-amplifiers, noise figure, optoelectronic circuits: transmitter and receiver design, OTDR, optical spectrum analyzer, sensors: fiber optic and radiation types, distributed sensors, fiber optic smart structure, display devices.

ELL730 I.C. Technology
3 Credits (3-0-0)
Course Introduction, Modern Semiconductor IC Fabrication Industrial, Academic Landscape; Overview of modern CMOS process flow – basic steps; Crystal growth and wafer basics; Cleanroom basics – environment, infrastructure, advanced MOS cleaning, getering etc.

Lithography; Oxidation; Diffusion; Ion-Implantation; Thin-Film Deposition; Etching; Backend processes; Process Simulation- tools, techniques and methods; Advanced device fabrication concepts – I (SOI, FDSOI, etc); Advanced device fabrication concepts – II (organic, PV, hetero); Advanced device fabrication concepts – III (CNTs, Self-assembly etc).

ELV730 Special Modules in V&ES – I
1 Credit (1-0-0)
Pre-requisites: to be decide by instructor

ELL731 Mixed Signal Circuit Design
3 Credits (3-0-0)
Pre-requisites: ELL782
Switched capacitor circuit principles and applications in filter design; issues of clock feed through, charge injection and other non-idealities; design of switches; data converters: characteristics, static and dynamic; types of ADCs; track and hold, and sample and hold circuits; comparators; flash ADCs; pipelined ADCs; successive approximation register type ADCs; discrete-time and continuous time delta-sigma ADCs; higher order delta-sigma design; MASH structure; multi-bit delta-sigmas; decimation filtering – sinc and comb filters; digital to analog conversion; voltage-based DACs; charge-based DACs; current-based DACs – binary and thermometer currents; linearizing techniques for DACs; delta-sigma DACs; interpolation filtering; phase-locked loop basics; PLL dynamics; frequency synthesis; all-digital PLLs.

ELV731 Special Modules in NE&PS – I
1 Credit (1-0-0)
Pre-requisites: to be decided by the instructor

ELL732 Micro and Nanoelectronics
3 Credits (3-0-0)
Technology basics and digital logic families such as static CMOS, pass transistor, transmission gate, dynamic and domino logic. Advanced sequential logic elements with latch-based design and timing and clocking concepts. Power and delay of digital circuits. Physical and logical synthesis for ASICs and FPGAs. Verilog and VHDL with design examples. Design for testability with fault models.

ELL733 Digital ASIC Design
4 Credits (3-0-2)
Pre-requisites: ELL308
Overlaps with: CSL316
Review of working of MOSFET, large signal and small signal models, biasing schemes, analysis and design of various single stage amplifier configuration, Noise and distortion analysis, Mismatch and non-linearity, low and high frequency analysis of single stage amplifiers, frequency compensation, current mirrors and reference circuits, multistage amplifiers; differential and operational amplifiers, negative and positive feedback, oscillators and power amplifiers.

ELL734 MOS VLSI design
3 Credits (3-0-0)
Overlaps with: ELL329, ELL324

ELV734 Special Module in Scientific Writing for Research
1 Credit (1-0-0)
Tools needed for scientific writing, ethics of publication, plagiarism, attribution, copyrights, writing impactful papers, writing theses, writing a technical disclosure or patent.

ELL735 Analog Integrated Circuits
3 Credits (3-0-0)
Pre-requisites: ELL204
Introduction to MOSFETs, Single stage amplifiers, Biasing circuits, Voltage and Current reference circuits, Feedback analysis, Multistage amplifiers, Mismatch and noise analysis, Differential amplifiers, High speed and low noise amplifiers, Output stage amplifiers, Oscillators.

ELL736 Solid State Imaging Sensors
3 Credits (3-0-0)
Pre-requisites: ELL204, ELL782
Radiometry and Photometry (Light radiation, photometry, light source, light units), Introduction to properties of silicon and photon absorption, Imager formats, Basics of image sensors (fundamental definition of image sensors, pixels, photo-conversion principles, Charge coupled devices (operational principles, types and performance metrics), CMOS image sensors (operational principles, types and performance metrics), Noise, quantum efficiency, dynamic range and modulation transfer function analysis in image sensors, High speed image sensors, Back side illumination, Electron multiplication CCDs and CMOS, Colour detection in silicon, 3D imaging, machine vision cameras, polarization detection and scientific applications.

ELP736 Physical Design Laboratory
3 Credits (0-0-6)
Pre-requisites: ELL218, ELL111, or ELL732 or equivalent

ELL737 Flexible Electronics
3 Credits (3-0-0)
Pre-requisites: ELL218, ELL111, or ELL732 or equivalent

ELL738 Micro and Nano Photonics
3 Credits (3-0-0)
Pre-requisites: PYL100, ELL207
Overlaps with: PYL795
Ray Optics; Wave Optics: Plane Waves, Spherical Waves, Interference, Diffraction; Paraxial Waves; Beam Optics; Fabry Perot Cavity; Microresonators - Ring Resonators, Disc Resonators; Review of
Electromagnetic (EM) Theory; Boundary Conditions; and some relevant EM problems; FDTD and FEM modeling; Fundamentals of Plasmonics - Surface Plasmon Resonance, Dispersion relation, Plasmon coupling conditions, Plasmonic gratings, Models describing the refractive index of metals; Localized Surface Plasmon Resonance; Plasmonic Sensors and Devices; Surface-enhanced Raman Scattering; Plasmonic waveguides and Interconnects; Photonic Crystals and Devices.

**ELL739 Advanced Semiconductor Devices**
3 Credits (3-0-0)
Pre-requisites: ELL218, ELL111(UG), ELL732(PG)
Solid state device physics, generation and recombination processes, radiation basics, density of states, gain and absorption, LEDs, OLEDs, heterojunction LEDs, lasers, population inversion, photodetectors, CCDs, image sensors, photocurrent, solar cells, efficiency measures, multijunction PVs, organic solar cells, economics, memory devices, sensors, MEMS devices.

**ELL740 Compact Modeling of Semiconductor Devices**
3 Credits (3-0-0)
Pre-requisites: Any course on MOS devices or Microelectronics or Physical Electronics or VLSI technology
Introduction to AMS enablement and PDK elements, Basics of semiconductor devices, Device modeling tools-TCAD and SPICE, Diode modeling, Resistor modeling, FEOL capacitor modeling, Advanced CMOS Technology, MOS transistor modeling, modeling of process variations, Mismatch and corners.

**ELL741 Neuromorphic Engineering**
3 Credits (3-0-0)
Motivation and Field Introduction, Emerging computing trends and roadmap, non-von Neumann computing approach; Basic Biology - 1: Neuron, Synapse, Synaptic Plasticity; Basic Biology - 2: Learning rules, Retina, Cochlea, STDP; Mathematical/Electrical modeling of Neurons - LIF, IF, HH; Hardware Implementation of Neuron circuits – VLSI Digital/Analog; Advanced Nanodevices for Neuron Implementation; Hardware Implementation of Synaptic and Learning circuits – VLSI Digital/Analog; Advanced Nanodevices for Synaptic emulation – 1 (NVM, Flash etc); Advanced Nanodevices for Synaptic emulation – 2 (RRAM, memristors, CNT etc); Synaptic programming methodology optimization; Nanodevice specific bio-inspired learning rule optimization; Full Network design example -1: Visual Application; Full Network design example -2: Auditory Application; Full system level power/energy dissipation considerations and course conclusion.

**ELL742 Introduction to MEMS Design**
3 Credits (3-0-0)
Overlaps with: CRL726
This course is an introduction to the multi-disciplinary and rapidly growing area of MEMS. A MEMS design engineer requires knowledge of several domains –namely mechanical, electrical, fluidic and thermal, as well as knowledge of circuits and microfabrication techniques. This course will cover the fundamentals as applicable to MEMS, as well as several case studies to understand the design process.

**ELL743 Photovoltaics**
3 Credits (3-0-0)
Pre-requisites: ELL218, ELL111(UG), ELL732(PG)
Overlaps with: ELL739

**ELL744 Electronic and Photonic Nanomaterials**
3 Credits (3-0-0)
Pre-requisites: PHL100
Overlaps with: EPL444, PHL726
1D, 2D and 3D confinement; Density of states; Excitons; Coulomb blockade; Optical properties of semiconducting nanoparticles; Fluorescence of semiconductor nanocrystals, core-shell nanocrystals, effect of nanocrystal size; Optical properties of metallic nanoparticles: Surface Plasmons, Localized Surface Plasmons, Surface-enhanced Raman scattering; Electronic Applications of Nanomaterials: Nanowire transistors, Memory Devices, Single electron devices, Biosensors; Optical Applications of Nanomaterials - Quantum well, wire, and dot Diodes, Lasers and Detectors, Chemical sensors, Gas sensors, Biosensors; Development of Electronic and Optical Nanomaterials: Epitaxial Growth, Deposition of Nanomaterials, Self-Assembly of Nanomaterials, Nanofabrication techniques; Characterization of Nanomaterials: Electron microscopic techniques (scanning and transmission), Atomic Force Microscopy, X-Ray Diffraction, Characterization of optical and electronic properties of nanomaterials.
ELL748 System-on-Chip Design and Test
3 Credits (3-0-0)
Pre-requisites: ELL201
Overview and definition of power quality (PQ), Sources of pollution, International power quality standards, and regulations. Power quality monitoring
Power quality problems. Loads which causes power quality problems.
Power factor correction, zero voltage regulation, reactive power compensation, load balancing using load compensation techniques: passive shunt and series compensation, DSTATCOM (Distribution Static Compensators), DVR (Dynamic Voltage Restorers), UPQC (Universal Power Quality Conditioners).
Harmonic effects-within the power system, interference with communication Harmonic measurements. Harmonic elimination-using active (shunt, series and hybrid) and passive (shunt and series) filters.
Improved power quality converters: single ac-dc converters, bridgeless isolated converter, bridgeless non-isolated converters, multi-pulse converters, multilevel converters, line commutated converters, power quality improvement in SMPS, UPS, drives, welding systems, lighting systems, and renewable energy systems.

ELL749 Semiconductor Memory Design
3 Credits (3-0-0)
Pre-requisites: ELL734
Introduction to Special Electrical Machines and Magnetic Devices, Permanent Magnet Machines, Permanent Magnet Brushless DC Machines, Stepper Motors, Hysteresis Motors, Switched Reluctance Motors, Hybrid Motors, Linear Machines, Magnetic Devices, Applications in Robotics, Industry Automation, Electric Vehicles, Aerospace and Defense Systems etc. Super conducting Machines and Other Advanced machines, Case Studies, Computer Aided Simulation and Design of Special Electrical Machines.

ELL750 Modelling of Electrical Machines
3 Credits (3-0-0)
Pre-requisites: ELL203
Review of dynamic Modeling of systems, Basic concepts of electromechanical energy conversion, Modeling of Transformer, Generalized Theory of Electrical machines, Modeling of DC Machine, Induction Machine, Wound Field Synchronous machine, and special machines such as BLDC, PMSM etc.

ELV750 Special Modules in AE–I
1 Credit (1-0-0)

ELL751 Appliance Systems
3 Credits (3-0-0)
Pre-requisites: ELL203, ELL332 ELL365
Introduction to Domestic Appliances, Embedded System Design issues, Ergonomic Design aspects, Review of Electrical Machines and Drives, Review of Embedded Systems, Drive and Control of Washing Machines, Refrigerators, Air Conditioners, Mixer-Grinders/Food Processors, Ceiling and other types of Fans, Introduction to Industrial Appliances, Drives and Control of Industrial Appliances, Computer Aided Simulation and Design of Drives and Control of Appliances, Smart Appliances.

ELL751 Power Electronic Converters
3 Credits (3-0-0)
Introduction to various power switching devices and their control, introducing various power electronic circuits for realization of AC-DC, AC-AC, DC-AC, DC-DC conversion, principle of operation, and analysis, pulse-width modulation and pulse frequency control of power electronic converters, design problems on power electronic converter systems.

ELL752 Electric Drive System
3 Credits (3-0-0)
Components of electric drive system- electrical machines, power converters and control system. Different types of loads encountered in modern drive applications. dynamics of drive systems, starting, braking, speed-control, steady-state and dynamic operation of motors, load variations, closed loop control of drives, phase controlled and chopper controlled dc drives, induction motor drives, synchronous motor drives, space phasor model, v/f control, direct and indirect vector control, direct torque control, PMSM drives, BLDC drive, drive controller design.

ELV752 Special Modules in EET–I
1 Credit (1-0-0)

ELL753 Physical Phenomena in Electrical Machines
3 Credits (3-0-0)
Pre-requisites: ELL103

ELV753 Special Modules in ET–I
1 Credit (1-0-0)

ELL754 Permanent Magnet Machines
3 Credits (3-0-0)
Introduction to Permanent Magnet Machines, Permanent Magnet DC Commutator Machines, Permanent Magnet Synchronous Machines, Permanent Magnet Brushless DC machines, Hysteresis motors, Stepper Motors. Moreover various applications of permanent magnet machines are also integral part of syllabus. Various upcoming applications in field of robotics, solar pumping, wind energy generation system and many more are covered in the syllabus. Computer aided simulation studies for modeling and performance analysis are also part of this course.

ELL755 Variable Reluctance Machines
3 Credits (3-0-0)
The objective of this course is to enhance the knowledge of students with the design, modeling, construction, operation and control of variable reluctance machines including the hybrid motors and their existing applications. The contents distinguish the variable reluctance machines from various conventional machines. Study of possible replacement of conventional machines by the variable reluctance machines for specific applications are the secondary objective of offering this course.

ELL756 Special Electrical Machines
3 Credits (3-0-0)
Pre-requisites: ELL103
Introduction to Special Electrical Machines and Magnetic Devices, Permanent Magnet Machines, Permanent Magnet Brushless DC Machines, Permanent Magnet Brushless Synchronous Machines, Stepper Motors, Hysteresis Motors, Switched Reluctance Motors, Hybrid Motors, Linear Machines, Magnetic Devices, Applications in Robotics, Industry Automation, Electric Vehicles, Aerospace and Defense Systems, etc., Super conducting Machines, Written Pole Machines, Micro-motors, PCB motors, Case Studies, Computer Aided Simulation and Design of Special Electrical Machines.

ELL757 Energy Efficient Motors
3 Credits (3-0-0)
Introduction to energy efficiency and its impacts on social life. Energy-efficient motors, fundamentals of electric motor drives, power factor under non sinusoidal conditions, energy efficient induction motor under different input parameters and applications, adjustable-speed drives their advantages and benefits from efficiency point of view, case studies related to induction motor variable seed drive system, brushless dc motor drive, switched reluctance motor drives, permanent magnet synchronous motor drive etc.
ELL758 Power Quality
3 Credits (3-0-0)
Overview and definition of power quality (PQ), Sources of pollution, International power quality standards, and regulations. Power quality monitoring. Power quality problems. Loads which causes power quality problems. Power factor correction, zero voltage regulation, reactive power compensation, load balancing using load compensation techniques: passive shunt and series compensation, DSTATCOM (Distribution Static Compensators), DVR (Dynamic Voltage Restorers), UPQC (Universal Power Quality Conditioners). Harmonic effects within the power system, interference with communication Harmonic measurements. Harmonic elimination using active (shunt, series and hybrid) and passive (shunt and series) filters. Improved power quality converters: single ac-dc converters, bridgeless isolated converter, bridgeless non-isolated converters, multi-pulse converters, multilevel converters, line commutated converters, power quality improvement in SMPS, UPS, drives, welding systems, lighting systems, and renewable energy systems.

ELL759 Power Electronic Converters for Renewable Energy Systems
3 Credits (3-0-0)

ELL760 Switched Mode Power Conversion
3 Credits (3-0-0)
To give an introduction about the power switching devices such as Thyristors, GTO, MOSFETS, BJT, IGBT and MCTs. Basic concept of gate drivers (Trigger techniques, optical isolators, protection circuits, and isolation transformers), snubber design and protection schemes of power devices are to be discussed. Basic circuit configurations, design and analysis of choppers (step-up, step-down, step-up-down and multi-phase choppers), DC-DC converters (non-isolated and isolated), inverters (voltage and current source and multi-level configurations) are discussed. This is followed by improved power quality converters (non-isolated and isolated) for reduction of harmonics at AC mains.

ELL761 Power Electronics for Utility Interface
3 Credits (3-0-0)
Overview of power electronic converters for utility applications, Converter requirements for Grid-interface, Harmonic compensation, Instantaneous power theory, STATCOM and active filtering and Control of converters under grid-faults.

ELL762 Intelligent Motor Controllers
3 Credits (3-0-0)
Pre-requisites: ELL305
Fundamental concepts in control of electric drive systems. Intelligent Control algorithms used for electric drive systems. Application of Fuzzy Logic, Neural Networks, Genetic Algorithm, Hybrid Fuzzy and Nonlinear Control of Power Converters and Drives. Other recent topics on Intelligent Control of Drives.

ELL763 Advanced Electric Drives
3 Credits (3-0-0)
Pre-requisites: ELL305

ELL764 Electric Vehicles
3 Credits (3-0-0)
The objective of this course is to familiarize students with fundamental issues related to electric vehicles (EVs) and hybrid electric vehicles (HEVs). The various brushless motors such as PMSM, PMBLDCM, SRM, synchronous reluctance motor, induction motor for EVs are to be covered. Moreover, several types of chargers and energy management strategies are to be discussed. The objective also involves analyzing and disseminating information relating to electric vehicle. Various design and control aspects of electric drives and chargers for EVs and HEVs are to be discussed.

ELL765 Smart Grid Technology
3 Credits (3-0-0)
Introduction: Smart Grid an Overview; Components of Smart Grid; Intelligent Appliances; Smart Substations; Smart Distributions-Generations; Smart Power meters; Universal Access (wind, solar, hydro etc.) Smart Grid Technologies: Integrated Communications; Sensing and Measurement; Advance Control Methods; Advance components and Improved Interfaces and Decision Support. Benefits of Smart Grid: Self-Healing; Power Quality Improvement; Utilization of all generation and storage options; Optimized use of assets and efficient Operation. Miscellaneous: Smart Grid Challenges; Smart Grid Projects; Contribution of Microgrid in development of Smart Grid.

ELL766 Appliance Systems
3 Credits (3-0-0)
Pre-requisites: ELL203, ELL322 ELL365
Overview of appliance systems, international standards and regulations, energy efficient appliances, energy efficiency in motor driven appliances, classification based on power rating: low, medium, and high power appliances, classification based on supply power: single-phase and three-phase, classification based on drives system, heating systems and renewable system.

To understand the various types of appliance systems used in domestic and office or commercial scenarios.

Low power appliances (working, types, power quality problems, numerical examples): laptops, mobile, fans, lighting system(CFL, LED, solar), water pumps, TV (LCD, LED Plasma), UPS, SMPS, computer, printer, scanner, hair drier, trimmer, electric rice cooker, induction heater, solar cooker, electric iron, micro-oven, driller etc.

Medium power appliances (working, types, power quality problems, numerical examples): Air conditioner, electrical vehicle, centralized heating system, washing machines, refrigerators, welding system, solar boiler, water pumps etc.

High power appliances (working, types, power quality problems, numerical examples): welding machines, hammers, centralized AC system, etc.

Power quality techniques used in appliances systems.

ELL767 Mechatronics
3 Credits (3-0-0)
The course articulates the essence of mechatronics and provide examples of mechatronic systems. Moreover, it explains analog-to-digital-conversion (A/D) and its implementation using a microcontroller and DSPs. Study of the underlying operational principles and construction of electromagnetic actuators such as DC, AC, and stepping motors. Study of various transducers their working principles etc. Selection of best electrical machines for a given motion control application considering system inertia, external forces or torques, and motion profiles and select an appropriate motor. Design and analysis for basic power controllers for various applications.
EL768 Computer Aided Design of Power Electronic Systems
3 Credits (3-0-0)
Introduction to modern simulation tools used for the power electronic systems analysis such as PSPICE, MATLAB, PSIM, SABER etc. Modeling of power electronic systems, filters designs. Introduction to advanced modeling techniques and their transformation into software platform, Closed-loop power electronic systems modeling and their simulation.

EL769 Electrical Systems for Construction Industries
4 Credits (3-0-2)
Elements of Distribution System: Distribution transformer circuit breakers, Cables, Fuses and protection schemes, Rectifiers, Battery chargers and inverters. Machines and Drives: D.C. Motors, 3-phase induction motors and HKW motors starting, speed control and braking, Application to air conditioning, lifts, cranes, water pumps. Illumination: Types of illumination, illumination laws, lamps & fixtures. Electrical Energy Conservation: Modern compact fluorescent lamps, energy audit methods of saving electricity in drives, lighting, air conditioning, pumps and distributions systems metering, KW, KWh and KVAR meters stand by power generation: DG sets, UPS, maintenance and protection of D.G. sets and UPS.

EL770 Power System Analysis
3 Credits (3-0-0)
Pre-requisites: ELL303

EL771 Advanced Power System Protection
3 Credits (3-0-0)

EL772 Planning and Operation of a Smart Grid
3 Credits (3-0-0)
Pre-requisites: ELL303
Smart grids key characteristics, demand side management, load characteristics, hybrid electric vehicles, energy markets, deregulation, wide area monitoring, protection and control, smart metering, adaptive relaying, power line carrier communication and networking, architectures and standards, renewable energy, distributed generation, smart grids policies.

EL773 High Voltage DC Transmission
3 Credits (3-0-0)
General aspects and comparison with AC transmission system. Thyristor based HVDC Converter and inverter operation. Control of HVDC link. Interaction between AC and DC system. Harmonic generation and their elimination. Protections for HVDC system. Modeling of HVDC link for AC-DC power flow. AC-DC system power flow solution techniques. HVDC light.

EL774 Flexible AC Transmission System
3 Credits (3-0-0)
The phenomenon of voltage collapse; the basic theory of line compensation. Static VAR compensators; static phase shifters; thyristors controlled series capacitors. Co-ordination of FACTS devices with HVDC links. The FACTS optimization problem. Transient and dynamic stability enhancement using FACTS components.

EL775 Power System Dynamics
3 Credits (3-0-0)
Pre-requisites: ELL303

EL776 Advanced Power System Optimization
3 Credits (3-0-0)
Introduction to power system optimization problems and linkages. Optimization basics and solution techniques for convex and non convex optimization problems. Basic Optimal power flow. Preventive and corrective security constrained optimal power flow, Unit commitment, hydrothermal scheduling, generation, transmission and reactive expansion planning. Optimization with uncertain data

EL777 Power System operation and control
3 Credits (3-0-0)
Control of active power. Turbine, governor and boiler modelling and control. Hydro and steam turbines, load frequency control, Automatic generation control in single-area and multi-area systems. Under-frequency load shedding, secondary frequency control. Automatic voltage regulators, excitation systems – modelling and control, small-signal stability studies, power system stabilizers, on-load tap-changing transformers.

EL778 Dynamic Modelling And Control of Sustainable Energy Systems
3 Credits (3-0-0)
Microgrids and distributed generation; Introduction to renewable energy technologies; electrical systems and generators used in wind energy conversion systems,diesel generators, combined heat cycle plants, inverter based generation, solar PV based systems, fuel cell and gas-electrolyzer, battery and flywheel based storage system; Voltage and frequency control in a microgrid; Grid connection interface issues.

EL779 Forecasting Techniques for Power System
3 Credits (3-0-0)
Principles of forecasting load, wind and price. Statistical and non statistical based approaches. AI application for forecasting.

ELD780 Minor Project
2 Credits (0-0-4)

EL780 Mathematical Foundations of Computer Technology
3 Credits (3-0-0)
Probability theory, stochastic processes, and statistical inference. Elements of real and complex analysis, and linear algebra. Optimization, with an emphasis on application and implementation.

ELP780 Software Lab
3 Credits (0-1-4)
Experiments related to the following topics: advanced data structures and algorithms, compilers, GUI, component-based software design, distributed and web based applications, UML, firmware, database applications.

ELV780 Special Module in Computers
1 Credit (1-0-0)
ELL781 Software Fundamentals for Computer Technology
3 Credits (3-0-0)
Introduction, data structures for combinatorial optimization: heaps, union-find, Fibonacci heaps, dynamic trees, dynamic graph structure; Asymptotic analysis; Divide & conquer and graph algorithms: Graph search; Breadth first, depth first, topological sorting, Fast Fourier Transform, Matrix Multiplication, Shortest path algorithms; Additional Data Structures: Suffix trees & string matching, Splay trees & amortized analysis; Advanced algorithmic design techniques: Dynamic programming (edit distance, chains of matrix multiplication, etc.), Network flow and its use for solving problems; Linear and integer programming; Randomized algorithms, NP-completeness (hashing & global minimum cut), Approximation Algorithms; Object oriented Software design, Design of Dependable Software.

ELL781 Digital Systems Lab
3 Credits (0-1-4)

ELV781 Special Modules in Information Processing-I
1 Credit (1-0-0)
Pre-requisites: to be decided by the instructor

ELL782 Computer Architecture
3 Credits (3-0-0)
Instruction set design, pipelining, memory hierarchy design, parallelism in various forms, warehouse scale computers, specific topics such as Vector, SIMD, GPU architectures, Embedded Systems, VLIW, EPIC, Multi-core architectures.

ELL782 Computer Networks Lab
3 Credits (0-1-4)
Simulation and hardware experiments on different aspects of computer communication networks. Network traffic generation and analysis, differentiated service queues, network of queues using discrete event simulations.

ELL783 Operating Systems
4 Credits (3-0-2)
Processes and threads; CPU scheduling; concurrency, synchronisation; deadlocks; Memory management; files and I/O; Real-time operating systems; basics of Cloud computing.

ELL784 Introduction to Machine Learning
3 Credits (3-0-0)
Pre-requisites: MTL106
Overlaps with: ELL409, COL341, COL774, MAL803
Introduction to Machine intelligence and learning; linear learning models; Artificial Neural Networks: Single Layer Networks, LTUs, Capacity of a Single Layer LTU, Nonlinear Dichotomies, MultiLayer Networks, Growth networks, Backpropagation and some variants; Support Vector Machines: Origin, Formulation of the L1 norm SVM, Solution methods (SMO, etc.), L2 norm SVM, Regression, Variants of the SVM; Complexity: Origin, Notion of the VC dimension, Derivation for an LTU, PAC learning, bounds, VC dimension for SVMs, Learning low complexity machines - Structural Risk Minimisation; Unsupervised learning: PCA, KPCA; Clustering: Origin, Exposition with some selected methods; Feature Selection: Origin, Filter and Wrapper methods, State of the art - FCBF, Relief, etc; Semi-supervised learning: introduction; Assignments/Short project on these topics.

ELL785 Computer Communication Networks
3 Credits (3-0-0)
Pre-requisites: MTL106/ELL711
Overlaps with: CSL374, CSL672 (20%)
Theory/Lecture: Review of data communication techniques, basic networking concepts, layered network and protocol concepts, quality of service, motivations for cross-layer protocol design. Motivations for performance analysis, forward error correction and re-transmission performances, Markov and semi-Markov processes, Little’s theorem, M/M/m/k, M/G/1 systems, priority queueing, network of queues, network traffic behavior. Concepts and analysis of multi-access protocols; contention-free and contention multi-access protocols. Basic graph theoretic concepts, routing algorithms and analysis.

Suggested lab Course content:
Laboratory: Simulation and hardware experiments on different aspects of computer communication networks. Network traffic generation and analysis, differentiated service queues, network of queues using discrete event simulations.

ELL786 Multimedia Systems
3 Credits (3-0-0)
Multimedia signal processing; coding and compression; standards: logic, issues, future directions; Multimedia issues governing developments in computer architecture and embedded systems, computer and communication networks, operating systems; Search and retrieval.

ELL787 Embedded Systems and Applications
3 Credits (3-0-0)

ELL788 Computational Perception and Cognition
3 Credits (3-0-0)
Introduction: Philosophical & Psychological models, Cognitive models & Bayesian Inferenceing framework; Visual Perception of 3D space & scene; Perceptual processes for Object recognition & memorization; Auditory Perception; Haptic Perception; Attentional mechanism in multimedia perception; Applications: Image & video quality assessment, compression; Audio quality assessment, compression & indexing; Haptic interfaces; Cognitive Architecture; Computational Consciousness, Cognitive Robotics & Other applications.

ELL789 Intelligent Systems
3 Credits (3-0-0)
Overlaps with: ELL409, COL333, COL770

ELL790 Digital Hardware Design
3 Credits (3-0-0)
To provide advanced level exposure to digital hardware design and interfacing, elements of hardware software co-design, synthesis of digital systems at logic/RTL and system levels, simulation aspects of synthesis.

ELL791 Neural Systems and Learning Machines
3 Credits (3-0-2)
Introduction to biological neural systems, artificial neural network models, feed forward models, recurrent systems, analysis and applications.

ELL792 Computer Graphics
3 Credits (3-0-0)
Image formation: the mathematic, as well as photometry and colour; transformations; basic graphics primitives; texture mapping; image-based rendering.

JTD792 Minor Project
3 Credits (0-0-6)
ELL793 Computer Vision
3 Credits (3-0-0)
Pre-requisites: ELL715, ELL784
Overlaps with: COL780
Link between Computer Vision, Computer Graphics, Image Processing and related fields; feature extraction; camera models; multi-view geometry; applications of Computer Vision in day-to-day life.

ELL794 Human-Computer Interface
3 Credits (3-0-0)
This course will present some of the necessary background in neuroscience and computational methods necessary to begin work in this emerging field that is rapidly acquiring growing significance.

ELL795 Swarm Intelligence
3 Credits (3-0-0)
Swarm intelligence, distributed optimization, ant colony algorithms, PSO, firefly, bee, and related methods, applications and implementation issues.

ELL796 Signals and Systems in Biology
3 Credits (3-0-0)
Introduction to Cell Biology (DNA and Proteins); Introduction to Evolution; Modelling Evolution (Genetic Algorithms, Quasispecies); Genomic Signal Processing; Transcriptomic/Proteomic signals; Regulatory networks and dynamics; Protein interaction networks; Signal transduction and metabolic networks; Evolvability and Learning. Project activities on these topics (involving the use of online biological databases and bioinformatics software tools); Student presentations and Journal Club.

ELL797 Energy-Efficient Computing
3 Credits (3-0-0)

ELL798 Agent Technologies
3 Credits (3-0-0)
The course will comprise lectures on the various topics on agent technology and self-study on its applications in various domains. The topics are elaborated below. The material of the lectures will be gathered from text-books and recent research papers. The self-study will comprise study and analysis of typically 5-8 substantial research papers and will result in a term paper that will be evaluated.

ELL799 Natural Computing
3 Credits (3-0-0)
Pre-requisites: COL106, MTL106
Introduction to natural computing uncertainty handling: probability and fuzzy logic; evolutionary computing and problem solving as search; swarm intelligence and colonies, swarm robotics; immunocomputing; introduction to DNA computing; basics of quantum computing.

JVD799 Minor Project
6 Credits (0-0-12)

ELD800 Minor Project (EEA)
3 Credits (0-0-6)
To be decided by the project supervisor.

ELL800 Numerical Linear Algebra and Optimization in Engineering
3 Credits (3-0-0)
Basics of Linear Algebra; Matrix decomposition - LU, LDU, QR and Cholesky factorization; Householder reflection, Givens rotation; Numerical implications of SVD; Numerical Solution for Linear Systems; Algorithm Stability; Problem Conditioning; Pivoting and scaling; Least Square Solutions; Numerical Matrix eigenvalue methods; Sparse Systems; Iterative methods for large systems; Krylov, Arnoldi, Lanczos methods; Numerical Optimization techniques - Conjugate gradient method, Linear and quadratic programming, Spectral and Pseudospectral methods.

ELP800 Control Systems Laboratory
1 Credit (0-0-2)
Basics of Sensors and Actuators, Study of AC and DC Motors, Linear Systems, Analog and Digital Motors, Synchros, Temperature Control.

ELD801 Major Project Part-I
6 Credits (0-0-12)
To be decided by the project supervisor.

ELL801 Nonlinear Control
3 Credits (3-0-0)

ELP801 Advanced Control Laboratory
2 Credits (0-0-4)

JTD801 Major Project-I
6 Credits (0-0-12)

JVD811 Major Project-I
12 Credits (0-0-24)

JVS801 Independent Study
3 Credits (0-3-0)

ELD802 Major Project Part-II
12 Credits (0-0-24)
To be decided by the project supervisor.

ELL802 Adaptive and Learning Control
3 Credits (3-0-0)
Introduction to adaptive control, Review of Lyapunov stability theory, Direct and indirect adaptive control, Model reference adaptive control, Parameter convergence, persistence of excitation, Adaptive backstepping, Adaptive control of nonlinear systems, Composite adaptation, Neural Network-based control, Repetitive learning control, Reinforcement learning-based control, Predictive control, Robust adaptive control.

JVD812 Major Project-II
12 Credits (0-0-24)

ELL803 Model Reduction in Control
3 Credits (3-0-0)
Introduction to Model Reduction; Sources of Large Models - Circuits, Electromagnetic Systems, Mechanical Systems; Discretization Methods - Finite Difference Method (FDM), Finite Element Method (FEM); Classical Model Reduction Methods - Padé Approximation, Moment matching, Routh Approximants; Modern Methods - Modal Model Reduction Methods, SVD (Grammian) based methods, Krylov based methods, SVD-Krylov based methods; MOR for Nonlinear Systems – SVD & POD Methods; Model Reduction in Control; Control Design on Reduced Models – Sub-optimal control; Sliding Mode Control as model reducing control - First Order SM, Higher Order Sliding Mode.
ELL804 Robust Control
3 Credits (3-0-0)
Modeling of uncertain systems, Signals and Norms, Lyapunov theory for LTI systems
Passive systems - frequency domain, Passive systems - time domain, Robust Stability and performance, Stabilizing controllers - Coprime factorization, LQR, LQG problems
Ricatti equations and solutions, H-infinity control and mu-synthesis, Linear matrix inequalities for robust control, Ricatti equation solution through LMI.

ELL805 Networked and Multi-Agent Control Systems
3 Credits (3-0-0)
Overview of networked systems, Graph Theory Fundamentals, Graph-based Network Models, Network Optimization, Consensus Problem: cooperative control, leader-follower architecture.
Control under Communication Constraints, Formation Control, Swarming and Flocking Collision Avoidance, Game Theoretic Control of Multi-Agent Systems, Applications: Multi-robot/vehicle coordination, Sensor Networks, Social Networks, Smart Grids, Biological Networks.

ELL806 Scientific Visualization
3 Credits (3-0-0)
ELL806 Modeling and Control of Distributed Parameter Systems
3 Credits (3-0-0)

ELL807 Stochastic Control
3 Credits (3-0-0)

ELL808 Advanced Topics in Systems and Control
3 Credits (3-0-0)
To be decided by the Instructor when floating this course: Can be anything that is related to systems and control engineering but is not covered in any of the established courses.

ELD810 Minor Project (Communication Engineering)
3 Credits (0-0-6)
ELD810 Cyber Security and Information Assurance
3 Credits (3-0-0)
Introduction to cyber security, information assurance, computer security and the associated threat, attack, adversary models, identity representation, management and access control, intrusion detection, security at different levels: network, system, user, program security, network security, wireless security, mobile security, hardware security and the security of cyber physical systems.

ELD811 Major Project Part-I (Communication Engineering)
6 Credits (0-0-12)
ELD812 Major Project Part-II
12 Credits (0-0-24)
ELD812 Microwave Propagation and Systems
3 Credits (3-0-0)

ELD813 Advanced Information Theory
3 Credits (3-0-0)

ELD814 Wireless Optical Communications
3 Credits (3-0-0)
General introduction, optical channel modeling, background noise calculations, Modulation techniques: M-PMM, OOK, mpm PAM, subcarrier modulation, DPPM, DHPIM, DAPPM, psd and bandwidth requirement evaluation, Detection techniques - Photon counter, PMT, coherent techniques, bit error rate evaluation in presence of atmospheric turbulence, concept of adaptive threshold, effect of turbulence and weather conditions viz., drizzle, haze fog on error performance and channel capacity, link availability.

ELD815 MIMO Wireless Communications
3 Credits (3-0-0)
Introduction to space-time diversity, MIMO channel, MIMO information theory, error probability analysis, transmit diversity and space-time coding, linear STBC design, differential coding for MIMO, precoding, multiuser MIMO; There are no laboratory or design activities involved with this course.

ELD816 Satellite Communication
3 Credits (3-0-0)
Introduction to satellite communication and orbital theory, satellite antennas, satellite link design, channel models for satellite links, modulation, multiple access techniques for satellite communication, VSAT, introduction to MIMO systems and error analysis, multiple antenna based satellite communication, hybrid satellite-terrestrial communication system. There are no laboratory or design activities involved with this course.

ELD817 Access Networks
3 Credits (3-0-0)
Contents: Types of access networks, wired (copper and optical) and wireless access networks, management, dimensioning and scaling of access networks, access network design.
ELL818 Telecommunication Technologies
3 Credits (3-0-0)
Types of Data Networks, types of access and edge networks, core networks, OSS/NMS and Telecom Management network (TMN), Teletraffic Theory and Network analysis.

ELL819 Introduction to Plasmonics
3 Credits (3-0-0)

ELL820 Photonic Switching and Networking
3 Credits (3-0-0)

ELL821 Selected Topics in Communication Systems and Networking-I
3 Credits (3-0-0)

ELP821 Advanced Telecommunication Networks Laboratory
3 Credits (0-1-4)
To provide advanced level laboratory experiments in telecom signaling and transmission.

ELV821 Special Module in Communication Systems and Networking-II
1 Credit (1-0-0)

ELL822 Selected Topics in Communication Systems and Networking-II
3 Credits (3-0-0)

ELP822 Network Software Laboratory
3 Credits (0-1-4)
Contents: CASE tools, client-server programming, middleware – and use of Object Request Broker architectures, use of network emulators, using networks APIs Parlay/JAIN, service-oriented architectures, openflow and SDN, network management software design.

ELL823 Selected Topics in Information Processing-I
3 Credits (3-0-0)

ELV823 Special Modules in Information Processing-II
1 Credit (1-0-0)

ELL824 Selected Topics in Information Processing-II
3 Credits (3-0-0)

ELD830 Minor Project
3 Credits (0-0-6)

ELL830 Issues in Deep Submicron VLSI Design
3 Credits (3-0-0)
VLSI Scaling rules and their impact: Short channel effect, Sub threshold leakage current, Gate leakage, VTH and body bias; Low power design: Technology level: 3D and 4 terminal MOSFETs, PDSOI, FDOSOI, FINFET; Sub threshold leakage control: Transistor stacking in digital logic Multiple VTH, VDD designs, Dynamically adjustable VTH; Digital Circuit Design: Digital Sub-threshold Logic, Noise Immunity, Clock gating, Switching activity minimization; Analog Circuit Design: gm/ID Methodology for Design, Low power, low voltage opamp design, Subthreshold operation of opamps; Architecture level: Array Based Architectures, Parallel and Pipelined Architectures; Interconnects & Noise: Capacitive & Inductive coupling Analysis & Optimization, Power/Ground Noise, L*di/dt noise, Power/Ground Placement Optimization, Decoupling.

ELP830 Semiconductor Processing Laboratory
3 Credits (0-0-6)
Deposition of Semiconductor Materials and Metals: Sputter Deposition, E-Beam Deposition, and Thermal Evaporation; Photolithography; Electron-Beam Lithography; Epitaxial Growth of Semiconductors, Materials Characterization.

ELV830 Special Module in Low Power IC Design
1 Credit (1-0-0)
Special Module that focuses on special topics, development and Research problems of importance in the area of Low Power IC Design.

ELD831 Major Project Part-I (Integrated Electronic Circuits)
6 Credits (0-0-12)

ELL831 CAD for VLSI, MEMS, and Nanoassembly
3 Credits (3-0-0)
Algorithms for design, modelling, and simulation ranging from VLSI, MEMS, to nanoassembly; computer aided nano-design for materials.

ELP831 IEC Laboratory-I
3 Credits (0-0-6)
Introduction to Cadence, Learning Cadence design framework and Virtuoso environment, Design with Virtuoso schematic editor, Layouts, Learning and applying Synopsys and Xilinx tools, Circuit simulation and SPICE.

ELV831 Special Module in VLSI Testing
1 Credit (1-0-0)
Special Module that focuses on special topics, development and Research problems of importance in the area of VLSI Testing.

ELD832 Major Project Part-II
12 Credits (0-0-24)

ELL832 Selected Topics in IEC-I
3 Credits (3-0-0)

ELP832 IEC Laboratory-II
3 Credits (0-0-6)
Introduction to Cadence, Learning Cadence design framework and Virtuoso environment, Design with Virtuoso schematic editor, Layouts, Learning and applying Synopsys and Xilinx tools, Circuit simulation and SPICE.

ELV832 Special Module in Machine Learning
1 Credit (1-0-0)
Special Module that focuses on special topics, development and Research problems of importance in this area.

ELL833 CMOS RF IC Design
3 Credits (3-0-0)
Historical Aspects – From Maxwell to Current Wireless standards; The bridge between communication system designer and RF IC Designer: a) Comm. system characterization, b)RF System Characterization; Transceiver Architectures – Motivation for the individual blocks; Lumpd, passive RLC, RF properties of MOS, Tuned Amplifiers; LNAs: Noise sources, Cascades and LNA Design; Mixers – passive and active mixers ; Oscillators: Analysis Fundamentals, Inductors, LC Oscillators and VCOs; Frequency synthesizers: Principles, Integer N vs Fractional PLL, Design Concepts.
ELP833 Device and Materials Characterization Laboratory
3 Credits (0-0-6)
Skill development in semiconductor modeling and characterization through hands on electrical characterization experiments. This includes wafer-level DC and RF characterization of p-n junction diode, MOS capacitor and transistor, photo-electric characterization of solar cells, TCAD and compact modeling of these devices, Materials Characterization (SEM, AFM, TEM, etc.).

ELV833 Special Module in Semiconductor Business Management
1 Credit (1-0-0)
To educate students about semiconductor business. This includes business domains in semiconductors, latest business challenges, market trends and forecasts, business planning and incubation, execution and delivery, technical and financial analysis of R&D, business and finance models of chip manufacturing units (or fabs.), foundries, and solar power plants.

ELL834 Selected Topics in IEC-II
3 Credits (3-0-0)

ELV834 Special Module in Nanoelectronics
1 Credit (1-0-0)
Special Module that focuses on special topics, development and Research problems of importance in the area of Nano Electronics.

ELD850 Minor Project
3 Credits (0-0-6)

ELL850 Digital Control of Power Electronics and Drive Systems
3 Credits (3-0-0)
Review of Digital signal processors, Laplace transforms, Theory of sampling, z-transformations, sampling techniques, Digital PWM generation schemes, Realization of different PWM's using DSP's, Control of DC-DC Converters, Inverters, DC and AC Machines.

ELP850 Electrical Machines Laboratory
1.5 Credits (0-0-3)
Experiments on Electrical Machines and their control.

ELT850 Industrial Training and Seminar
3 Credits (0-0-6)

ELD851 Major Project Part-I
6 Credits (0-0-12)

ELL851 Computer Aided Design of Electrical Machines
3 Credits (3-0-0)

ELP851 Power Electronics Laboratory
1.5 Credits (0-0-3)
Experiments on Power electronic converters and their control.

ELD852 Major Project Part-II
12 Credits (0-0-24)

ELL852 Condition Monitoring of Electrical Machines
3 Credits (3-0-0)
The course includes the need for condition monitoring. Three main subdivisions of the course are types of fault and their symptoms, diagnostic methods to identify these faults and a deep signal processing analysis for fault diagnosis. The various components prone to fault are stator, rotor, shaft, gear box, bearing etc. The diagnosis methods includes diagnosis based on temperature, infrared signal, vibration, noise, motor current signature analysis etc. various signal processing techniques such as fuzzy logic, neural network from fault diagnosis point of view are also included in this course.

ELP852 Electrical Drives Laboratory
1.5 Credits (0-0-3)
Experiments on drive systems with converter fed dc and ac drives and their control.

ELL853 Advanced Topics in Electrical Machines
3 Credits (3-0-0)
Introduction to Advanced Topics in Electrical Machines, Synchronous Reluctance Machines, Hybrid Motors, Linear Motors, Super conducting Machines, PCB Motors, Micro motors, Written Pole Machines. Applications of all these advanced motors in field of Robotics, Automation, Electric Vehicles, pumping etc. The rating consideration and special advantages with these motors in various practical or field conditions is primary objective of this course. Other Advanced machines, Case Studies, Computer Aided Simulation of Electrical Machines are added for enhanced understanding of the topic.

ELP853 DSP Based Control of Power Electronics and Drives Laboratory
1.5 Credits (0-0-3)
Experiments on the DSP/Digital signal controllers, Interfacing peripherals to DSP, Assembly language programming, Real-time voltage/ current, speed sensing signal and processing, PWM strategies realization through DSP and controlling power electronic and Drive Systems.

ELL854 Selected Topics in Electrical Machines
3 Credits (3-0-0)
Recent developments in the area of electrical machines.

ELP854 Electrical Machines CAD Laboratory
3 Credits (0-1-4)
Computer aided design of electrical machines.

ELL855 High Power Converters
3 Credits (3-0-0)

ELP855 Smart-Grids Laboratory
3 Credits (0-1-4)
Experiments related to smart-Grids measurement and control.

ELL856 Advanced Topics in Power Electronics
3 Credits (3-0-0)

ELL857 Selected Topics in Power Electronics
3 Credits (3-0-0)
Recent developments in power electronics.
ELL858 Advanced Topics in Electric Drives  
3 Credits (3-0-0)  
Advanced PWM Techniques. Control of switched reluctance motor drives.
Control of slip-ring induction motor drives. Self-commissioning and
self-adaptation techniques in drives. Sensor-less techniques in drives.
Fault tolerant controllers and converters. Other recent topics on drives.

ELL859 Selected Topics in Electric Drives  
3 Credits (3-0-0)  
Recent developments in the area of electric drives.

ELL870 Minor Project-I  
3 Credits (0-0-6)  
To be decided by the project supervisor

ELL871 Major Project Part-I  
6 Credits (0-0-12)  
To be decided by the project supervisor

ELL872 Major Project Part-II  
12 Credits (0-0-24)  
To be decided by the project supervisor.

ELL873 Power System Transient  
3 Credits (3-0-0)  
Origin and nature of transients and surges. Lumpfed and distributed
circuit representations. Line energisation and de-energisation
transients, current chopping, short-line faults, trapped charge effects,
effect of source, control of transients, Lightening, effect of tower
footing resistance, travelling waves, insulation coordination, circuit
breakers duty, surge arresters, overvoltage limiting devices.

ELL874 Power System Reliability  
3 Credits (3-0-0)  
Review of basic probability theory, reliability theory, network modeling
and evaluation of simple and complex systems, generation system
reliability – concept of loss of load probability, energy not served,
transmission system reliability, component failure, distribution system
reliability with perfect and imperfect switching.

ELL880 Major Project Part-I  
6 Credits (0-0-12)

ELL887 Cloud Computing  
3 Credits (3-0-0)  
Introduction; Example System: Apple iCloud, Amazon-AWS;
Fundamental Concepts: Cloud Characteristics, Cloud delivery models;
Cloud Enabling Technology: broad-band network, virtualisation
technology; Cloud Infrastructure Mechanisms: Logical Network
Perimeter, Virtual Server, Cloud Storage Devices; Cloud Architecture:
Workload Distribution Architecture, Resource Pooling Architecture,
Dynamic Scalability Architecture, Hypervisor Clustering Architecture,
Load Balanced Virtual Server Instances Architecture, Elastic Resource
Capacity Architecture, Elastic Disk Provisioning Architecture,
Redundant Storage Architecture; Cloud Security: Encryption, Identity
and Access management, Cloud-based Security Groups; Working
ELL888 Advanced Machine Learning
3 Credits (3-0-0)
Advanced topics in machine learning, including Nonlinear Dimension Reduction, Maximum Entropy, Exponential Family Models, Graphical Models; Computational Learning Theory, Structured Support Vector Machines, Feature Selection, Kernel Selection, Meta-Learning, Multi-Task Learning, Semi-Supervised Learning, Reinforcement Learning, Approximate Inference, Clustering, and Boosting.

ELL889 Protocol Engineering
3 Credits (3-0-0)
Principles, stages, specification formalisms (UML, SDL, ASN.1) of telecom protocol design, protocol software development process, computer aided protocol engineering, verification and testing of protocols, object oriented techniques in protocol development, kernel level development and programming of protocols.

ELL890 Computational Neuroscience
3 Credits (3-0-0)
Fundamentals of brain anatomy and physiology, signals of brain, Brain signal recording and imaging techniques, Human experimentation study design, Processing the X-D neural data, Machine learning approaches, Graph theory and neural networks, Multivariate pattern analysis in 4D Imaging data, Statistical inferences, student projects and presentations.

ELL891 Computational Linguistics
3 Credits (3-0-0)
Introduction to language and linguistics; Mathematical foundations: statistics and machine learning; Introduction to corpus-based computational linguistics; Lexical analysis; Syntactic analysis; Semantic analysis; Discourse analysis; Psycholinguistics, computational cognitive models of language processing and evolution; Assignments and practical exercises involving the application of these techniques to real-word corpora.

ELL892 Internet Technologies
3 Credits (3-0-0)
Web and service oriented architectures, dynamic web site programming (client side and server side), web application development, web based repositories, UI design, XML, Web 2.0 and the semantic web, applications.

ELL893 Cyber-Physical Systems
3 Credits (3-0-0)
Introduction: core principles behind CPSs; Specification of CPS, CPS models: Continuous, Discrete, Hybrid, Compositional; Abstraction and System Architecture, Design by Invariants, Sensing and Fusion, Cloud of Robots/CPS; Case Studies: Healthcare, Smart Grid, Transportation.

ELL894 Network Performance Modeling and Analysis
3 Credits (3-0-0)

ELL895 Network Security
3 Credits (3-0-0)
Introduction to cryptography, public key distribution and user authentication, TLS and wireless network security, secure email and PGP, IP security, system security - intrusion, malicious software and firewalls.

ELL896 Mobile Computing
3 Credits (3-0-0)
Overview of mobile computing; introduction to GSM, 3GPP, 4G LTE, LTE-A standards; wireless networking protocols: mobile IP, ad hoc networks, wireless TCP; cognitive radio networks; data broadcasting; location and context awareness; QoS, QoE; disconnected or weakly connected operations; protocol and resource optimization; wireless security issues.

ELL897 Network Management
3 Credits (3-0-0)
Activities, methods, operational procedures, tools, communications interfaces, protocols, and human resources that pertain to the operation, administration, maintenance, and provisioning of communications networks, network management standards, technologies; functional areas of fault management, configuration management, accounting management, performance management, and security management, major Internet and telecommunications standards for network management: SNMPv3, RMON, CMIP and TMN.

ELL898 Pervasive Computing
3 Credits (3-0-0)
Introduction, computer and network architectures for pervasive computing, mobile computing mechanisms, human-computer interaction using speech and vision, pervasive software systems, location mechanisms, practical techniques for security and user-authentication, and experimental pervasive computing systems.

ELL899 Testing and Fault Tolerance
3 Credits (3-0-0)
Introduction to testing, simulation, fault simulation, automatic test pattern generator, sequential logic tests, automatic test equipment, design for testability, Built-In-Self-Test (BIST), behavioral test and verification.
HUL201 English in Practice
3 Credits (2-0-2)
Verb structures and patterns, avoiding common errors, vocabulary building, spelling patterns, developing writing skills (composition, letter writing) etc. developing listening skills.

HUP102 Psychology Laboratory
1 Credit (0-0-2)
To familiarize students with psychological concepts through practical training in a laboratory through experiments pertaining to cognitive psychology, environmental psychology and physiological psychology.

HUL211 Introduction to Economics
4 Credits (3-1-0)
Pre-requisites: NLN101

HUL212 Microeconomics
4 Credits (3-1-0)
Pre-requisites: NLN101

HUL213 Macroeconomics
4 Credits (3-1-0)
Pre-requisites: NLN101

HUL217 History of Economic Thought
4 Credits (3-1-0)
This course will introduce ideas in the history of economic thought, from mercantilism, socialism, communism, capitalism to the rise of modern economic theory (e.g. utilitarianism), along with questions about economic theory (especially from behavioural sciences).

HUL232 Modern Indian Fiction in Translation
4 Credits (3-1-0)
Pre-requisites: NLN101
Students would be introduced to the conditions, beginning in 19th century colonial rule in India, which led to the emergent Indian middle-class intelligentsia to experiment with European forms of literature but striving for an alternative expression. Indian languages became the medium through which writers sought to address issues of identity, tradition, modernity, gender, the rural and the urban, the private and the public. The course will study the various experiments in narration, language, characterization and style undertaken by authors to shape these themes.

HUL235 Rise of the Novel
4 Credits (3-1-0)
Pre-requisites: NLN101
The socio-political contexts which lead to the rise of the novel in Europe – the emergence of print, the expansion of literacy, and the establishment of capitalism. Close reading of selected texts accompanying concepts like the rise of the modern individual, varied narrative techniques and national consciousness. The emerging sub-genres of the novel – the comic, the picaresque, the historical novel and the realist novel. The linkage of the novel to the colonial project and its influence on world literature.

HUL236 Introduction to Drama
4 Credits (3-1-0)
Pre-requisites: NLN101
Brief history of the development and importance of drama in Western and Indian contexts. Readings from both ancient and contemporary drama theorists. Generic differences between different forms of drama such as tragedy, comedy, realist, ‘folk’, Absurd, etc. Detailed study of important examples of different forms of drama.

HUL237 Contemporary Fiction
4 Credits (3-1-0)
Pre-requisites: NLN101
- Approaches to contemporary fiction - Looking at contemporary styles - realism, modernism, postmodernism - Contemporary versions of classical genres - the diary, epistolary form, epic, etc. - the relationship of society with science and technology through fiction - the relationship between self and society through fiction -Race, nationality, culture and identity - contemporary forms.

HUL239 Indian fiction In English
4 Credits (3-1-0)
Pre-requisites: NLN101
The course involves a detailed study of 3-4 texts corresponding to the distinct phases of literary activity in the genre: the early period of the 1940s and 50s in which writers like Mulk Raj Anand, Raja Rao and R.K. Narayan made their presence felt, before Salman Rushdie, and more quietly, Amitav Ghosh and Vikram Seth, erupted into the scene in the 1980s, spawning a generation of writers attaining international acclaim - Arundhati Roy, Aravind Adiga, Kiran Desai, and many others. Some of the questions that will be addressed are: Who constitutes the main audience for this writing, and (how) does the writing cater to it? How does one position the expatriate Indian writer both residing and publishing abroad? How does English become an Indian language? Is there a thematic congruence in the novels that fall under this category, and does it differ from the thematic concerns of novels written in other Indian languages? Students will be encouraged to read a novel in at least one other Indian language in order to allow them to pose these questions in a more pointed manner.

HUL240 Indian English Poetry
4 Credits (3-1-0)
Pre-requisites: NLN101
The aim of this course will be to read the poems of Indian English Writers (pre and post-Independence), with specific reference to the
articulation of their identity. Some of the perspectives from which the poems will be discussed include the notion of home (childhood, family and ancestors); land (history, geography, community, caste and contemporary politics); language (the dialogue between the different languages in the creative repertoire of the poets); and culture (ritual, traditions, legends and myths). The course will also look at the differences between the resident and expatriate poets vis-a-vis the conflicts and resolutions as expressed in their poems.

HUL242 Fundamentals of language sciences
4 Credits (3-1-0)
Pre–requisites: NLN101
This course provides answers to basic questions about the nature and constitution of human language in the mind/brain of native speakers. Varied aspects of linguistic organization, including structures of sounds, words and sentences are considered to understand the core universals of all languages as well as their variations. Cases of feral children, language deficiencies and cognition-language interactions are also highlighted.

HUL243 Language and Communication
4 Credits (3-1-0)
Pre–requisites: NLN101
This course offers a wide-ranging introduction to, and analysis of, varieties of spoken and written language. From political oratory to examination answer scripts to computer codes, not to mention riddles and poetry, human language offers an amazingly rich set of structures for expressing and conveying our thoughts, intentions and desires. The course will consider some of these linguistic structures and communicative strategies in detail, beginning with early childhood development. How is it that children in every culture learn language so effortlessly despite its great complexity? The course aims to introduce students to a set of theories that address this and other puzzles and mysteries in the arena of language studies. Finally, since a central focus of the course is communication, it will strive to be as interactive as possible, with lots of scope for the discussion and working out of actual ‘problems’ in language use.

HUL251 Introduction to Logic
4 Credits (3-1-0)
In this course, students are introduced to fundamentals of informal logic and verbal analysis, material and formal fallacies of reasoning often found in ordinary discourse, deductive and Inductive reasoning, validity and soundness, formal rules and principles of the deductive system of Aristotelian logic, traditional square of opposition; propositional calculus; first order predicate calculus; the modern square of opposition and the problem of existential import; identity and definite descriptions; methods for formulating natural language arguments in symbolic forms and techniques for checking their validity; various meta-logical theorems and their proofs.

HUL253 Moral Literacy and Moral choices
4 Credits (3-1-0)
Pre–requisites: NLN101
This is primarily a course in applied ethics. It will focus primarily on questions like: What is the meaning of right action? Can ethical assertions be true or false? Is morality relative to society? Or can we say that acts have universal moral content? The course discussions will help to demonstrate that morality is not always self-evident and that rational morality must come in place of taboo based moralities.

HUL256 Critical Thinking
4 Credits (3-1-0)
Pre–requisites: NLN101
What makes philosophical thinking radically critical? Investigation of the nature of knowledge about the world and justification of knowledge claims. Metaphysical understanding of the Absolute and Mind-Body relation. The nature of ethical and aesthetic beliefs and attitudes as part of understanding the nature of values. The discussion of the above issues will be influenced by three philosophical orientational perspectives: Anglo-American Analytic, Continental Phenomenological and Classical Indian.

HUL258 Social and Political Philosophy
4 Credits (3-1-0)
Pre–requisites: NLN101
As closely aligned areas in philosophy- social philosophy with the role of individual in society and political philosophy with the role of government- this course bridges divides between social theory, political philosophy, and the history of social and political thought as also between empirical and normative analysis through perspectives from metaphysics, epistemology and axiology. A range of socio-political thinkers, theories and concepts will be taught. It will provide a broad survey of fundamental social and political questions in current contexts discussing philosophical issues central to political thought and radical critiques of current political theories.

HUL261 Introduction to Psychology
4 Credits (3-1-0)
Pre–requisites: NLN101
Psychological Science- Assumptions, schools, methods of doing psychology research, The relationship between brain, body and mental functioning, Sensation, perception and making sense of the world, Consciousness, Life span development and motor and language development, Nature and nurture controversy, The learning process and some important explanations of how we learn, Meaning of motivation and explanations, Theories of emotions and expression and regulation of emotions, Basic cognitive processes, Language development, why we remember and why we forget- some explanations, Different kinds of intelligence, explanations of creativity, Differences among individuals and explanations for personality differences, Application of psychology to everyday life- enhancing health and well-being, performance, social relations, and sensitivity to environmental, social and cultural contexts.

HUL265 Theories of Personality
4 Credits (3-1-0)
Pre–requisites: NLN101
Personality: Meaning & Assessment. Psychoanalytic & Neo-Psychoanalytic Approach ; Behavioural Approach; Cognitive Approach; Social- Cognitive Approach; Humanistic Approach; The Traits Approach; Models of healthy personality: the notion of the mature person, the self-actualizing personality etc. Personality disorders; Psychotherapeutic techniques and Yoga & Meditation; Indian perspective on personality; Personality in Socio-cultural context.

HUL267 Positive Psychology
4 Credits (3-1-0)
Pre–requisites: NLN101
Positive Psychology: A historical and contextual overview; Relationship between Indian Psychology and Positive Psychology; Correlates and predictors of life satisfaction and subjective well-being across various cultures; Latest researches on self-esteem, optimism, flow, post-traumatic growth, positive ageing, character strengths, etc.; Major theories and models within positive psychology — Self-Determination theory, Broaden-and-Build theory, Authentic Happiness, Psychological Well-being, etc., Interpersonal character strengths & well-being; Specific Coping Approaches: meditation, yoga and spirituality; Future of the Field.

HUL271 Introduction to Sociology
4 Credits (3-1-0)
Pre–requisites: NLN101
Introduction to the discipline of sociology and its emergence as a science in the context of the development of modern industrial society in Europe. Introduction to key classical and contemporary theorists in Sociology.
HUL272 Introduction to Sociology of India
4 Credits (3-1-0)
Pre-requisites: NLN101
This course will begin with a discussion on the various constructions of Indian society from colonial to contemporary times. The structural and cultural dimensions of Indian society are explored at the level of village, city, region, nation and civilization. Sources of differentiation, diversity and unity are explored through institutions such as caste, class and tribe; kinship, family, marriage and gender systems, religious traditions and political organisations. Transformations in these institutions are analysed and fault lines explored by studying contemporary issues of secularism, communalism, religious conversions, caste and identity movements. The sociological perspective remains key to interpreting changes in Indian society in the era of globalization and rapid economic change.

HUL274 Re-thinking the Indian Tradition
4 Credits (3-1-0)
Pre-requisites: NLN101
The examination of sources, the structure, the texts and exemplars of the Indian tradition provide the theoretical framework for the discussion of contemporary political and social issues. These are economic development and social justice religion and the nation, communalism and secularism, caste class and gender equity and so on. The political misuse of tradition in programs of reform and revival both in the past and in modern times will be highlighted to underline the need for rethinking tradition in an academically serious manner.

HUL275 Environment, Development and Society
4 Credits (3-1-0)
Pre-requisites: NLN101
Students will be exposed to contemporary themes and debates on connection between environment, development, and society; industrialization and risk society; challenge of sustainable development; perception of the environment, dependence for livelihood, identity, and power on natural resources; social ecology; what is the role of religion in determining our world view and relation with the environment; recognition of indigenous knowledge; rise of environmental movements, development projects and recent conflict over natural resources; understanding major environmental disasters and industrial accidents; global climate change negotiations; gender and environment.

HUL276 Sociology of Knowledge
4 Credits (3-1-0)
Pre-requisites: NLN101
The de-mystification of science as a privileged form of knowledge since Copernicus. Re-examining the laboratory, the factory and the nation-state, structures linked to the West-European model of science. Examining systems deemed ethno-science or folk-lore, to set up a dialogue with institutionalized science. Comparing science with religion as forms of knowledge having competing power over human belief and action. Examining Traditional Knowledge (TK) systems and their relevance for global economy.

HUL281 Technology and Governance
4 Credits (3-1-0)
Pre-requisites: NLN101
The course will begin with theories and concepts on the use of technologies to improve governance such as efficiency, transparency, empowerment, economic gains, decentralization etc. It will discuss the concepts of democracy and governance, corruption and accountability. Examples and case studies from topics such as information and communication technologies for development, electronic governance, electronic voting, electronic databases (UID), web portals, community radio etc. Public-private partnerships, regulation of technology by the state, surveillance, and the role of stakeholders in the policy making process.

HUL282 System and Structure: An Introduction to Communication Theory
4 Credits (3-1-0)
Pre-requisites: NLN101
This course is an introduction to theories of communication for which there is not sufficient time in the other communication courses, which are mainly applied in their orientation. This is an interdisciplinary course. It will examine how the notion of communication is used in different disciplines in the humanities and the social sciences. It will intersect with problems of organizational structure, linguistic structure, interpersonal structure and the problem of what is involved in changing a structure. This course will include no components of remedial English, business correspondence or skill building activities. Only those really interested in theoretical questions should enroll.

HUL286 Social Science Approaches to Development
4 Credits (3-1-0)
Pre-requisites: NLN101
Distinction between ‘growth’ and ‘development’; historical genesis and evolution of the concept of development; theories of development and underdevelopment; the political nature of the development process. Role of state, market, culture and civil society in development. Gendered nature of development. Post-independence Indian experience (centralized planning and socialism) of development; selected comparisons with China, East Asia, South Asia, Africa, Latin America. Explaining India’s slow progress in human and social development, poor record in reduction of poverty and inequality. Impact of globalization, foreign aid and economic reform on India’s development. Experiments with decentralization and sustainable development.

HUL289 Science, Technology and Human Development
4 Credits (3-1-0)
Pre-requisites: NLN101
The course will begin by identifying various dimensions of human development and mapping the state of India and the world on these indicators. It will then discuss theories about how science and technology (S&T) have shaped human development historically and the dynamics of technological change. Relationship between innovation and human development will be discussed using examples from the appropriate technology movement, health, education, nutrition, energy, environment, and others. Gender dimensions of S&T, indigenous knowledge, and radical critiques of S&T will be discussed.

HUL290 Technology and Culture
4 Credits (3-1-0)
Pre-requisites: NLN101
To examine the relationship between technology and culture through a consideration of modern/current developments in various specific areas: e.g. Biotechnology and Medicine, IT, AI & Robotics, Fashion Technology, Magic Technology, Communications, Defense and Space Research. To focus on the roles played by the IITs themselves in creating ‘knowledge societies’ - that is, in influencing, formulating and envisioning the links between technological ‘solutions’ and socio-cultural ‘problems’ especially in the Indian context. Here we will discuss, for example: Patent Laws, Gender Issues, Environmental Ethics, Design(er) and Person(al) Technological Aesthetics, Technologies for the Disabled, Educational Technologies.

HUL310 Selected Topics in Policy Studies
3 Credits (3-0-0)
Pre-requisites: Any Two courses from HUL2XX category
Allocation Preferences : HUL281, HUL289, HUL290
The course will introduce students to selected topics in Policy Studies as decided by the instructor.
HUL311 Applied Game Theory
3 Credits (3-0-0)
Pre–requisites: Any Two courses from HUL2XX category
Allocation Preferences : HUL211, HUL212, HUL213
This module introduces students in economics and other social sciences to game theory, a theory of interactive decision making. This module provides students with the basic solution concepts for different types of non-cooperative games, including static and dynamic games under complete and incomplete information. The basic solution concepts that this module covers are Nash equilibrium, subgame perfect equilibrium, and perfect Bayesian equilibrium. This module emphasizes the applications of game theory to economics, such as duopolies, bargaining, and auctions.

HUL312 Distribution and Growth
3 Credits (3-0-0)
Pre–requisites: Any Two courses from HUL2XX category
Allocation Preferences : HUL211, HUL212, HUL213
Though empirical questions are central in motivating the issues on distribution, this course will mostly draw from theory. Papers published in established journals will cover the major references for this course. It will start from some empirical pattern of development (Kuznet’s hypothesis), country experiences, etc. to motivate the subject. Then it will try to understand the process of distribution, growth and structural change using standard macroeconomic models. This course will be heavily dependent on Mathematics - mainly calculus.

HUL314 International Economics
3 Credits (3-0-0)
Pre–requisites: Any Two courses from HUL2XX category
Allocation Preferences : HUL211, HUL212, HUL213
Basic concepts of national income accounting, money, and balance of payments; output and exchange-rate determination under fixed and flexible exchange-rate regimes; fiscal and monetary policies in an open economy; international capital movements and their impacts; Case Studies: East Asian crisis, global financial crisis; theories of international trade including factor-proportions and economies of scale; the international trading regime and its implications for developing countries.

HUL315 Econometric Methods
3 Credits (3-0-0)
Pre–requisites: Any Two courses from HUL2XX category
Allocation Preferences : HUL211, HUL212, HUL213
Basics of sample survey; variance and covariance; correlation coefficient; simple regression analysis; Gauss-Markov theorem; estimation of regression coefficients; confidence intervals and hypothesis testing in regression analysis; type-I and type-II errors; transformation of variables; multiple regression analysis; multicollinearity, heteroscedasticity, dummy variables, basics of time-series analysis.

HUL316 Indian Economic Problems and Policies
3 Credits (3-0-0)
Pre–requisites: Any Two courses from HUL2XX category
Allocation Preferences : HUL211, HUL212, HUL213
The course is aimed at developing an understanding of the economic issues in a range of economic activities in the Indian economy. The themes that can be covered include performance of the Indian Economy since 1951, agricultural growth in India, inter-regional variation in growth of output and productivity, farm price policy, recent trends in industrial growth, industrial and licensing policy, policy changes for industrial growth, economic reforms and liberalization, population growth, unemployment, food and nutrition security, and education. It will also include some contemporary issues.

HUL318 Public Finance and Public Economics
3 Credits (3-0-0)
Pre–requisites: Any Two courses from HUL2XX category
Allocation Preferences : HUL211, HUL212, HUL213
The course is aimed at developing an understanding of the basics in Public Economics and Public Finance. Public economics is the study of government policy from the points of view of economic efficiency and equity. The course deals with the nature of government intervention and its implications for allocation, distribution and stabilization. Inherently, this study involves a formal analysis of government taxation and expenditures. The subject encompasses a host of topics including public goods, market failures and externalities. The course is divided into two sections, one dealing with the theory of public economics and the other with the Indian public finances.

HUL320 Selected Topics in Economics
3 Credits (3-0-0)
Pre–requisites: Any Two courses from HUL2XX category
Allocation Preferences : HUL211, HUL212, HUL213
The course will introduce students to selected topics in Economics as decided by the instructor.

HUL331 Modernist Fiction
3 Credits (3-0-0)
Pre–requisites: Any Two courses from HUL2XX category
Allocation Preferences : HUL231, HUL232, HUL235, HUL236, HUL237, HUL240, HUL239
The course will undertake a detailed study of some of the most iconic Modernist novels by writers such as Virginia Woolf, James Joyce, Franz Kafka and Samuel Beckett. It will examine the radical new ways in which they grappled with language, turned towards interiority, and pushed, in the process, narrative art to its very limits. The discussion will highlight the experimental quality of Modernist literature, as well as situate it within the context of its emergence - the two world wars, the development of psychoanalysis, the growth of metropolitan cities, and scientific and technological advancements.

HUL332 Fantasy Literature
3 Credits (3-0-0)
Pre–requisites: Any Two courses from HUL2XX category
Allocation Preferences : HUL231, HUL232, HUL235, HUL236, HUL237, HUL240, HUL239
Major Themes of Fantasy: Archetypes and Myths; Motifs - journeys, theology, devices and aides; creation of alternate worlds; treatment of time and space; close readings of individual texts.

HUL333 Theatre of the absurd
3 Credits (3-0-0)
Pre–requisites: Any Two courses from HUL2XX category
Allocation Preferences : HUL231, HUL232, HUL235, HUL236, HUL237, HUL240, HUL239
Socio-political background of the theatre of the Absurd, its basis in Existentialist philosophy. The reactions against the conventions of realist theater that dominated this theatre. The pre-occupations of major playwrights with issues of language and the difficulty of communication, the isolation that human beings tend to feel from each other and themes of violence.

HUL334 From Text to Film
3 Credits (3-0-0)
Pre–requisites: Any Two courses from HUL2XX category
Allocation Preferences : HUL231, HUL232, HUL235, HUL236, HUL237, HUL240, HUL239
The course will involve a detailed study of 3-4 texts and their corresponding adaptations into film. By means of close reading, analysis, and discussion, it will seek to identify the changes that take place during the process of adapting one art-form into another.
and ask why those modifications occur. An evaluation of what each art-form enables and what it restricts or denies will enable a better understanding of form per se, and of these two forms in particular. Further, the course will address the question of genre and its conventions especially with regard to film, and observe the extent to which generic expectations shape the process of adaptation of text into film. Film screenings will be held outside class hours in the evenings.

**HUL335 Indian Theatre**

- **3 Credits (3-0-0)**
- **Pre-requisites:** Any Two courses from HUL2XX category
- **Allocation Preferences:** HUL231, HUL232, HUL235, HUL236, HUL237, HUL240, HUL239

This course will study the various aspects of Indian theatre. The linkages between ancient theatre forms and existing forms of indigenous performance in various parts of India – such as the nautanki, the tamasha and the jatra. The energies which were generated in the urban centres through the encounter with European drama – the Parsi theatre, the nascent Marathi stage, the Hindi theatre of Bhartendu Harishchandra and the nationalist theatre of Calcutta – will be explored. Special attention would be paid to the transformation of theatre values with the intervention of the Indian People’s Theatre Association (IPTA). The focus for the post-Independence period would be on the diverse energies of urban theatre, group theatre and the ‘back to the roots’ movement. The course would require students to study play-scripts as well as look at accompanying literature to form a concrete idea of the philosophy behind Indian theatrical practice.

**HUL336 Workshop in Creative Writing**

- **3 Credits (3-0-0)**
- **Pre-requisites:** Any Two courses from HUL2XX category
- **Allocation Preferences:** HUL231, HUL232, HUL235, HUL236, HUL237, HUL240, HUL239

The course will begin by seeking to distinguish the notion of ‘creative’ writing. It will contrast this heterogeneous category with other kinds of writing such as the ‘functional’ writing found in text-books and reportage. Through an analysis of various techniques of writing - in master-texts as well as students’ own productions - the course will explore why and how literary texts continue to be a prime source of emotional and intellectual stimulation across cultures. As far as possible, the course will focus on contemporary writing, given that writers write in the ‘here and now’ even as they imagine the future or return to past memories. Selected readings will be used to focus students’ attention on that most difficult of problems: to acquire a style of writing that makes a writer’s ‘voice’ both unique and universal. Finally, students will be required to write in some genre(s) of their choice. These genres will include the classic areas of poetry, fiction and play-writing but will neither exclude non-fiction genres like the essay and biography nor forms of writing thrown up by the ‘new media’ such as blogs, photo-essays and narrative-writing for story-boards and video-games.

**HUL338 Functions of Satire**

- **3 Credits (3-0-0)**
- **Pre-requisites:** Any Two courses from HUL2XX category
- **Allocation Preferences:** HUL231, HUL232, HUL235, HUL236, HUL237, HUL240, HUL239, HUL256

Satire is a classical genre that has thrived over the centuries in almost all languages and cultures, and is found in a range of media. Life, in all aspects, everyday provides grist to the mill of satire, but does satire change anything? How do we define satire? Why is it considered the social genre? What are the contemporary forms of satire? Who can practice satire? It draws upon diverse techniques such as allegory, irony, caricature and laughter. Through analyses of examples, this course will familiarize students with satirical sub-genres and related literary practices, such as parody, burlesque, black humour, the grotesque, coarse humour, high and low comedy. It will examine the structure of satire, its relation with community, democracy and matters of gender, caste race, and religion.

**HUL340 Selected Topics in Literature**

- **3 Credits (3-0-0)**
- **Pre-requisites:** Any Two courses from HUL2XX category
- **Allocation Preferences:** HUL231, HUL232, HUL235, HUL236, HUL237, HUL240, HUL239

The course will introduce students to selected topics in Literature as decided by the instructor.

**HUL341: Meaning in Natural Language**

- **3 Credits (3-0-0)**
- **Pre-requisites:** Any Two courses from HUL2XX category
- **Allocation Preferences:** HUL242, HUL243, HUL282

This course examines different aspects of meaning/semantics in language. Some specific questions addressed here are: a) what is meaning?, b) how do we use words to convey meanings?, and c) how does our grammatical knowledge interact with the interpretive system? We try to answer these and other questions while introducing students to the formal techniques used in research on the semantics of natural language.

**HUL350 Selected Topics in Linguistics**

- **3 Credits (3-0-0)**
- **Pre-requisites:** Any Two courses from HUL2XX category
- **Allocation Preferences:** HUL242, HUL243, HUL282

The course will introduce students to selected topics in Linguistics as decided by the instructor.

**HUL351 Philosophy of History**

- **3 Credits (3-0-0)**
- **Pre-requisites:** Any Two courses from HUL2XX category
- **Allocation Preferences:** HUL251, HUL258, HUL253, HUL256

What kind of understanding of the past does history provide? Is it speculative or analytical? What constitutes historical evidence and how does it confine historical understanding? Questions of objectivity are the central focus of this course: that of historians themselves—constructionist and objectivist— as they debate methodological issues and disagreements about the aim of their discipline, and that of philosophers whose interest in history springs from their attention on history’s objectivist ideals and “the objectivity crisis” in history providing a philosophical rationale for reframing the two oppositions that dominate debates about the status of historical knowledge.

**HUL352 Problems in Classical Indian Philosophy**

- **3 Credits (3-0-0)**
- **Pre-requisites:** Any Two courses from HUL2XX category
- **Allocation Preferences:** HUL251, HUL258, HUL253, HUL256

The course will begin by exploring the worldview implicit in the Vedas, the Upasnas, and the orthodox systems and then move on to the rejection of this entire system in Buddhism and Materialism. Emphasis will be on the diversity of systems and healthy dialogue between antagonistic schools of thought. Discussions will focus on the nature of consciousness in relation to cognition of reality, theories of reality in terms of realism and anti-realism; the nature of self and no-self theory, theories of perceptual knowledge, theories of error; theories of causation and other relations, and key concepts of moral and aesthetic thought. Wherever appropriate, problems will be discussed in comparison with parallel discussions in western philosophy.

**HUL353 Philosophical Themes in Biological Sciences**

- **3 Credits (3-0-0)**
- **Pre-requisites:** Any Two courses from HUL2XX category
- **Allocation Preferences:** HUL251, HUL258, HUL253, HUL256

This course addresses various philosophical questions that arise from the recent developments in evolutionary biology, genetics, immunology, sociobiology, molecular biology and synthetic biology.
How do these developments affect our ideas about life, evolution and the place of man in relation to other living beings. What is the nature of explanation in biological sciences? Does the idea of immunity demand rethinking on the nature of our embodied self? What can biological sciences tell us about healing, pain and death?

**HUL354 Art and Technology**
3 Credits (3-0-0)  
Pre-requisites: Any Two courses from HUL2XX category  
Allocation Preferences: HUL251, HUL258, HUL253, HUL256, HUL290  
The course begins by registering the increased presence of technology in contemporary art. We shall keep the experiences of both classical Greece and Classical India alive where art and technology were not clearly separated in the manner familiar to us. By positioning us between these two experiences - classical and contemporary we shall critically examine the complex relationship between art, science and technology which characterizes modernity. The course uses both materials from philosophical aesthetics, philosophy of science and technology. It also discusses the philosophical writings on specific areas like architecture, photography, cinema and digital art.

**HUL355 Philosophy and Intellectual History in India**
3 Credits (3-0-0)  
Pre-requisites: Any Two courses from HUL2XX category  
Allocation Preferences: HUL251, HUL258, HUL253, HUL256, HUL290  
What defines the Indian tradition? Is there a singular Indian tradition or is there a plurality of Indian traditions in the public sphere today? How do these find representation in the modern and textual frameworks? Is modernity antithetical to tradition?  
The aim of this course is to take up these varied questions along with their nuances to understand and re-negotiate Indian intellectual traditions. In this course, the examination of sources, structure, texts and exemplars from Indian intellectual tradition provide a theoretical framework for the discussion of contemporary political and social issues. Economic development, social justice, religion and the nation, communalism and secularism, caste, class and gender equality are themes to be addressed. The political misuse of tradition in programs of reform and revival both in the past and in modern times will be highlighted to underline the need for rethinking Indian Philosophy and intellectual tradition in an academically rigorous manner.  
This course will also take into cognisance the intellectual history of the ancient past as it comes through the Vedic thought and its contestations.

**HUL356 Buddhism Across Time and Place**
3 Credits (3-0-0)  
Pre-requisites: Any Two courses from HUL2XX category  
Allocation Preferences: HUL251, HUL258, HUL253, HUL256, HUL290  
Literature on Buddhism and Buddhist literature brings out the historical, philosophical and political synthesis of Buddhism in ever new cultural contexts. Interrogating and contextualizing engagements of Buddhism's classical roots in modernity will be a key concerns in this course.

**HUL357 Philosophy of Science**
3 Credits (3-0-0)  
Pre-requisites: Any Two courses from HUL2XX category  
Allocation Preferences: HUL251, HUL258, HUL253, HUL256, HUL290  
Science is regarded as the most significant cognitive enterprise of the modern society. In view of this, the course addresses the question what sets science apart from other epistemic activities. Further it concentrates on debates on the nature of scientific methods, logical reconstruction of scientific explanation, the relation between theories and laws on the one hand, and empirical evidence on the other, the nature of the justification and the notion of truth involved in scientific knowledge, and the societal influence on scientific practice.

**HUL358 Philosophy of mind**
3 Credits (3-0-0)  
Pre-requisites: Any Two courses from HUL2XX category  
Allocation Preferences: HUL251, HUL258, HUL253, HUL256, HUL290  
Categorial taxonomy of Mental Phenomena: Intentional and Phenomenal.  
Theories of the Mind-Body relation: Cartesian Dualism; Behaviourism; Identity Theory or Physicalism; Functionalism.  
Personal Identity and the Self: The First-person Point of View.  
Consciousness and Content: Phenomenal Intentionality; Representationalism; Internalism and Externalism about Experience; Qualia and the Knowledge Argument.  
Consciousness and Self-consciousness: Pre-reflective Self-consciousness; One-level Accounts of Self-consciousness; Temporality and the Limits of Reflective Self-consciousness; Bodily Self-awareness; Social Forms of Self-awareness.  

**HUL359 Metaphysics of the self**
3 Credits (3-0-0)  
Pre-requisites: Any Two courses from HUL2XX category  
Allocation Preferences: HUL251, HUL258, HUL253, HUL256  
The course is a critical study of the problem of the self taken to be a substance by some and denied to have any substantial reality by others. Focus will be given on examining the worldview from which stems the idea of a continuing self, as a subject of consciousness and agent of action. Questions about whether it is material or immaterial, real or nominal object will centre the ontological investigation into the nature of the self. Special consideration will be given to the issue of self-awareness and self-reference, and its relation to the linguistic phenomenon of the first-person pronoun ‘I’.

**HUL360 Selected Topics in Philosophy**
3 Credits (3-0-0)  
Pre-requisites: Any Two courses from HUL2XX category  
Allocation Preferences: HUL251, HUL258, HUL253, HUL256  
The course will introduce students to selected topics in Philosophy as decided by the instructor.

**HUL361 Applied Positive Psychology**
3 Credits (3-0-0)  
Pre-requisites: Any Two courses from HUL2XX category  
Allocation Preferences: HUL261, HUL265, HUL267  
Meaning and goals of applied positive psychology; Relevant research methods of the field; Introduction to intervention programmes including internet based intervention; Researches that support intervention strategies ; Psychological well-being and its intervention programmes; Emotional intelligence and its intervention programmes; Strategies for achieving well-Being; Mindfulness and its intervention programmes; Intervention module on stress and time management; Character strengths : their role in well being; How psychosocial resources enhance health and well being; Intervention researches in Indian socio-cultural context; Current issues and future directions in this Area.

**HUL362 Organizational Behaviour**
3 Credits (3-0-0)  
Pre-requisites: Any Two courses from HUL2XX category  
Allocation Preferences: HUL261, HUL265, HUL267  
Introduction to organizational behaviour, Historical development of the field and some challenges in contemporary times, Learning and perceptual processes in organizations and their implications for work-life,Work related attitudes- job satisfaction, organizational commitment, organizational justice, organizational citizenship behaviour, Individual differences related to personality, emotions and abilities and functioning in organization, Group processes in organizations, Formation of groups and teams, Effective teams, Communication in organizations, Social influence processes in organizations, influencing people, power dynamics and politics and impact on organizational functioning, Theories and styles of leadership in organization and their impact on organizational functioning,
Organizational ethos and culture and its impact on productivity and well-being. Various kinds of organizational structures and their effectiveness, managing organizations in times of change.

HUL363 Community Psychology
3 Credits (3-0-0)
Pre-requisites: Any Two courses from HUL2XX category
Allocation Preferences: HUL261, HUL265, HUL267
Introduction to Community Psychology; Understanding Individuals within Environments; Individualism collectivism & community Psychology; Understanding Human Diversity; Understanding Coping in Context; Community and Social Change; Prevention and Promotion: Key Concepts, Current and Future Applications & implementing programs; Overview of Community Interventions; Social support research in community psychology; Recent community researches in Indian socio-cultural context: Effects of various socio-cultural issues on individual and community well-being.

HUL364 Understanding the Social Being
3 Credits (3-0-0)
Pre-requisites: Any Two courses from HUL2XX category
Allocation Preferences: HUL261, HUL265, HUL267

HUL365 Environmental Issues: Psychological Analysis
3 Credits (3-0-0)
Pre-requisites: Any Two courses from HUL2XX category
Allocation Preferences: HUL261, HUL265, HUL267
The implications of natural, built and social environment on human functioning, Making sense of environment-environmental perception and cognition, Nature of environmental attitudes and implications for inculcating pro-environmental attitudes, Various kinds of environmental stressors and human response to these stressors, Psychological analysis of climate change related issues, Psychology and energy conservation- social and collective dilemmas and individual interests, Environmental disasters and disaster preparedness, Assessing environmental risks, Place attachment, territoriality, personal space and notion of privacy and identity issues, Designing better environments and role of psychological factors in the design process, Examining specific built environments.

HUL370: Selected Topics in Psychology
3 Credits (3-0-0)
Pre-requisites: Any Two courses from HUL2XX category
Allocation Preferences: HUL261, HUL265, HUL267
The course will introduce students to selected topics in Psychology as decided by the instructor.

HUL371 Science, Technology and Society
3 Credits (3-0-0)
Pre-requisites: Any Two courses from HUL2XX category
Allocation Preferences: HUL271, HUL272, HUL274 HUL275, HUL276, HUL281, HUL286, HUL289, HUL290
The course will begin with social theories on the production of technology and scientific knowledge systems, stratification within the community of technologists and scientists, discrimination (race, class, gender, caste) and the role of power in shaping the production of technology and scientific knowledge. Scientific controversies, both historical and emerging, and the organization of innovation and its geographical will be discussed. Case studies exploring ethical questions arising from new technologies such as information technology, nanotechnologies, biotechnologies, etc. will be used. Discussions on public understanding of science and role of the public and experts in influencing policies related to science and technology will conclude the course.

HUL372 Agrarian India: Past and Present
3 Credits (3-0-0)
Pre-requisites: Any Two courses from HUL2XX category
Allocation Preferences: HUL271, HUL272, HUL274 HUL275, HUL276, HUL286
The course will use interdisciplinary texts to give students a historical overview of agrarian India starting from the colonial period, plantation and export economies, recurring famines, community development programs and land reforms after independence, the green revolution, and the neglect of rainfed/dryland regions. It will explore various dimensions of development in agriculture including the advent of the agricultural sciences and the birth of the agricultural extension system. The myth of the ignorant farmer and the self-sufficient village will be discussed. Case studies on the historical roots of globalization and agricultural commodity chains related to new technologies, and the linkages between the market and the state in contemporary agriculture will be discussed. The growing social and geographical disparity with ecological distress and the threat of climate change, farmer suicides, and debt spirals on the one hand, and a risky but rewarding cash crop economy on the other, will also be explored. Finally the course will discuss aspirations of rural youth, opportunities for livelihoods, and gender and caste dimensions of the growing urbanization of rural centres.

HUL375 The Sociology of Religion
3 Credits (3-0-0)
Pre-requisites: Any Two courses from HUL2XX category
Allocation Preferences: HUL271, HUL272, HUL274 HUL275, HUL276, HUL286
This course will introduce students to sociological approaches to the study of religion in contemporary society. Religion will be understood in terms of its social and cultural structure; in addition the course will also encourage a critical perspective on religion and society – its interface with society, polity and the economy. Religious conflict and change, syncretism, popular religion, revivalism and fundamentalism will also be considered.

HUL376 Political Ecology of Water
3 Credits (3-0-0)
Pre-requisites: Any Two courses from HUL2XX category
Allocation Preferences: HUL271, HUL272, HUL274 HUL275, HUL276, HUL286
This course is an advanced undergraduate sociology course on the political ecology of water. It discusses people’s historic and current engagement with water, sustainable development and water, the recent controversies and emergent resource conflict over water in the context of industrial development, design and implementation of hydropower projects, water pollution management, and conservation strategies (modern and traditional) and relates them to relevant national policies.

HUL377 Gender, Technology and Society
3 Credits (3-0-0)
Pre-requisites: Any Two courses from HUL2XX category
Allocation Preferences: HUL271, HUL272, HUL274 HUL275, HUL276, HUL286, HUL289, HUL290
The manner in which gender is conceptualized and performed is foundational to the understanding of human social relationships. Gender identities are not fixed or determined purely by physiology; their social construction affects ideas of masculinity and femininity or other sexual identities. Besides understanding how sex and gender are interrelated, we will look at how gender intertwines with societal
areas of economy, technology, polity, religion and demography. The important role played by social structures and institutions such as caste, kinship, family, marriage, ethnicity, religion and class in structuring gender and vice-versa will be brought out.

Technologies associated with population and biological sciences have transformed and are continuing to transform society and human relationships in particular directions. The course will examine these transformations at the global and local levels and consider their impact on individual lives. Challenges posed to intimate human relationships and identities by new reproductive technologies such as invitro-fertilization, surrogacy, sex selection will be explored. What does the emergence/ institutionalization of new social forms - such as same sex marriages and parenthood by surrogacy - tell us about the possibilities and limits of human relationships?

HUL378 Industry and Work Culture under Globalization
3 Credits (3-0-0)
Pre–requisites: Any Two courses from HUL2XX category
Allocation Preferences: HUL271, HUL272, HUL274 HUL275, HUL276, HUL286
Globalization and Globality; Classical theories to understanding work and industry; Understanding Work, Work Ethic and Work Culture; Post-industrial society and rise of informational economy; Job-satisfaction and alienation; Equalization of Opportunities and the Flattening of the World; Outsourcing as a Business Strategy; Important changes in industry and rise of IT sector and BPO industry; Governance and Collective Organization of Workers in select sectors; Corporate Social Responsibility.

HUL380 Selected Topics in Sociology
3 Credits (3-0-0)
Pre–requisites: Any Two courses from HUL2XX category
Allocation Preferences: HUL271, HUL272, HUL274 HUL275, HUL276, HUL286
The course will introduce students to selected topics in Sociology as decided by the instructor.

HUL381 Mind, Machines and Language
3 Credits (3-0-0)
Pre–requisites: Any Two courses from HUL2XX category
Allocation Preferences: HUL243
Exploratory in nature, the course seeks to debate questions such as: What are the implications of conceiving the mind as a ‘machine’? Can evolutionary theories about language and tool-using help us understand how we continually manage today to process the world around us ‘online’? On this course, the class will be introduced to some state-of-the-art discussions in the interdisciplinary field of cognitive studies. These topics will include: (i) the modularity of mind (ii) the content of consciousness, (iii) the language bio-programme hypothesis, (iv) the relativism versus universals of controversy; (v) strong and weak positions on AI, etc. The course will rely on down-to-earth examples to demonstrate that such an interconnected area of study is not remote or esoteric but part of the intellectual excitement of living in the new millennium and attempting to anticipate both how it will shape us and how we will shape it.

HUL382: Romanticism: The Theory of Animals, Monsters and Machines
3 Credits (3-0-0)
Pre–requisites: Any Two courses from HUL2XX category
Allocation Preferences: HUL231, HUL235
There is more to romanticism than Wordsworth’s poetry, or even literature in general. Nor is it confined between 1780s and 1830s. Least is it a trend succeeded by Victorianism and realism, and assailed by modernism. Romanticism contends with the question of presentation – of representation of and to oneself. It therefore directly participates in the philosophical discussions of reason, sensibility, emotion, subjectivity, and most importantly the idea of human freedom. This course will familiarize students with romantic movements in arts, in theories of language and society, in post-Kantian philosophy, in attitudes to religion. Romantics not only engaged in experimental social practices and literary collaborations, but also articulated their necessity for the first time. Can we say that romanticism is at an end? How does it contribute to both a nationalism rooted in folk tradition, and individualism expressed in the cult of the hero, the solitary intellectual? How does it both look back to medieval occult and forward to novelties of science? Why is romanticism fascinated with animals, monsters and machines alike?

HUL700 Seminar (Case Material-based) Minor Project
3 Credits (0-0-6)
Students would under take a supervised research project.

HUL701 Introduction to Science and Technology Policy Studies
1.5 Credits (1.5-0-0)
The course will begin with a brief theoretical understanding of policy making processes and touch upon the specificities of science and technology policy systems in India. It will specifically examine the role of stakeholders in the process such as grassroots voices and civil society organizations, industry, academia, international actors, and policy makers. It will then examine the role of science and technology in policies in selected current and emerging key sectors, e.g., transport, agriculture, health, energy, environment, or information and communication technologies. The course will also explore the inherently political and contested nature of decision making in the policy arena.

HUL702 Approaches to Science and Technology Policy Studies
1.5 Credits (1.5-0-0)
The course identifies six themes which are key to understanding Science and Technology Policy (STP) viz., Safety, Ownership, Ethics/morality, Knowledge base, Participation and Choice of policy instruments. Through sociological, economic, regulatory and legal literature on selected current and emerging key sectors, e.g., transport, agriculture, health, energy, environment, or information and communication technologies, it invites the students to keenly understand the various underlying approaches in STP.

HUL703 Perspectives on Climate Change: Implications for Policy
3 Credits (3-0-0)
The course will develop a basic understanding of science of climate change, the associated uncertainties and the processes that link this science with policymaking. The impacts of climate change on socio-economic and natural systems and the link between climate change, and development policies will be discussed. The global distribution of greenhouse gas emissions and possible technological, market and regulatory trajectories to mitigate them will be discussed with the emphasis on how different trajectories lead to questions on geographic, inter-generational and distributional equity. The students would examine economic, political and institutional frameworks for understanding policies and practices designed to reduce greenhouse gas emissions, vulnerability to climate change and facilitate adaptation in the face of climate threats and explore how policy can produce or reduce vulnerability. The course will draw on theoretical framings and methodological tools from multiple disciplines including atmospheric sciences, economics, environmental policy, psychology and sociology.

HUL704 : Inclusive Innovation: Theory and Practice
4 Credits (2-0-4)
The course will familiarize students with key concepts in innovation, including various elements of the innovation cycle going all the way from need identification to deployment. Key aspects relating to inclusive innovation - the public goods nature of many basic needs, user and market characteristics, delivery and scaling-up considerations, and the role of partnerships and policies - will receive particular focus. The students will also be introduced to the state-of-the-art thinking in organizing for innovation, especially for the bottom of the pyramid. This theoretical knowledge will be complemented with hands-on exercises aimed to familiarize students with some of the key issues in coming
up with technologies and products for the marginalized, including user needs and context analysis, ideation involving user interaction and co-creation, and assessment of the potential of technology for success.

**HUL706 Language, Society and Culture**  
3 Credits (2-1-0)  
Psycho-linguistics and sociolinguistics; culture and identity studies; studies in expressive culture: idea-systems, myths and archetypes.

**HUL707 Social Psychology**  
3 Credits (2-1-0)  

**HUL709 Social Research Methods**  
3 Credits (2-1-0)  

**HUL710 Personality Structure and Dynamics**  
3 Credits (2-1-0)  

**HUL711 Psychological Testing & Behavioral Assessment**  
3 Credits (2-1-0)  

**HUL712 Microeconomics**  
3 Credits (3-0-0)  
Pre-requisites: For UG students: HUL212 & HUL311  
This course provides an introduction to microeconomic theory and is the first course in the microeconomic theory series. The course will begin with detailed analysis of consumer's choice behavior and required mathematical tools from optimization theory and real analysis would be reviewed. Producer's behavior is analyzed next where emphasis is put on characterization results under different market structures, especially strategic aspects in an oligopolistic market. The next topic is analysis of decision-making under uncertainty and Anscombe-Aumann framework is introduced. Next non-expected utility theories are covered. Topics of recent and relevant interest will also be covered if time permits.

**HUL713 Macroeconomics**  
3 Credits (3-0-0)  
Pre-requisites: For UG students: HUL211, HUL212, HUL213, HUL311, HUL312, HUL314, HUL315, HUL318, HUL320  
This course begins with a detailed study of macroeconomic concepts, which include an analysis of India's national income and balance of payments data. It provides an understanding of the contending theories of employment, income distribution, money supply, and price-wage relationships. The course also deals with exchange rates and other open economy macro issues. It discusses the classical and neoclassical theories of the macroeconomy, as also the critiques of these theories by Keynes, Kalecki, and their followers. The course examines macroeconomic policies, and the challenges faced by governments and the Central Banks in implementing them, especially in the context of the integrated nature of global finance and production.

**HUL714 International Economics**  
3 Credits (3-0-0)  
Pre-requisites: For UG students: HUL211, HUL212, HUL213, HUL311, HUL312, HUL314, HUL318, HUL320  
This course discusses the various theories on trade, including the Ricardian and Heckscher-Ohlin models. It deals with instruments of trade policies, and also the political economy issues such as trade agreements under the WTO. It examines how international trade affect developing countries, with a particular emphasis on the Indian case. Further, the course will trace the emergence of the international monetary system, including the international gold standard and the Breton Woods system. The ascent of global finance and its implications for macroeconomic policymaking will be covered in this course. Theories on finance, financial regulation and financial crises will also be discussed in this course.

**HUL715 Time Series Econometrics and Forecasting**  
3 Credits (3-0-0)  
Pre-requisites: For UG students: HUL215 / HUL215  
1. Stationary Univariate Models: (a) Difference equation; (b) Wold's decomposition; (c) ARMA models; d. Box-Jenkins methodology; (e) Model Selection; (f) Forecasting.  
2. Non-stationary univariate models: (a) Trend/cyclical decomposition; (b) Deterministic and stochastic trend models; (c) Unit root tests; (d) Stationarity tests.  
3. Structural change and non-linear models: (a) Test for structural change with unknown change point; (b) Estimation of linear models with structural change; (c) Regime switching models.  
4. Stationary multivariate models: (a) Dynamic simultaneous equation models; (b) Vector Auto Regression (VAR); (c) Granger causality; (d) Impulse response function.  
5. Non-stationary multivariate models: (a) Spurious regression; (b) Co-integration; (c) Vector Error Correction (VECM) model.  
6. Time series model of heteroskedasticity: (a) ARCH, GARCH models.

**HUL716 Industrial Economics**  
3 Credits (3-0-0)  
Pre-requisites: For UG students: HUL212 & HUL311  
The course aims to formalize microeconomic treatment of industry and firm's behaviour, decision-making in consumer's choice problems, rationality theory (as well as its exceptions). Emphasis will be put to conceptualize various aspects of firm's and consumer's choice. Market structures, pricing under alternative market structures, market power and concentration will also form an integral part of the course. Behavioural and strategic aspects of the agents would be emphasized in various cases e.g. auctions, economic networks etc.

**HUL717 Perspectives on Indian Economy**  
3 Credits (3-0-0)  
Pre-requisites: Any ONE of: HUL211, HUL212, HUL213, HUL311, HUL312, HUL314, HUL318, HUL320  
The course begins with a detailed study of macroeconomic concepts, which include an analysis of India's national income and balance of payments data. It provides an understanding of the contending theories of employment, income distribution, money supply, and price-wage relationships. The course also deals with exchange rates and other open economy macro issues. It discusses the classical and neoclassical theories of the macroeconomy, as also the critiques of these theories by Keynes, Kalecki, and their followers. The course examines macroeconomic policies, and the challenges faced by governments and the Central Banks in implementing them, especially in the context of the integrated nature of global finance and production.
This course discusses the various phases in India’s development transition. They include the economic changes during the colonial period, development under the planning regime, the transition from state to markets in India, and economic growth under liberalization. The course will deal with the varied inequalities in the country, along the lines of caste, class, and gender, as well as across regions. It will feature issues related to Indian agriculture, industry, services, as well as trade and investment. The course will aim to provide various points of view on each of these topics.

**HUL718 Political Economy of Development**
3 Credits (3-0-0)
Pre-requisites: Any ONE of: HUL211, HUL212, HUL213, HUL311, HUL312, HUL314, HUL318, HUL320, HUL271, HUL272, HUL275, HUL281, HUL286, HUL289, HUL310

The course will be a survey on the theories and issues related to the political economy of development. It discusses the emergence of industrial capitalism in Europe and North America, as well as its spread to third world countries since the mid-twentieth century. The course will deal with contemporary issues such as the growth of international trade and finance, the emergence of China as a global economic power, and the crisis in global capitalism that deepened since 2008. Issues related to human development, labour rights, migration and environmental sustainability will also be covered.

**HUL719 Advanced Econometrics**
3 Credits (3-0-0)
Pre-requisites: For UG students: HUL315 / HUL215

Course content (about 100 words) (Include laboratory/design activities):
1. Review of Classical Linear Regression Model: Gauss-Markov assumptions, finite sample properties, large sample properties.
2. Instrumental Variable Estimation: Motivation for instrumentation, simultaneity, endogeneity and measurement error; IV Estimation; 2SLS Estimation.
7. Censored Regression Models: Estimation and Inference with Censored Tobit.
8. Estimating Average Treatment Effects: Regression Methods, Methods Based on the Propensity Score, Estimating the ATE Using IV.

**HUL720 Development Economics**
3 Credits (3-0-0)
Pre-requisites: For UG students--any ONE of: HUL211, HUL212, HUL213, HUL311, HUL312, HUL314, HUL315, HUL318, HUL320

This course discusses experiences in economic growth and development transitions from around the world. Some of the topics that will be covered in this course include poverty, inequality, education, health, and gender aspects of development. The course will deal with history and persistence in development, as well as with the roles of agrarian institutions and credit markets. Other topics covered will include culture, social capital, behavior, corruption, violence and conflict. The impacts of international trade, foreign aid, and foreign investment on development will also feature in this course.

**HUL731 What is a Text**
3 Credits (3-0-0)

We will study the fundamental assumptions supporting the various definitions of text, and their possible mutual incompatibility, for the ways in which the question “what is a text” exposes the issues in characterizing, interpreting and attributing meaning to text. The course will take into account hermeneutic, phenomenological and deconstructionist theories of text, the historicality of the idea of text, the distinctions between text and work, the metaphysics of text and its epistemological status, and the possibility of classifying kinds of text. It will also consider the different cultural ways of producing, circulating and relating to texts.

**HUL732 Contemporary Critical Theory**
3 Credits (3-0-0)
Pre-requisites: For Ph.D. students: No prerequisites for all other students: Any one of the following: HUL331, HUL332, HUL333, HUL334, HUL335, HUL336, HUL337, HUL338, HUL339, HUL340

A particular theoretical position would be explored through the detailed study of selected work which trace the history of the development of that critical position. The study would also include the analysis of a text which would illustrate the critical position being studied.

Detailed course contents would be announced by the course coordinator at the time of offering the course.

**HUL733 Study of an Author/Writer in Focus**
3 Credits (3-0-0)

- Brief biography and study of the historical/social context of the selected writer
- Intellectual milieu of the writer
- Overview of the major works and overall trajectory of the development of his/her thought
- Understanding the influences and impact of the work/s
- Detailed study of the selected text/s

**HUL734 Themes in Modern Indian Thought**
3 Credits (3-0-0)

This course will focus on significant themes in modern Indian thought (Equality, Freedom, Sexuality, Gender, Caste, Religion, Violence, Modernity, Education, the Arts etc) and introduce students to major works that engage the specific theme(s) that have been chosen. Works studied may be cinematic, theatrical, fictional or non-fictional. The course will study both the genealogy of significant concepts in modern Indian thought (examining English as well as non-English language materials) as well as the range of debate about these concepts and their deployment. The course is envisaged as an interdisciplinary course, though we will pay close attention to questions of reading, textuality and interpretation. Lecture outline given for a possible course on gender and sexuality, as ONE possible example of a theme that could be pursued.

**HUL735 Research Methods in Economics**
2 Credits (1-0-2)

Pre-requisites: Either HUL701 or HUL 707 or HUL736 OR HUL738 or HUL754 or HUL755 or HUL761 or HUL762

The course will cover theory and practice of doing applied research in economics, with special emphasis on primary and secondary data uses. The course will familiarize students with sampling techniques, questionnaire design, implementation of field-based studies, including randomized controlled trials. Students will be provided training in STATA for carrying out data analysis, including use of data sets such as the National Sample Survey, National Family Health Survey, Indian Human Development Survey. Students will be expected to design and implement a small study during the course of the semester and will be evaluated on this.

**HUL736 Planning and Economic Development**
3 Credits (3-0-0)

HUL737 Advanced Economic Growth Theory
3 Credits (3-0-0)
Pre-requisites: either HUL736 or HUL738 or HUL755 or HUL762 or any other 7XX level economics course.

Primary objective of this course is to introduce students with the process of economic growth and the long run sources of differences in economic performances across nations. Emphasis will be placed on developing theoretical tool kits in understanding growth mechanics. It is intended that this course will make students learn some of the workhorse models in modern macroeconomics, namely, Solow model, Neo-classical model, overlapping generations’ model, models with technological change and technology adoption etc.

HUL738 International Economics
3 Credits (2-1-0)

HUL741 Sociolinguistics: Language Variation, Culture and Society
3 Credits (3-0-0)
Pre-requisites: HUL 234, HUL242 and HUL 350 for UG or Prior Permission of Coordinator
This course aims at understanding variation mainly from a sociolinguistics perspective, but while also considering some relevant cues from generative views of the phenomenon. It will cover aspects of language change (bilingualism, multilingualism, language deaths, pidgin and creole formation etc.) as explained by feature-based and parameter-based grammars, as well by socio-cultural-political factors. The focus will then shift towards how homogenization of language also happens - combating the natural tendency towards variation - triggered by external factors. Concepts of race, gender, nation and identity will also be brought up to show the pervasive role of language in varied aspects of our socio-cultural-political lives.

HUL742 Transformational Theories of Language
3 Credits (3-0-0)
Pre-requisites: HUL 234, HUL242 and HUL 350 for UG students and/or prior permission of the course coordinator
This course will cover the fundamental concepts that have defined generative/transformational grammars since their inception in the 1950s. It will introduce students to the main motivations for such grammars for natural language, as stated in Chomsky (1957). A substantial part of the course will therefore be devoted to understanding the inadequacies of immediate constituent analysis and the need to include optional and obligatory transformational rules in the grammar. This will be followed by a detailed study of later theoretical developments, including those found in Standard Theory, Extended Standard Theory, Revised Extended Standard Theory and Government and Binding Theory.

HUL743 Language Acquisition, Teaching and Assessment
3 Credits (3-0-0)
This is a literature review course that will explore the existing literature in the domains of Language Acquisition (both first and second), Language teaching (approaches and methods), as well as language assessment. In doing so, the course will include aspects of the philosophy of language, and the resultant application of these philosophical approaches in the form of classroom pedagogy. The course will also include substantial literature on “action research” where language teachers have written about the results of implementing various cognitive tasks in their classroom.

HUL745 Psycholinguistics
3 Credits (3-0-0)
We will first introduce the relevant questions, theories, methodologies with regard to the historical trajectory of Psycholinguistics. We will then look at language processing at different linguistic dimensions. We will start with words, their meaning and access. We then look at processing sentences. The course will also cover important topics such as language and speech production. Reading processes (and its relation to processing) will be covered. We course will also cover the current theories of Bilingualism and Aphasia.

HUL746 Phonological Markedness
3 Credits (2-0-2)
Pre-requisites: HUL 234, HUL242 and HUL 350 for UG
This course explores the connection between a unit of acoustic speech signal and its environment (sounds preceding or following it). Phonological theory is thus composed on context-free and context-sensitive notions of markedness. While these are supposed to be universal, individual languages might vary significantly in prioritizing between these. The course therefore involves a major practical component where the speech units of individual languages (vowels, consonants and tones) are studied with respect to their phonological contexts.

HUL748 Community Psychology
3 Credits (2-1-0)
Concept of community and their implications for community psychology. Community processes and orientations toward change. Examinations of the models; the mental health model; the organizational model; the social action model; the ecological model. Implications for a psychology of the community: the study of community life, interaction strategies; implications for manpower and training; family therapy and the community; crisis intervention; advocacy and community psychology.

HUL751 Critical Reading in Philosophical Texts
3 Credits (3-0-0)
The instructor will select a seminal text in philosophy and read it along with the class. Emphasis will be given to the textual material and issues in reading and understanding. An overview of the following will be provided: The nature the text, specificity of philosophical texts, text and context, issues in translation, interpretation and understanding.

HUL752 Philosophy of Social Sciences
3 Credits (3-0-0)
Some of the key issues which arise in Social Sciences will be discussed in this course. These are: (1) What is ‘out there’ in the social universe? (2) What are the most fundamental properties of the social world? (3) What kind(s) of analysis of these properties is (are) possible and/or appropriate? (4) What are the natures of theory, law, and explanation? (5) Problems of reductionism. (6) Problems of free will versus determinism, purposeful behaviour, interpretations of actions. (7) Philosophical issues specific to various Social Sciences, e.g., philosophical bases of various economic theories, or of theories of psychology, or issues regarding the assumptions concerning human nature made by various social science disciplines.

HUL753 Philosophy of Science
3 Credits (3-0-0)
The course will address three sorts of questions. The first set involves the status of science as a privileged source of knowledge: what, if anything, justifies this status? The second set involves concepts such as ‘law’, ‘cause’, and ‘explanation’ which occur within scientific practice: how are these to be understood? The third set involves understanding the relationship between different scientific enterprises: is there a hierarchy of sciences ranging from physics at one end to the human or social sciences at the other? If so, how should this hierarchy be understood?

HUL754 The Philosophy of Plato
3.0 Credits (3-0-0)
This is a survey of Plato’s thinking about politics, ethics, epistemology, and metaphysics. We will focus on a careful and critical reading of the
primary texts, and attempt to get a sense both of their historical and cultural specificity, as well as their interest more generally as sources of philosophical insight.

**HUL755 Fascism: Philosophical Perspectives**  
*3 Credits (3-0-0)*  
Fascism is one of the pernicious forms of power that emerged in the 19th and 20th century and posed a serious to challenge democratic forms of life. The course will discuss the philosophical understanding of power, state, law, sovereignty and freedom with the special focus on gaining a conceptual grasp on fascism. Some of the classical and contemporary philosophers who have directly or indirectly contributed towards constructing the intellectual edifice of fascism will be studied. Philosophical criticisms of fascism and the ethical and political explorations of resistance and the possibility of alternative forms of power and governance will also be studied. The bio politics of fascism, its relationship with Nazism, racism and religious and other forms of fanaticism, and the aestheticization of politics will also be covered.

**HUL756 Philosophy and Film**  
*3 Credits (3-0-0)*  
This course develops the conceptual resources of philosophy to respond to the cinematic image. The topics include: Ontology of the cinematic Image; cognitive and phenomenological approaches to perception and imagination; relationship between representation and reality and between seeing and saying; space, time and image; movement and animation, memory, history, narrative; anthropology of images, truth in cinema; Cinema as art; Cinema's relationship to painting and literature; cinema and technology, the digital image.

**HUL759 Urban Social Systems**  
*3 Credits (2-1-0)*  
This course intends to impart a comprehensive and systematic understanding of urban social systems. Students completing this course will have a detailed knowledge of urban-growth and urban behaviour analysis, and urban planning through a feedback analysis approach. Following will be the main course contents: Nature, types and growth of cities, Some important aspects of urban-systems: migration; neighbourhood; social groups; and voluntary associations. Trend of urbanisation. Urban influences on rural areas. A profile of urban India and its problems. Solution of the problems through various approaches. Urban planning.

**HUL760 Industry and Society**  
*3 Credits (2-1-0)*  
The basic aim of this course is to introduce students from various backgrounds scientists, technologists to the study and understanding of modern industrial societies. The course material will focus on the following topics. Nature and type of industrial society. Workers in modern industrial societies: the work situation; alienation; and embourgeoisement. White collar worker. Trade-unionisation. Industrial democracy. Labour-management relations in Indian industries.

**HUL761 Theories of Psychology**  
*3 Credits (3-0-0)*  
The course will provide a history of the discipline of psychology and its evolution over the years. Major schools of psychology will be discussed. The key theories -psychoanalytic theory, the various learning theories, theories of emotion and cognition, humanistic approaches and evolutionary perspective will be the focus. Social psychology theories, cognitive and neuroscience perspectives and positive psychology theories will be discussed in detail.

**HUL762 Social issues:Analysis and Policy**  
*3 Credits (3-0-0)*  
The courses will focus on the following: Social psychological theory and application, examine the various methods of research, examine some social psychology applications and evaluate them. Issues of Inequality, deprivation and justice, in the context of Intergroup relations, Psychology of legitimacy, Violence, reconciliation and peace will be examined. Environment and energy conservation issues and applied research and the criminal justice system will be critically examined. Social psychology and social policy implications will be discussed.

**HUL763 Cognitive Psychology**  
*3 Credits (3-0-0)*  
The course will cover the following topics: Historical account of brain-mind, classification of cognition theories, methods of studying cognition, visual perception, top-down-bottom-up processing, visual recognition, information processing theories and attention, long-term memory, three stage theory of memory, types of memory, working memory and executive processing, emotion-cognition, decision making and dual process theories.

**HUL764 Psychological Interventions**  
*3 Credits (3-0-0)*  
Introduction: Psychological Intervention modules including Yoga & Meditation; relevant research methods of the field specifically for intervention programmes development and evaluation - research design, testing, evaluation of results etc; Broad objectives of the field; Intervention programmes in the various field of psychology: Applied positive psychology, health psychology, applied social psychology, community psychology, cognitive psychology etc.; Meta - analysis research on intervention programmes; Intervention programmes in Indian setting and role of socio-cultural factors; Critical evaluation and Future orientation of the field.

**HUL765 Psychological Testing and Behavioral Assessment**  
*3 Credits (3-0-0)*  
Psychological testing: Uses and Varieties of Psychological Tests, Item Analysis, Norms and the Meaning of Tests Scores; Reliability and its Types; Validity and its Basic Concepts; Steps for Test Construction, Test adaptation and revalidation; Other Techniques of Behavioral Assessment; Ethical and Social Considerations in Testing; Ethical Guidelines in Behavioral Assessment.

**HUL771 Sociological Theory**  
*3 Credits (3-0-0)*  
This is an advanced course that introduces students to a range of classical and contemporary sociological theory.

**HUL772 Sociology of India**  
*3 Credits (3-0-0)*  
The major themes covered in this course include the debates on continuity and change in relation to colonial rule, ideas of tradition and modernity, models of development, agrarian structure and rural transformation, marriage and family, caste and kinship, secularism, Subaltern religion and religious conflict, class and social mobility. The course takes a critical and engaged perspective on concepts such as the village, family, caste, region, nation, language, religion, gender, class, development, tradition, indigenousness, tribe, modernisation and others. Various approaches that have influenced the study of Indian society such as Orientalism, Indology, Structuralism, Structural-FunctionSubaltern Studies will also be discussed.

**HUL773 Media, Culture and Society**  
*3 Credits (3-0-0)*  
The course examines contemporary manifestations of the 'media-event', the 'spectacle' and the fetishism of the image-object in determining the collective consciousness of our times. How are 'media-events' created? What is the role of the media (this includes mass media, advertisements, as well as social and digital media) in determining the nature of the 'self' and 'society'? How do media-trials alter the manner in which we relate to issues of justice and fairness? What is the manifestation of social movements in a media-saturated age? How do we recalibrate our understanding of privacy and what does this do to the ways in which we can create ever-changing and new 'selves'? These questions will be examined through case studies from South Asia and beyond.
HUL774 Visual Methods in Social Research
3 Credits (3-0-0)
The course analyses visual material in cross-cultural contexts and how the Internet in particular is being used to disseminate information and (re)present content. Importance of visual research methods; visuals as texts and framing; representing images and images in social research; Internet and online ethnography; analyzing websites - qualitative content; politics of digital culture.

HUL775 Agrarian Societies and Rural Development
3 Credits (3-0-0)
Pre-requisites: For UG students: Any ONE course from HUL 271, HUL 272, HUL 275, HUL 281, HUL 286, HUL 371, HUL 372, HUL 375, HUL 376, HUL 377, HUL 378 OR HUL 380 OR any new 200 or 300 level Sociology course floated in future.
For PG students: None
The course will introduce students to theories related to agriculture and development including modernization theory, the rational peasant, moral economy, the agrarian question, modes of production debates, peasantry as a class, etc. Readings from the history of agriculture in various countries including the United States, Asia, Africa and India will be taught in comparative perspective. The course will help students understand the economic, social, cultural, ecological, political dimensions to the agrarian question, especially in the light of urbanization and globalization over the last 150 years.

HUL776 Capitalism: Theory and Development
3 Credits (3-0-0)
What is capitalism and how did it emerge? What are its strengths and weaknesses? How have the social scientists analyzed it and understood its implications for and relationship with other social phenomena? Addressing these questions, this course discusses the historical development of capitalist institutions and social relations in the context of the advanced industrial and developing societies. Particularly, it analyses the various theories and paradigms of capitalistic development, such as the Marxist political economy, classical liberalism, world systems theory, economic history and neoliberalism. Furthermore, it analyses the relationship between the state and market, capitalism and liberal democracy, the religious roots of capitalism, social embeddedness of economic activity, and the ‘new realities’ of capitalism, such as displacement, inequality and rampant environmental degradation.

HUL777 Sociology of Science
3 Credits (3-0-0)
Basic theories in the sociology of science such as functionalism, the theory of paradigm shift, social construction of scientific facts, stratification and discrimination in science, feminist epistemologies of science, theories of standardization and objectivity. Historical and contemporary debates on scientific and indigenous knowledge from India and the world, relationship between science and the state, and role of experts and the public in evaluating and regulating science.

HUL778 Urban Sociology
3 Credits (3-0-0)
This seminar course critically examines the production of urban space and culture. The ‘urban’ denotes an aspect of physical space as much as a way of life and a mentality. A critical reading of ethnographic studies on the city provides a cross-cultural perspective on how space becomes culturally meaningful. The rise of the urban centre and metropolis are the product of a certain historical moment, yet they also produce distinctive mentalities and cultures that are unique to them.

HUL779 Gender and Society
3 Credits (3-0-0)
Sex and gender; masculinities, gender as performance and identity; sexuality and gender identities, masculinity and femininity. Hegemonic masculinity; Inter-sections of gender and race, ethnicity, caste and class. Institutionalization of gender via the state, family, marriage, religion etc.; the political economy of gender relating to reproduction, care, work and property. Issues of gender inequality, patriarchal oppression, violence, voice and agency.

HUL782 Perspectives on Development in India
3 Credits (3-0-0)
Pre-requisites: For UG students: ONE course out of (HUL 212, HUL 213, HUL 311, HUL 312, HUL 314, HUL 315, HUL 316, HUL 318, HUL 320 OR any new 200 level or 300 level Economics Courses floated in future) AND ONE course out of (HUL 271, HUL 272, HUL 275, HUL 281, HUL 286)
This seminar course will undertake a critical examination of the development process in India. The course introduces students to a historical overview of social, economic and political issues related to the ideas of development and growth. Starting from notions of improvement mooted under the colonial regime, to the processes of planning in independent India, the radical new agrarian policy of the 1960s and 70s, down to the era of liberalization in the 1990s and beyond, the course familiarises students with the political economy of development in India. It uses inter-disciplinary sources and texts to expose students to multiple ways of understanding and analyzing problems. Other topics covered include poverty and inequality, economics of discrimination (gender and caste) and the conflicts over land and natural resources in the 21st century.

HUL783 Science, Technology and Society
3 Credits (3-0-0)
Introduction to the discipline of Science and Technology Studies covering topics such as the technological determinism, social construction of technology (SCOT), actor-network theory, laboratory studies, scientific controversies, the theory of paradigm shift, social construction of knowledge, feminist theories of science and technology, the idea of technoscience, risk society, ethics in engineering, and the role of experts and the public in evaluating and regulating the production of science and technology.

HUL800 Research Writing
3 Credits (3-0-0)
The course will include aspects of writing composition and stylistics that are essential to write a coherent research paper/abstract. Topics will include text structure, common writing mistakes, ethical issues, etc. This will be a hands-on course; it will extensively use in-class exercises (as well as assignments) to help students learn the necessary skills.

HUL801 Law, Technology and Citizenship
3 Credits (3-0-0)
Although there has been considerable focus in political theory and legal studies on the concept of citizenship, and its relationship with the law, through the last six decades, the study of the importance of technology to this relationship is only an emerging field. Four performative sites of citizenship discourse/citizen action viz., (a) human rights approaches and the regulation of technology, (b) Surveillance state and citizenship, (c) Technological ethics as a site for citizenship discourse, and d) Posthuman citizen, are focused upon to offer possible (conceptual and practical) implications for the ways in which ‘law and technology’ impacts existing rights discourse. Further, four important sites of contemporary debates on technology and citizenship, viz., UID/Aadhaar, Human DNA profiling for crime control, nuclear technology and genetically modified technologies in agriculture are focussed on to contextualise the key issues that are identified in the earlier modules.

HUL810 Advanced Topics in Policy Studies
3 Credits (3-0-0)
This course will introduce students to advanced topics in Policy Studies as decided by the instructor.

HUL811 Advanced Economic Growth Theory
3 Credits (3-0-0)
Pre-requisites: For UG students-any ONE of: HUL212, HUL213,
HUL311, HUL312, HUL211, HUL314, HUL318, HUL320

The course aims to develop an understanding of the process of economic growth and income distribution in an economy. Historical and contemporary experiences of countries on growth and developmental outcomes will be dealt with in this course. The impacts of capital accumulation, technological progress, and international trade on economic performance will be discussed. Further, this course will focus on how global capital movements, domestic institutions and political economy can affect economic growth and development.

HUL812 Advanced International Trade
3 Credits (3-0-0)
Pre-requisites: For UG students any ONE of: HUL212, HUL213, HUL311, HUL312, HUL211, HUL314, HUL318, HUL320

The contents of this course will include topics such as - Ricardian and Heckscher-Ohlin models, their extension to many goods and factors, the role of tariffs, quotas, and other trade policies, trade under imperfect competition, outsourcing, political economy, multinationals, trade and growth, gravity equation, organization of the firms, etc.

HUL813 Foundations of Decision Theory
3 Credits (3-0-0)
Pre-requisites: HUL212

The course aims to formalize microeconomic treatment of decision-making by economic agents. It will encompass consumer’s choice problems, rationality theory and also bounded rationality theory. The course will conceptualize behavioural aspects of firm’s decision-making - non-cooperation strategies and cartel formation would be discussed with respect to various market structures. Basic ideas of auction models would also be discussed and reference would be made to e-auctions and spectrum (or natural resource) auction markets. Latest developments in social and economic networks would be introduced and behavioural underpinnings would be discussed.

HUL814 Research Methods in Economics
2 Credits (1-0-2)
Pre-requisites: For M.Tech.: Any two of the following HUL712, HUL713, HUL714, HUL715, HUL716, HUL717, HUL718, HUL719, HUL720. For UG: Any two of the following: HUL311, HUL312, HUL314, HUL316, HUL318, HUL320, HUL712, HUL713, HUL714, HUL715, HUL716, HUL717, HUL718, HUL719

The course will cover theory and practice of doing applied research in economics, with special emphasis on primary and secondary data uses. The course will familiarize students with sampling techniques, questionnaire design, implementation of field-based studies, including randomized controlled trials. Students will be provided training in STATA for carrying out data analysis, including use of data sets such as the National Sample Survey, National Family Health Survey, Indian Human Development Survey. Students will be expected to design and implement a small study during the course of the semester and will be evaluated on this.

HUL820 Advanced Topics in Economics
3 Credits (3-0-0)
Pre-requisites: For UG students any ONE of: HUL211, HUL212, HUL213, HUL215, HUL311, HUL312, HUL314, HUL315, HUL318, HUL320

This course will introduce students to advanced topics in Economics as decided by the instructor.

HUL821 Performance/ Theatre: Theory and Practice
3 Credits (3-0-0)

The course would introduce students to the theories of performance and a selection of theatrical practices. Reading theatrical perspectives on the study of performances, alongside studying the development of theatre practices and the insights offered by various theatre practitioners would prepare the student for studying the performative.

HUL823 Contemporary Critical Theory
3 Credits (2-1-0)

Recent developments in linguistics, philosophy and the social sciences; interdisciplinary cross-talk in these areas, concerning the status of canonical literary as well as marginal texts; feminist, post-modernist, post-colonial, subaltern, orientalist, new historicist, liberal Marxist and critical practice. The aim of the course is to familiarise students with some of the vocabulary of theoretical inquiry today, so that they are enabled in their own research to question the verities which their disciplines seem to offer.

HUL831 Authorship and Copyright
3 Credits (3-0-0)

Pre-requisites: No prerequisite for Ph.D. For UG any ONE of the following: HUL331, HUL332, HUL333, HUL334, HUL335, HUL336, HUL338, HUL340, HUL351, HUL352, HUL353, HUL354, HUL355, HUL356, HUL357, HUL358, HUL359, HUL360, HUL375

The course would study the history of the print while keeping in perspective the changes in transmission of knowledge brought about by changes in technologies of representation – oral, manuscript, print. The coming of print is accompanied by the regulation of knowledge circulation by systems of profit. This amalgamation leads to the emergence of the idea of copyright which is further strengthened by the conceptualization of the author as a genius. The course will study the prospects of the concepts of the author and copyright in the digital age.

HUL832 South Asian Writing
3 Credits (3-0-0)

The course will include discussions on the place of the English language and “imported” literary forms in South Asia, the fragmented and divided terrain of the South Asian nation, the figure of the expatriate writer, and the context within which to understand the stylistic and narrative aspects of this writing. It will undertake detailed analyses of the works of 3-4 writers, out of a longer list comprising Anita Desai, G V Desani, Salman Rushdie, Amitav Ghosh, Vikram Seth, Kiran Nagarark, Aravind Adiga, Jeet Thayil, Mohammed Hanif, Mohsin Hamid, Shyam Sevadurai, Romesh Gunesekhera, and others.

HUL833 The English Renaissance: Selfhood and Survival
3 Credits (3-0-0)

The idea of the Renaissance, the historical, political and social context
The idea of the self and how it was conceived of during this period as different from previous notions
The importance of the stage and theatre in Elizabethan England
Shakespeare, Marlow and other dramatists
Milton, John Donne and other poets.

HUL834 Literature and the City
3 Credits (3-0-0)

The course examines in some detail the nature of the challenge that traditionally preoccupied European writers - how to map the experience of the modern city, and what representational strategies were adequate for capturing the opacity, the fragmentation, and the transitory nature of urban modernity. It goes on to investigate the contemporary postcolonial city in order to understand it in relation to late capitalism, globalization, migration, and postmodern culture, and the challenges these pose to classic modernity. It begins by providing an introduction to some of the most important literature on the city and the major theoretical debates around it, offering students a set of conceptual tools with which to approach the city’s incommensurable realities, its problems and its potential. It moves on to a detailed analysis of a number of literary texts, examining some of the ways in which the disjunctive realities of city-life shape new modes of experience, creative expression, and solidarity, without losing sight of the inequities of gender, culture, class, and race that persist and indeed strengthen in the current global economic system.

HUL835 Modern Indian Theatre
3 Credits (3-0-0)

- History of modern Indian theatre through its relationship with colonial
to post-colonial and nationalist concerns. • Understanding the concept of modernity and its contested and changing forms in urban Indian theatre. • Examining the trajectory of modern Indian theatre from the formation of institutions such as the National School of Drama as well as movements such as IPTA. • The negotiation of modern theatre with its colonial and pre-colonial past – the Theatre of Roots. • The impact and influence of the Parsi Theatre and the Marathi Sangeet Natakas. • Development and concerns of original English theatre in India. • Studies of individual plays and playwrights within the aesthetic and political context of their productions.

HUL836 Performance/Theatre: Theory/Practice
3 Credits (3-0-0)
Pre-requisites: No Pre-requisite for Ph.D. for UG any one of the following: HUL333, HUL335
The course will look upon performance practices both within and beyond the theatre viz, the spectacular, the digital media, sports etc. It will take the students through a variety of performance practices and across the world. The history of the development of performance forms and conditions of performance would be studied. Special focus would be on the theorisation of theatre and performance both by theatre practitioners and those emanating from the area of Performance Studies. The role of performance in maintaining and countering relations of power would be explored. Students would be required to observe, study and analyse live performances as part of the course.

HUL840 Advanced Topics in Literature
3 Credits (3-0-0)
This course will introduce students to advanced topics in Literature as decided by the instructor.

HUL841 Minimalist Architecture of Grammar
3 Credits (3-0-0)
Pre-requisites: HUL 742: Transformational Theories of Language Or prior permission of the course co-ordinator
his is an advanced course in theoretical syntax and will benefit students interested in learning more about recent generative syntactic theories. There are two main objectives of the course: a) to provide the rationale for the ‘Strong Minimalist Thesis: language as an optimal system’, and, b) to learn to generate syntactic structures using fewer transformations/ operations and features and, with stronger economy considerations. On finishing the course, students will be familiar with both theoretical (substantive) aspects of the minimalist architecture of grammar, as well the technical (methodological) know-how of the system.

HUL842 Prosodic Morphology
3 Credits (2-0-2)
Pre-requisites: HUL 234, HUL242 and HUL 350 for UG
This course explores the connection between sounds and words. While the correlation between the meaning and sounds of a word are arbitrary, the string of sounds or phonological shape of words and other morphological units follow certain universal well-formedness principles. While many of these principles derive from the manner in which individual languages form rhythmic/ prosodic domains in speech, some make crucial reference to morphological notions such as homonymy and synonymy. The aim of the course is to impart certain theoretical tools to analyze words from any natural language data. Since the objective of the course is to learn to analyze natural language data, it involves a substantial practical component.

HUL843 Reading and Sentence Processing
3 Credits (2-1-0)
The course content will cover state-of-the-art models of reading. The course will situate itself in the larger domain of sentence processing and address the important question of how reading and sentence processing are related. Distributed (SWIFT) as well as undistributed (EZ Reader) attention models will be discussed. Influence of low-level factors (eg. Word length, word frequency, etc) and contribution of high-level sentential factors on reading patterns will be introduced. Work on Indian languages will be discussed. Finally, models that integrate sentence processing and reading will be taken up.

[Note: Once an eyetracker is available, hands on sessions will be conducted to run simple reading experiments. See tutorial section for more details.]

HUL845 Environmental Ethics
3 Credits (3-0-0)
Objectives: To acquaint the student with (a) philosophical concepts underlying thinking about the environmental crisis and (b) the models of human-nature relationship found in some of the classical philosophical systems of India.
Contents: (a) What is ‘environment’? (b) Conceptual basis for the split between ‘nature’ and ‘culture’ (c) Philosophical theories about the environment: Utilitarianism: Deep Ecology: Ecowomanism. (d) Non-humans as recipients of moral consideration (e) Environment and Gender (f) Environment and Development (g) The Third World perspective (h) Revisioning Ethics, Metaphysics and Epistemology in the light of the above debates.

HUL846 Philosophy and Film
3 Credits (3-0-0)
Film Theories: Classical theories: Eisenstein, Arndt, Bazin, Pudovkin, Contemporary theories: Semiotics, Psychoanalysis, Marxism, Post-structuralism, Feminism, Auteur theory. Aesthetics of Film: Cinema as art, entertainment and technology, Cinema’s relationship with literature and other arts, Cinema and Digital Art, Aesthetics of interactive cinema, Aesthetics of special effects.

HUL850 Advanced Topics in Linguistics
3 Credits (3-0-0)
This course will introduce students to advanced topics in Linguistics as decided by the instructor.

HUL851 Philosophy of Literature
3 Credits (3-0-0)
The course examines the philosophical bases and problems that define key literary and literary-theoretical concepts, such as text, context, paratext, literary history, narration, meaning, interpretation, voice, style, literary specificity. Through the study texts of philosophy (both Anglo-American and European), literature and literary theory, which have influenced or responded to each other, the following topics and questions will be addressed: The ontological status of the text-context discontinuity; Through what concept of difference do we think the specificity of the literary? The epistemology of literature; Fictionality, Possible Worlds; Through what concept of existence do we distinguish literature from other phenomena, such as, hypotheses, lies, counterfactuals, dreams? Literature and/as Moral Philosophy; Is there literature relate to non-literary, scientific, and everyday discourses? Life as Narrative and theories of narrative self; The relation between literature, aesthetic and reason; and emotional response to Fiction.

HUL852 Political Philosophy
3 Credits (3-0-0)
This course will introduce students to key concepts and theories in political philosophy, such as justice, democracy, citizenship, secularism, sovereignty, equality, rights, and freedom. The approach will sometimes be historical, involving an intense engagement with the work of a particular thinker or philosophical tradition; at other times is will be thematic, taking up a particular notion such as secularism and addressing it from many different points of view. The emphasis will be on a close and rigorous reading of these texts, while also addressing questions about their contemporary relevance. The lecture outline is for ONE possible course on key texts in the Western liberal tradition.

HUL853 Art and Aesthetics
3 Credits (3-0-0)
• Aesthetic Attitude and Aesthetic Experience • The Ontology of Art: on what kind of a thing is a work of art • Theories of Art: Resemblance, Representation, Expression and Form • Aesthetic Judgement:
Perception and Imagination; The Sublime and the Beautiful • Emotional Response to Fiction • Criticism and Interpretation: on whether critical-interpretative cannons are fixed or open-ended • Art, Tradition and Modernity • Art, Morality and Politics: Art as Ideology • Metaphor, Narrative and Fictionality • Philosophy and Literature: on Literature as Cognitive Thought-Experiment about Human Possibility

HUL854 Problems in Metaphysics
3 Credits (3-0-0)
Ontological issues concerning God or Necessary Being, Mind, Self and Personal Identity, Universals and Particulars, Primary and Secondary Qualities, and Fictional Objects. Understanding the place of Mind in the Natural World, the distinction between Being-in-Itself and Being-for-Itself, Agency and Freedom, Subjective and Objective, Consciousness and Self-Consciousness, and the notion of Inter-subjectivity. Special study on the conceptualization of reality in terms of Phenomena and Noumena will form an important part of the course.

HUL856 Philosophy of Language
3 Credits (3-0-0)
The course is a study of four major topics: Reference and Descriptions; Truth and Meaning; Pragmatics and Speech Acts; Language and Metaphor. The course covers analyses of the following specific concepts: Sense, Reference, Descriptions, Proper Names, Natural Kind Terms, Truth, Intentional semantics, Communicative Utterances; Figurative Speech.

HUL857 Epistemology
3 Credits (3-0-0)

HUL860 Advanced Topics in Philosophy
3 Credits (3-0-0)
This course will introduce students to advanced topics in Philosophy as decided by the instructor.

HUL861 Psychology of Decision Making
3 Credits (3-0-0)
The course will cover topics on psychological constructs affecting decision-making (e.g., IQ, memory, motivation, emotion), decision-making processes (e.g., information search, risk perception), decision-making contexts (e.g., constraints, culture), and applications of behavioral decision making related to consumption (e.g., environment, technology, consumer decision making).

HUL862 Special Module in Cognitive Psychology
3 Credits (2-0-2)
The course will cover brief history of cognitive psychology, approaches, theoretical frameworks, and current issues in cognitive psychology.

HUL863 Emotion and Cognition
3 Credits (3-0-0)
The course will cover the following topics: theoretical approaches to emotion (evolutionary, biological, social, cognitive), select emotions and emotion expression (e.g., anger, fear, sadness, joy, surprise, disgust), and implications of emotion and cognition (e.g., stress, health, sex-differences)

HUL870 Advanced Topics in Psychology
3 Credits (3-0-0)
This course will introduce students to advanced topics in Policy Studies as decided by the instructor.

HUL871 Ethnographic Perspectives on the State
3 Credits (3-0-0)
Traditionally studied by political scientists, the state has increasingly come to be regarded as an object of anthropological study. Ethnographic perspectives on the state seek to open up the state to critical scrutiny, dislodging it as a monolithic conceptual or territorial apparatus. These studies allow us to think of the state beyond governmentality or bureaucracy, to engaging with the multiple ways in which state 'effects' shape our engagement with it. How does the 'idea' of the state constrain the way in which we 'think' the state? What are the ethnographic sites through which the state emerges as an object of study, e.g., bureaucracy, law, sexuality, marriage, citizenship, borders etc? The course will consist of seminars designed around a set of readings, which will be discussed in detail each week.

HUL872 Sexuality, Governmentality, and the State
3 Credits (3-0-0)
Sexual governance or state surveillance of issues pertaining to sexuality, marriage and mobility highlight the problematic division between the 'public' and the 'private'. The 'intimate' sphere is no longer one that is outside the purview of states; indeed the 'private' or the 'intimate' is often co-produced as a corollary of the public face of a state's legitimacy. Nationalism and patriotism are heavily grounded in issues pertaining to culture and sexuality, often thought of as 'private'. This course will provide a historical and sociological perspective to how sexual governance – the control of women's sexuality, conjugality and the definition of 'marriage' and the 'family' by a patriarchal state shows that the state has always concerned itself with the intimate lives of its citizens.

HUL873 Language, Culture and Society
3 Credits (3-0-0)
What is language? How does it relate to the 'collective consciousness' of a society? How does language relate to ideology and when does language become 'linguistic capital'? This course introduces students to some theoretical approaches to the study of language in social anthropology, such as structuralism and Marxism. This will be followed by studies of language movements, language policy in colonial and postcolonial India. The course concludes with questions of 'free speech', 'hate speech' and some debates on censorship.

HUL874 Civil Society and Democracy in India
3 Credits (3-0-0)
This is a post-graduate level seminar based course. The objective of this course is to discuss the complex and contingent relationships between state, market and civil society in India and examine the implications of their relationships for the broader processes of development, democratization, citizenship rights and governance in India. The course begins with an overview of the classical and modern theories of the state and civil society. Students read Hobbes, Locke, Hegel, Marx, Gramsci, Toqueville and other political theorists. The course will then focus on the role that civil society has played in Indian development and democracy. The course will discuss topics such as civil society and political society, NGO-ization, non-party political processes, social capital and ethnic conflict, economic roots of civil society and participatory development and democratization.

HUL875 Ethnic Identity, Development and Democratization in North-east India
3 Credits (3-0-0)
Making of Northeast India (NEI) – past and present; Regional identity and Nationalism; Look East policy and Vision 2020; Identity politics, ethnic affirmation, territorial sovereignty and ethnic violence; underdevelopment and development challenges; social movements; ethnic movements for political autonomy and secessionism; responses of Indian state and AFSPA; gender, tribalism, race, and religion; civil society in NEI; human development report.

HUL877 Industry and Society
3 Credits (3-0-0)
The course material will include the following topics: evolution of
industrial society, industry and industrialization, class and work in modern industrial societies, alienation and bourgeoisie, labour management relations and labour reforms, family in industrial society, formal and informal sector, technology and new economy, industry, industrial resources and new social movement, post-industrial society.

HUL878 Globalization
3 Credits (3-0-0)
Globalization and Globalism; Economic Globalization and Neo-Liberalism; Political Globalization; Social and Cultural Globalization; Civil Society and International Politics; Anti-Globalization.

HUL879 Political Ecology as a Development Critique
3 Credits (3-0-0)
Questions of conflict over natural resources, the conservation of biodiversity under market environmentalism, the political ecology of farming and industry, the emergence of environmental movements, the political ecology of indigenous people, feminist political ecology, urban ecology, environmental justice, and degrowth comprise core concerns of this course. The influence of globalization and neo-liberalism provides a rich context to understand these contestations and conflict over resource distribution. These propel the debates on ecological utopias. Case Studies include (any two per semester): forestry; industry and mining; body and health; climate change; water; political ecology of tribal areas of India.

HUL880 Advanced Topics in Sociology
3 Credits (3-0-0)
This course will introduce students to advanced topics in Sociology as decided by the instructor.

HUL881 Narratology: Foundations, Domains, Frontiers
3 Credits (3-0-0)
The course will familiarise students with the beginnings of this field of study in Russian formalism, structural linguistics and anthropology, and then its entry into literary studies, discourse and stylistics. The course will trace the development of narratological concepts (e.g. fabula/sujet, narrative voice, focalisation, paratext metalepsis, unreliability, free indirect speech, orientation, evaluation, coda etc.) within schools of thought since the 1970s on. It will visit the debates on narrativity and gender, race, history, ideology, culture and cognition. The spread of narrative theory beyond literary works to other areas such as comic books and video games, as well as its relevance to other disciplinary inquires in sociology, legal studies, political theory, postcolonial theory and psychology will be discussed. The course will consider the philosophical questions of narrative and temporality, anti-narrative, subjectivity, language, action, personhood, framing, closure and evolutionary theory.

HUL882 CyberPower and Cyber-Protest
3 Credits (3-0-0)
Network Society and the Internet, Cyberspace and the Virtual Individual; ICT Outreach, Social Inclusion, and Digital Divide in Developing countries; Digital Democracy and the Online Public Sphere; Cyberpower, and Cyberpolitics; Smart mobs; Cyberprotest; Case Studies

HUL883 History and Revolution
3 Credits (3-0-0)
The course will study major concepts of historicality and revolution in order to examine the role played by revolution in bringing or blocking historical change, in breaking with certain social and intellectual patterns. It will respond to questions about the nature of the pre-revolutionary moment emergent within existing historical situations and yet departing from them; the designation of selective historical moments as revolutionary; the variety of domains beyond the narrowly defined domain of politics that have seen revolution, for instance, in science, technology, social relations, and philosophy. With respect to political revolutions, how is a revolution in history analysed, and what happens to sovereignty? What is the role of violence in revolution as compared to other categories of history (period, epoch), and how does it affect language itself, both of literary representations of revolution and of historiography?

HUL884 Environmental Ethics
3 Credits (3-0-0)
Pre-requisites: HUL275
The course introduces different understandings about categories of ‘environment’ and ‘environmentalism’ that have emerged in contemporary thought, and its implications to its study in an ethics framework. It seeks to explore three tropes. First, is a foray into the nature-culture debate, a debate central to environmental ethics. It seeks to lay the basis for the field by tracing key texts in the debate, viz., how the category of ‘nature’ is understood to be something which is external to humans. Second, we seek to understand the ways in which the ‘crisis’ in environment is constructed, a crisis which then would require certain ethical approaches to amelioration of our relationship with our surroundings. Third, is an exploration of specific themes in the field of contemporary environmental ethics - critical environmental aesthetics, applied ethics in agriculture, and explore ethical frameworks from non Western realms like in the Indic context, and Buddhist environmental ethics. This course looks at the imperatives and politics that shaped the literatures and discourses that shaped environmental ethics as a distinct discipline.

HUL885 Criticism, Crisis and Critique
3 Credits (3-0-0)
In this course we will inquire into some or all of the following questions pertaining to the relation between criticism, crisis, critique and critical theory: a) the development of criticism as a part of the literary as well as philosophical inquiries into morals and tastes from antiquity to the present; b) the manner in which the development of the idea of critique in the context of the crisis that accompanied 18th century "Enlightenment", the rise of the public sphere, and colonialism; c) the relation of criticism and critique to literature and to metaphysical inquiry; d) the concepts and concerns that inform theoretical and critical activity today, i.e., the critiques of gender, religion, race and caste; e) the relation of critical theory to critical practice, e.g., application, evaluation, description, self-reflexivity, and resistance, as observed in various schools of literary theory and criticism.

HUL886 American Fiction II
3 Credits (3-0-0)
This is a survey course covering American fiction of the post- World War-I period. Some of the major novelists of the period will be studied, including Hemingway, Scott Fitzgerald, Steinbeck, Richard Wright, Ralph Ellison, Saul Bellow, Bernard Malamud, John Barth, John Updike.

HUL888 Applied Linguistics
3 Credits (3-0-0)
Notions of applied linguistics; psycholinguistics; socio-linguistics; language learning; language teaching; contrastive analysis; error analysis; pedagogic grammars; applied lexicology; communicative teaching; discourse analysis; stylistic and literature.

HUL889 British Fiction – A Stylistics Approach
3 Credits (3-0-0)
Language in prose and poetry; stylistics; deviance; prominence, foregrounding; literary relevance; stylistic variants; language and the fictional world; the rhetoric of text; discourse situation; conversation, speech and thought.

HUL891 Globalization and Transnationalism
3 Credits (2-1-0)
HUL893 Literature and the City
The course examines in some detail the nature of the challenge that traditionally preoccupied European writers - how to map the experience of the modern city, and what representational strategies were adequate for capturing the opacity, the fragmentation, and the transitory nature of urban modernity. It goes on to investigate the contemporary postcolonial city in order to understand it in relation to late capitalism, globalization, migration, and postmodern culture, and the challenges these pose to classic modernity. It begins by providing an introduction to some of the most important literature on the city and the major theoretical debates around it, offering students a set of conceptual tools with which to approach the city's incommensurable realities, its problems and its potential. It moves on to a detailed analysis of a number of literary texts, examining some of the ways in which the disjunctive realities of city-life shape new modes of experience, creative expression, and solidarity, without losing sight of the inequities of gender, culture, class, and race that persist and indeed strengthen in the current global economic system.

HUP102 Research Participation
1 Credits (0-0-1)
This course will expose students to various experimental methodologies in sub-fields of Psychology and Psycho/Cognitive-linguistics. These will be behavioral experiments that will investigate theoretical questions (e.g., psychological questions related to perception, attention, emotion, choice behavior; psycho-linguistic questions related to sentence comprehension, sentence production, memory, attention, language-perception interaction). The course will illustrate ways in which theoretical/practical research query pertaining to human cognition is translated into a testable problem with the help of widely used behavioral methods.

HUV731 Critical Reading
1 Credits (1-0-0)
The course will introduce students to the tools of critical analysis of a variety of verbal texts – poetry, short stories, essays, non-fiction and academic writing. It will require students to study basic semiotics, and critical terms and study a variety of texts prescribed for the course.

HUV734 Dimensions of Language
1 Credits (1-0-0)
The course will provide a brief overview of the important contributions to the study of language, its origin, diversity, and its metaphysical, historical and political dimensions in order to attend to the multiple levels at which literature plays with and transforms language on the one hand, and is conditioned by on the other. A range of readings will be used to focus on: the relation between language use and a particular historical and social situation, and the work of literature in defining this relation; the politics of language with respect to state, religion, nation, gender and caste; subjectivity in language; metaphor and metonymy, literary stylistics and rhetoric; agrammaticality.

HUV735 Narrative Matters
1 Credits (1-0-0)
The course will acquaint students with the distinctions of formal and conversational, fictional and non-fictional narratives. Students will acquire the training to think about and conduct research on discourse by going beyond the story and plot and considering discourses in terms of salient narrative features such as narration, author, reception, motivation, tradition, and framing. The politics of culture, representation and the working of power can be better analysed with a mind to the role of narrative in action, communication and signification.

HUV747 Data-driven Analysis and Tools for Linguistic research
2 Credits (2-0-0)
Pre-requisites: HUL 242 for UG
The course will cover the following topics: (1) Quick introduction to Python (2) It will give a broad overview of how one can use natural language text for making linguistic generalization and discovering linguistics patterns, (3) We will also look at how the data can be used to make automatic tools such as taggers and parsers. In the process we will learn to use the following resources/tools: (a) NLTK (b) MaltParser (c) WordNet.

HUV748 Data Analysis for Psycholinguistics using R
2 Credits (2-0-0)
Pre-requisites: HUL 242 and HUL 381 for UG
The course will comprise of 4 broad themes. In the 1st part of the course we will introduce the basics of R. R syntax and its libraries will be extensively used for other parts of the course. In the 2nd part we will introduce basics of statistics that are needed for understanding ideas of frequentist-based hypothesis testing methods. We will then move on to linear regression which will form the background using which we introduce linear-mixed models in the final section of the course. The course will also provide assignments and projects where the students can practice the course content and apply the learnt concepts to real experimental data.

HUV773 Tools for Sociological Research
1.5 Credits (1.5-0-0)
In this course, the students will be introduced to mixed methods research (quantitative and qualitative). They will be familiarized with specific modes of observation such as surveys, focus group discussions, interviews, and participatory rural appraisal, followed by designing specific tools of data collection such as questionnaires and interview protocols for different modes of observation. Special emphasis will be given to household surveys and data from large surveys such as census, NFHS, NSS, migration and urban surveys. This will be followed by elementary data analysis techniques and inferential statistics, converting qualitative data into quantitative data and the use of qualitative data analysis software.

HUV774 Methods in Historical Sociology
1.5 Credits (1.5-0-0)
As sociologists increasingly turn to the past for an understanding of the present, the discipline has incorporated methods from historical research. These include debates on what constitutes an archive, the production of the past as an exercise of power, and how to read historical sources in an ethnographic vein. The significance of the ‘fragment’ or documentary evidence for ethnographic research will be considered. This module will introduce students to some of these larger methodological and theoretical debates from history and sociology.

HUV781 Introduction to Research Methods
1.5 Credits (1.5-0-0)
This course will begin with introducing students to different paradigms of inquiry and research with implications for methodology. It will then provide an overview of how to formulate research questions and hypotheses, identify unit of analysis, conceptualize and operationalize variables of interest. The students will be familiarized with random and non-random methods of sampling. The discourse on research ethics will be an integral part of most discussions in this course.

HUV886 Special Module in Cognitive Psychology
2 Credits (1-0-2)
The course will focus on current relevant and emerging issues, and experiments in the field of cognitive psychology.

HUV887 Special Module on Econometric Tools
1 Credits (1-0-0)
Pre-requisites: HUL or SML 700/800 category courses
Estimation and inference in two variable model; OLS assumption; Extension of the two variable model; OLS assumption : autocorrelation, multicollinearity, and heteroskedasticity, models with limited dependent variables : LPM, logit, and probit; Panel data modelling : fixed effect and random effect models; Time series analysis: introduction to non-stationarity, AR and MA modelling.
MSL301 Organization & People Management
3 Credits (3-0-0)
Lectures on multidisciplinary perspective on organizations, Organizational structure & Design, Organizational stakeholder Ethics, Organizational Culture, Organizational Environment, Strategy and Structure, Technology and organizational structures, Lifecycle of an organization will be supported with case studies & exercises.

MSL302 Managerial Accounting & Financial Management
3 Credits (3-0-0)
On completion of this course the student will be able to: Understand accounting for managerial decisions. Assess financial health of a corporate firm. Design profit planning. Understand cost concepts and financial decision making.

MSL303 Marketing Management
3 Credits (3-0-0)
Marketing concept, Environment of Marketing, Marketing Strategy, Marketing Plan, Marketing Concept, Product life cycle, Pricing, Advertising and Promotion Strategies, Concept of Unique selling proposition, Product and Brand Management, Marketing Research Methodologies, Case study discussions.

MSL304 Managing Operations
3 Credits (3-0-0)
The objective of the course is to provide the students about the application of Industrial management in various functional areas of business especially industrial operations such as linear programming, assignment and transportation problem, layout/location design, quality, materials management, Preventive maintenance, project management, supply chain management, scheduling/sequencing, ergonomics, operations strategy. The entire course is a case based where the participants will be given a case. Participants will be asked to tackle the case problem without using linear programming techniques.

MSL700 Fundamentals of Management of Technology
3 Credits (3-0-0)


MSL701 Strategic Technology Management
3 Credits (3-0-0)
Module I: Emerging technology-strategy relationship in the large corporation from the perspective of individual firm, and entire industry. Global technology comparison, technological change, sources of technology, Technology Information. Criticality of technology for growth, core competencies, R&D productivity, Resource Leverage. World Class Organisation.

Module II: Corporate technology strategy, Generic competitive technology strategies. Corporate R&D, Strategic technology management process, relationship between technology strategy and corporate strategy, Strategic shifts and resource commitments, technology vision and goals, technology leadership. SWOT analysis for technology, Matching Business Portfolio and Technology Portfolio, Technology- Market matrix. Innovation and entry strategy, Flexibility in Technology strategy.


MSL702 Management of Innovation and R&D
3 Credits (3-0-0)
Module I: Technological innovation systems and processes. Understanding the process of technological innovation and the factors affecting successful innovation. Management problems from the product/service concept-stage to end-product/service marketing. Creativity and Innovation- Creativity process, Individual and group creativity, Critical functions in the innovation process, Evolving innovative culture, teams for innovation.


Module III: Issues relating to managing scientists and technologists as individual, in teams, and in large organisations. Human Resource Management in R&D and Innovation, training, motivation, communication, group dynamics. Information management for innovation and R&D- strategies, sources, channels, and flows. Standardisation and Quality management.

MSL703 Management of Technology Transfer and Absorption
3 Credits (3-0-0)
Module I: Transfer of technology from R&D to field and at international level. Commercialization of new technology and new venture management, prototyping, test marketing, pilot plant, project viability, Technology push and market full. Quality management, customer education and awareness. Assessment, justification and financing of new technology, source of funds, venture capital financing. New venture products and services.

Module II: Global transfer of technology, Technology transfer models: Active, passive. Multi channel approach: from hardware technical services acquisitions to strategic partnering and networking arrangements. Sourcing technology, technology negotiation, licensing agreement. Fee for technology transfer, royalty, equity participation. Modes: technological collaboration, joint venture, alliance, acquisition. International S&T cooperation: institutional framework, multilateral/ bilateral cooperation, pre-emptive R&D cooperation.


MSL704 Science & Technology Policy Systems
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
Module I: Role of S&T in economic development, Modern analysis of growth and structural change, international economic relations, liberalisation, globalisation/ regionalisation, industrial/technological partnerships, S&T in Indian Economic Policy. Government policy and its impacts on technology development. Living with the new technology, social issues. International trends, Technology policy in USA, Japan, European Commission, and other select countries.


**MSL705 HRM Systems**

1.5 Credits (1.5-0-0)

This course focuses on various functions of human resource management. The course begins with the context and evolution of HR, followed by functions of HR via cases and various exercises. Manpower planning, job description, recruitment & selection, training & development, performance appraisal & management, compensation & reward management and career management, legal issues in HRM are the topics covered.

**MSL706 Business Laws**

3 Credits (3-0-0)


Module III: Negotiable Instrument act. Definition and characteristic of Negotiable instrument. Liabilities of Parties to Negotiable Instruments. Brief exposure to Company law including incorporation of a company - objects, registration, article of association, raising capital from public, company management and reconstruction, amalgamation and winding up.

**MSL707 Management Accounting**

3 Credits (3-0-0)

On completion of this course the student will be able to: Understand accounting principles governing preparation of financial statements. Assess financial health of a corporate firm. Design profit planning. Understand cost control systems. Understand techniques of pricing, product and capital budgeting decisions.

**MSL708 Financial Management**

3 Credits (3-0-0)

The course is comprehensive and is designed to equip the students with tools and techniques to enable them to make sound financial decisions, among others, related to capital budgeting, working capital, capital structure and dividend policy.

**MSL709 Business Research Methods**

1.5 Credits (1.5-0-0)

Pre-requisites: MSL301 & MSL302

Introduction to Business Research Methods; Theoretical approaches; Problem definition; Research Design; Questionnaires & Scales; Sampling - Probability, size and challenges; Survey & Observation, Experiments; Qualitative Research, Secondary Data; Data Preparation & Analysis, Report Writing.

**MSL710 Creative Problem Solving**

3 Credits (3-0-0)

Pre-requisites: MSL301 & MSL302


**MSL711 Strategic Management**

3 Credits (3-0-0)

Pre-requisites: MSL301 & MSL302

Understanding new perspectives on strategic management, Content and process of strategic management, Formulation and implementation of strategies, Developing cross-functional trade-off decision making skills, and Help appreciate new themes in strategic management. This course will require reading books, articles, case studies and literature from the field of Strategic Management. The sessions would be interactive where attempts will be made to understand the theories and concepts through discussion of the readings and their application in cases. Student will be required to prepare and effectively participate in class and make impromptu or scheduled presentations of issues and learnings. Besides the readings, groups of students will have to work on a comprehensive research project to investigate and validate some of the key learnings.

**MSL712 Ethics & Values Based Leadership**

1.5 Credits (1.5-0-0)

Pre-requisites: MSL301 & MSL302


**MSL713 Information Systems Management**

3 Credits (3-0-0)

Pre-requisites: MSL301 & MSL302

This course may expose the participants to the following topics: Information Systems and its impact in Organization and People, Information Technologies: concepts, types and usage, Information Systems, Organizations and Strategy, Economics of Information Systems, Foundations of E-Business, Foundations of Data management, Foundations of Business Analytics, Networks and Collaboration as Business Solutions, Information Security & Risk Management, Building and Managing Systems, Enterprise Systems, etc. Hands on training would also be provided, using specific tools.

**MSL714 Organizational Dynamics and Environment**

3 Credits (3-0-0)

Pre-requisites: MSL301 & MSL302


Module II: Constituent systems for organizational functioning - planning, learning, organising, communication and control systems.
Organizational systems and mechanisms related to technology. Systems for managing strategy, and structure related to new technology.

Module III: Systems for managing continuous and radical change for organizational renewal and transformation. Adaptiveness and flexibility in organizational systems. Systems for managing collective action within the organization. Feminism and organizational systems for managing gender diversity.

MSL715 Quality and Environment Management Systems
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302


MSL716 Fundamentals of Management Systems
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302


MSL717 Business Systems Analysis & Design
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
This course will have the following topics: System Analysis Fundamentals: Introducing SAD& for Systems Professionals, Analyzing the Business Case and Managing Systems Projects, Overview to Data Structure in Systems Modeling, Data Flow Diagrams and Modelling DFDs, Requirements Modelling and Systems Specification, User Driven Business Analysis, Role of the consultant, Object Oriented Modelling: Object Relationships, Hierarchies, Use Case Approaches to identify and model classes, Process Driven Approaches: Gane, Sarson and Young, Data Driven Approaches: Entity Relationship Diagrams, Designing the User Interface and Output, Verification & Validation of new systems.

MSL719 Statistics for Management
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302

MSL720 Macroeconomic Environment of Business
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302

MSL721 Econometrics
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
Introduction to Econometrics, Simple linear regression model. Multiple linear regression model, Discrete Choice, Panel Data, Time Series, Stationarity, VAR, Co-integration and Error correction models.

MSL723 Telecommunications Systems Management
3 Credits (3-0-0)
Module I: Telecom Technology Systems Evolution: Recent Developments in Telecom Industry, Regulation & Liberalization policy, Techno-managerial aspects of telecommunication, role of the telecommunication managers in a dynamic environment. The business of telecommunication; telecommunication as a facilitating infrastructure for economic development of the country, technical survey of the ways and means that voice, data and video traffic are moved long distances, data network, the telephone system.

Module II: Issues of the monopolization and deregulation of telecom, national telecom policy, various institutions/organizations like telecom regulatory authority etc; conveyance. Telecom service costing, economic evaluation of telecom projects, telecom project financing.

Module III: Telecom marketing, building brand equity for competitive advantage, Customer care, total service quality management, preparing for the new millennium managing change and people development.

MSL724 Business Communication
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302
On completion of this course, students would be able to: Evaluate the key purposes of communication in business. Explain the communication process model and the barriers to effective communication. Understand & evaluate the changing landscape of business communication. Apply techniques for effective communication.

MSL725 Business Negotiations
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302
Students who complete this course would be able to: (a) Understand the nature, process and structure of negotiations. (b) Understand different types of negotiations and the dynamics of cooperative and competitive interaction in negotiations. (d) Appreciate and leverage their bargaining position in a situation. (e) Learn and apply influence and persuasion techniques. (f) Learn ways to build lasting working relationships. (g) Understand and appreciate ethical negotiations.
MSL726 Telecom Systems Analysis, Planning and Design
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
Module I: An introduction to the basic system analysis tools, the procedures for conducting system analysis advanced software principles, techniques and processes for designing and implementing complex telecommunication systems.
Module II: Planning and implementation of telecommunications systems from strategic planning through requirements, the initial analysis, the general feasibility study, structured analysis, detailed analysis, logical design, and implementation.
Module III: Current system documentation through use of classical and structural tools and techniques for describing flows, data flows, data structures, file designs, input and output designs, and program specifications. The student would gain practical experience through a project as part of a term paper.

MSL727 Interpersonal Behavior & Team Dynamics
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302
On completion of this course, students would be able to: Understand the nature, structure and formation of teams. Appreciate the competitive and collaborative dynamics between teams and sub-teams. Understand and apply techniques for building and sustaining high performing teams. Reflect on their roles within teams and its impact on other members.

MSL728 International Telecommunication Management
3 Credits (3-0-0)
Module I: Historical development and evolution of telecom, managerial issues and structure of industry; evolution and role of international institutions; global trends in liberalization and de-regulations, Patterns of Transaction in international telecom management; managing the market growth; developing, operating and monitoring regulation issues.
Module II: Role of telecommunication in socio-economic development; ICT & Social change, new technologies and services for international telecommunications; data services and business applications, Telecom prospectus of WTO & other international bodies.
Module III: Current issues and organisational growth; telecom implications for the industry, value added services and market drives; regional prospective on development of telecom; Human Resources Planning and Industrial relations in ITSM; skill formation for ITSM and learning renewal, future directions of growth.

MSL729 Individual Behavior in Organization
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302
This course will focus on understanding the nature, composition and relevance of organizational behaviour. Students will be introduced to the fundamental concepts and theories underpinning organizational behaviour. For every concept/theory introduced, its application for organizations would be discussed.

MSL730 Managing With Power
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302
This course covers power dynamics, the basic art of influencing, types of power, display of power at various levels and power vs empowerment and ethics. Various cases and readings are included for deeper understanding and application of the learnings.

MSL731 Developing Self Awareness
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302
Important areas of self awareness: Personal values, moral maturity, cognitive styles, attitude towards change, Locus of control, social needs of achievement, inclusion, control and affiliation.

MSL733 Organization Theory
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302
Different issues related to the organization would be discussed and then applied in real life situations, the emphasis will be on application of theory to real life situations. The course would be imparted through a combination of lectures, cases and simulation exercises.

MSL734 Management of Small & Medium Scale Industrial Enterprises
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
Module I: MSME Act 2006; Nature of entrepreneurial management, the new entrepreneur, his problems and prospects in the Indian environment. Practical aspects of setting up and running of industrial enterprises including formulation of projects and feasibility study for new projects.

MSL740 Quantitative Methods in Management
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
Module II: Non-Linear Programming, introduction to Quadratic Programming, Geometric Programming and Direct Search techniques. Multiple Criteria Decision making- Goal programming, TOPSIS and AHP.
Module III: Sequential decisions using Dynamic Programming. PERT and CPM. Queuing theory- M/M/1 and M/M/n model. Monte Carlo System Simulation concepts and applications. Brief introduction to Non-traditional optimization. Case Study applications and use of OR software packages.

MSL745 Operations Management
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
Module I: Managing operations; planning and design of production and operations systems. Service characteristics. Facilities planning- location, layout and movement of materials. Line balancing. Analytical tools and techniques for facilities planning and design.
Module II: Production forecasting. Aggregate planning and operations scheduling, Production Planning and Control. Purchasing, Materials Management and Inventory Control and JIT Material Requirements Planning. MRPII, ERP, Optimization techniques applications.

MSL760 Marketing Management
3 Credits (3-0-0)
Module II : Marketing Strategy- Marketing planning and Marketing programming. The concept of marketing mix, Product policy; the concept of product life cycle. New product decisions. Test marketing- Pricing, Management of distribution: channels of distribution. Advertising and promotions. The concept of Unique Selling Proposition. Module III : Implementation and Control. The marketing organization- alternative organization structures; the concept of product management. Administration of the marketing programme: sales forecasting; marketing and sales budgeting; sales management; management of sales force. Evaluation of marketing performance; sales analysis; control of marketing effort; marketing audit.

MSL780 Managerial Economics
1.5 Credits (1.5-0-0)
Pre–requisites: MSL301 & MSL302

MSL801 Technology Forecasting & Assessment
3 Credits (3-0-0)
Pre–requisites: MSL301 & MSL302
Module I : Forecasting as an input to technology planning, Futures Research, Elements of forecasting process. Types of forecasting methods. Quantitative methods of forecasting: time series models, growth curves, Precursor, Envelope curves, Experience curves, technical assessment.
Module II : Qualitative methods: Morphological analysis, Relevance trees, Delphi, Technological gap analysis, Analogy method, Organising for Technology Forecasting.

MSV803 Selected Topics in Information Technology Management
1 Credit (1-0-0)
Cutting edge will be covered.

MSL804 Procurement Management
3 Credits (3-0-0)
Pre–requisites: MSL301 & MSL302
This course will introduce students to purchasing and materials management by learning the planning production process, master scheduling, material requirements, and forecasting material demands and inventory levels. This course is designed to build on the student’s knowledge of how effective material management improves supply chain performance.

MSV804 Selected Topics in Operations Management
1 Credit (1-0-0)
Cutting edge will be covered.


MSV805 Services Operations Management
3 Credits (3-0-0)
Pre–requisites: MSL301 & MSL302
This case course explores the dimensions of successful service firms. It prepares students for enlightened management and suggests creative entrepreneurial opportunities. The main idea behind the course is: To study “breakthrough” services in order to understand the operations of successful service firms that can be benchmarks for future management practice.
To develop an understanding of the “state of the art” of service management thinking.
To understand the dimensions of service growth both domestically and internationally.

MSL805 Services Operations Management
1 Credit (1-0-0)
Cutting edge will be covered.

MSL806 Mergers & Acquisitions
3 Credits (3-0-0)
Pre–requisites: MSL301 & MSL302

MSV806 Selected Topics in Marketing Management
1 Credit (1-0-0)
Cutting edge will be covered.


MSL807 Selected Topics in Strategic Management
1 Credit (1-0-0)
Pre–requisites: MSL301 & MSL302
Open Slot Course (To be decided when the course is floated).

MSL808 Systems Thinking
3 Credits (3-0-0)
Pre–requisites: MSL301 & MSL302
Module I: Systems thinking in management; Hard and soft systems thinking; open systems thinking; Analytical and systems approaches; System concepts, principles and metaphors; General systems theory and cybernetics.
Module II: Theory building with causal loop diagrams; Feedback loop structures; Linking feedback, stock and flow structures; Tutorial on Stella; Case Studies on system dynamics modelling

Module III: Soft systems methodology; Flexible systems thinking; Management of continuity and change; Interpretive systems model.

**MSL809 Cyber Security: Managing Risks**
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302

This course introduces students to the interdisciplinary field of cybersecurity by discussing the following: cybersecurity theory, and the relationship of cybersecurity to nations, businesses, society, and people, cybersecurity technologies, processes, and procedures, analyzing threats, vulnerabilities and risks present in these environments, and develop appropriate strategies to mitigate potential cybersecurity problems, advanced policy related topics would also be covered through which these risks may be mitigated. Other relevant advanced topics may be explored.

**MSL810 Advanced Data Mining for Business Decisions**
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302

This course will expose the participants to the following topics within this domain: Understanding advanced models of data mining, advanced unsupervised mining methods and approaches, Decision Support Systems, Group Decision Support Systems, Consensus based systems, Multi-criteria decision systems, Knowledge management systems, knowledge management methods, Intelligent systems, Hybrid data mining methods, Advanced and emergent topics and applications.

**MSL811 Management Control Systems**
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302


**MSL812 Flexible Systems Management**
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302


Module II: Validation, Simulation and testing of System Dynamics models, Policy analysis, Micro world and Management games, Managerial applications of Systems methodology.

Module III: Management of physical systems. Physical system theory: fundamental premises and postulates, modelling of basic processes, application to manufacturing, managerial, and socio-economic systems. Critical comparison and integration of Physical System Theory and System Dynamics. Flexibility in physical system theory.

**MSL814 Data Visualization**
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302

This course would have the following: It would train the participants to use visual imagery to present complex information and the trends associated with extensive data. Visualization provides a solution to address information overload, through a well-designed visual encoding to aid comprehension, memory, and decision making. Furthermore, visual representations may help engage more diverse audiences in the process of analytic thinking. Topics like data and image models, heat maps, infographics, multidimensional data visualization and representation, graphical perceptions, mapping & cartography and text visualization may be covered. Other relevant topics within the subject domain may also be explored.

**MSL815 Decision Support and Expert Systems**
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302


Module III: Integrating expert systems and DSSs. Strategies for implementing and maintaining management support systems. Case studies, and laboratory and filed projects.

**MSV815 Case Study Writing and Teaching**
1 Credit (1-0-0)

Various concepts of case study teaching and writing will be covered.

**MSL816 Total Quality Management**
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302

Module I: Introduction to TQM; Customer Orientation, Continuous Improvement, Quality, Productivity and Flexibility, Approaches and philosophies of TQM, Quality Awards, Strategic Quality Management, TQM and corporate culture, Total Quality Control; Basic Analytical tools-Check Sheets; Histograms; Pareto charts, Cause and Effect diagrams; Flow charts.

Module II: Statistical Process Control; Advanced Analytical tools-Statistical Design of Experiments; Taguchi Approach; Cost of Quality; Reliability and failure analysis. FMECA, Quality Function Deployment, Benchmarking, Concurrent Engineering.

Module III: Quality Teams, Employee practices in TQM organisations: Leadership, delegation; empowerment and motivation; role of communication in Total Quality, Quality Circles; Total Employee Involvement; Problem Solving in TQM- Brain storming; Nominal Group Technique Team process; Kaizen and Innovation; Measurement and audit for TQM; Quality Information Systems, ISO 9000 series of Quality Standards; TQM Implementation; Reengineering and TQM.
MSL817 Systems Waste & Sustainability
3 Credits (3-0-0)
Pre–requisites: MSL301 & MSL302

MSL818 Industrial Waste Management
3 Credits (3-0-0)
Pre–requisites: MSL301 & MSL302
Module III : Waste management in Indian industries-present practices, potentials and perspectives. Management of waste in different industrial systems- steel, aluminum, power, automobile, transport and other service industries. Economic analysis and system models of industrial waste management systems. Analytical and Creative techniques to waste control.

MSL819 Business Process Re-engineering
3 Credits (3-0-0)
Pre–requisites: MSL301 & MSL302
Module I : Nature, significance and rationale of Business Process Reengineering, Reengineering scenarios in major countries, Problems issues, scope and trends in BPR, Implementing BPR: Methodology and steps, IT enabled reengineering, mediation and collaboration.
Module II : The paradigm of Mass customization, managing organisational change, Transforming/ Reinventing the enterprise, Team building, Case studies of success as well as failure.
Module III : People view, empowering people, reengineering management. Issues of purpose, culture, process and performance, and people.

MSL820 Global Business Environment
3 Credits (3-0-0)
Pre–requisites: MSL301 & MSL302
Module III : Globalization of Indian Economy. Liberalization and globalization of Indian business. India's multinationals, Indian laws and policies relating to investment in India by international firms and outside India by Indian firms.

MSL821 Strategy Execution Excellence
3 Credits (3-0-0)
Pre–requisites: MSL301 & MSL302
Maximize your leadership potential by expanding your management skills through this one-year graduate certificate management program. This comprehensive program offers you the opportunity to broaden your perspective on salient management responsibilities and skills in key sectors such as healthcare, not-for-profit, community services, and technology and trades. Students must also participate in two weekend residency (virtual or on-campus) activities. This program enables you to leverage your existing career and educational experiences to move into management positions. You will take a series of carefully selected business courses that will build and enhance your skills in critical areas of management such as finance, marketing, human resources, and leadership. In addition, you will have the option to select courses from specific industry streams-health care, community services, not-for-profit, and trades/technology. These courses are designed to provide industry-specific perspectives that will enhance your employability and career advancement.

MSL822 International Business
3 Credits (3-0-0)
Pre–requisites: MSL301 & MSL302

MSL823 Strategic Change & Flexibility
3 Credits (3-0-0)
Pre–requisites: MSL301 & MSL302
Module II : Revising Strategies Postures. Corporate restructuring, Alliances, joint ventures, acquisitions and merges. Reorganising the firm, the impact of mergers and acquisitions on organizational performance. Management of continuity and change, Blue Ocean strategy.
MSL824 Policy Dynamics & Learning Organization
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
Module I: Learning Organization. Emergence of learning organization. Strategies for organization learning, using feedback, shared vision, team work, personal mastery, mental models, systems thinking, role of leader, organizational dynamics. Soft Systems Methodology application to policy formulation. Flexibility in policy strategy. Strategy formulation in a learning organization, clarifying vision and opportunities for change in a learning organization.

MSL825 Strategies in Functional Management
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302

MSL826 Business Ethics
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
Module II: Ethical Responsibilities. Ethical responsibilities of economic agents: role obligations, obligation to shareholder, rights and, obligations to customers, obligations to pay taxes. Environmental protection. Corporate accountability, Ethical conflicts, concern for the locality, Attitude to labour. Ethics and Government policies and laws.

MSL827 International Competitiveness
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
Module I: Introduction to Competitiveness. Background, Need, Basics, Myths; Global Perspectives, Context, Definitions, Benchmarking & Key Issues; Related concepts: Excellence, Value Creation; Competitiveness at Different Levels.
Module III: Practitioners Perspectives. Business Models for Competitiveness, Functional (e.g. HR, Operational, Financial, Technological) Linkages, Partnerships/Cooperation for Competitiveness, Emerging Issues/Practices.

MSL828 Global Strategic Management
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302

MSL829 Current and Emerging Issues in Strategic Management
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
(Relevant current and Emerging Issues)

MSL830 Organizational Structure and Processes
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
Module III: Interface of structure and processes- structural functionalism; Allport and Event- Structure theory. Organizational Governance- organizations as a subject of political enquiry, Models of organizational governance. Making and breaking patterns.

MSL831 Management of Change
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
Module II: Change and the use of power. Nature and sources of power. Leadership and change- Transactional vs. Transformational change. Change cycle including participative and coerced change.

MSL832 Managing Innovation for Organizational Effectiveness
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
Module II: Managing social equity and organisation efficiency paradox, blocks to creativity, methods to overcome the blocks. Introducing creativity
The course introduces students to the relational framework towards diversity management by discussing the macro, meso and micro factors influencing DM. Through analysis of the different organizational approaches and initiatives towards diversity management, it highlights ways in which inclusive workplaces can be created and diversity leveraged for business performance.

MSL835 Labor Legislation and Industrial Relations
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302

MSL836 International Human Resources Management
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302
The course would cover issues pertaining to selecting, managing and developing international workforce. It would sensitize students to the cross-cultural issues faced by global organizations and emerging issues within international HRM. Lectures, small group discussions and case study analysis would be the primary teaching methods adopted in this course.

MSL839 Current and Emerging Issues in Organizational Management
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
(Relevant current and Emerging Issues)
MSL844 Systems Reliability, Safety and Maintenance Management
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
Module II: Maintenance Planning and Control.
Module III: Information System for Reliability, Safety and Maintenance Management.
Organizational aspects and a computer aided management information system for reliability, safety and maintenance. Life cycle costing and cost management for maintenance. Human factors in maintenance, Maintenance Manpower Planning. Case Studies.

MSL845 Total Project Systems Management
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
Module I: Project Systems Management: a life cycle approach, project characteristics; project life cycle phases: conception, definition, planning and organising, implementation and project clean up. Project feasibility analysis. The project manager: role and responsibilities, Team Building and Conflict Management. Tools and techniques for project management. Environmental impact analysis of a project.
Module II: Network techniques for project management-PERT, CPM and GERT. Accountancy for risk, uncertainty and fuzziness. Time cost tradeoffs and crashing procedures. Multi project planning and scheduling with limited resources. Multi objective, fuzzy and stochastic based formulations in a project environment.

MSL846 Total Productivity Management
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
Module I: Total Productivity overview; meaning, relevance and scope for productivity and effectiveness. Productivity conceptualisation. Productivity mission, objectives, policies and strategies. Productivity environment. Corporate culture, management styles, employees participation, trade unions and role of governmental agencies. Productivity measurement, monitoring and management both at micro and macro levels. Corporate and annual productivity plans.
Module II: Benchmarking: Management issues, modelling, tools and techniques; indicators for evaluation of manufacturing, business or services organizational performance and its measurement.

MSL847 Advanced Methods for Management Research
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
Introduction to management research, types of management research, research designs, Portfolio of management research methodologies involving qualitative and quantitative tools, optimization approaches, Multi-criteria decision making tools, case studies, interpretative models, soft system methodology, simulation, etc. Design of a questionnaire-based survey instrument, development of data measurement, scale development, testing the validity and reliability of data, sampling techniques, descriptive statistical analysis, inferential analysis, sampling techniques, sampling distribution, hypothesis testing, ANOVA, factor analysis, correlation, regression : OLS, Logic, Tobit, Probit, Discriminant analysis, Co-integration, unit root testing, Granger, causality, VAR, GARCH and its variants. Structural equation modelling and other related research tools. Portfolio of optimization tools such as linear programming, goal programming, integer programming, Data Envelopment Analysis for designing a management research. Case study approach with SWOT, SAP-LAP, value chain, PEST, etc. AHP, ANP modeling of risk and uncertainty in management, real life case development with appropriate research design.

MSL848 Applied Operations Research
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
The objective of the course is to provide the students about the application of Operations Research (OR) in various functional areas of business such as operation, supply chain management, materials management, marketing, finance, and human resource. The entire course is a case based where the participants will be given a case. Participants will be asked to tackle the case problem without using OR using their own experience or any other logical method and then they will be asked to tackle the same situation applying OR. At the end of the course they will appreciate how OR can help the decision makers in an efficient decision making process.

MSL849 Current and Emerging Issues in Manufacturing Management
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
(Relevant current and Emerging Issues)

MSL850 Management of Information Technology
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
Module I: The Strategic Framework for IT Management. Emerging information technologies: IT for competitive advantage; IT for internal effectiveness; IT for inter- organizational linkage; Module II Strategy Development and Planning Techniques. Module II: IT Planning (CSFs, Scenario analysis, Linkage analysis, Enterprise modeling); Strategy formulation techniques; Nolan’s stage model and revised models for Nolan’s stages; IT investment decisions; methods for evaluating IT effectiveness; IT enabled business process redesign. Module III: Strategic Issues Related to IT Management. Relating IT to organizational leadership, culture, structure, policy and strategy; programmer productivity; Managing legacy systems; evaluating centralization- issues; IT-forecasting.

MSL851 Strategic Alliance
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302
This is an advanced strategy course that focuses on the role of strategic alliances and inter-firm networks in the overall strategic adaptation process of the firm. Inter-firm networks and strategic alliances have emerged as important strategic options for navigating survival and creating competitive advantage in times of high velocity turbulent environments characterized by pressures to master rapid technological developments, counteract new competitors and the never ending need
to acquire and master new capabilities (technical and managerial). The course explores crucial success factors that distinguish successful from failing strategic alliances. The course utilizes case discussions supplemented with readings, lectures, and conceptual discussions.

**MSL852 Network System: Applications and Management**
3 Credits (3-0-0)

**Pre-requisites:** MSL301 & MSL302

Module I : Networking fundamentals. Communication fundamentals (transmission and transmission media; communication techniques; transmission efficiency) Wide area networks, local area networks, ISDNs; OSI architecture, IBM's SNA, Digital DNA, Internetworking; network applications- EDI, Email, file transfer, conferencing, Enterprise networking.

Module II : Networking technologies and applications. Design and development of enterprise network; Web-based application development, Design of large-scale intranets, Network and systems management issues, Remote access to computer resources, Network and system security.


**MSL853 Software Project Management**
3 Credits (3-0-0)

**Pre-requisites:** MSL301 & MSL302

This course may expose the participants to the following topics: IT Evolution and its implications for business, IT Productivity Paradox - Issues and Implications, Impact of IS in the Networked Economy, Reasons for success and failure of IT projects, Disaster planning, Approaches to IS Development (e.g. Portfolio approaches), Technology Justification and Alignment Models, Strategic impact of IT /IS, Role of the CIO and challenges in business continuity.

**MSL854 Big Data Analytics & Data Science**
1.5 Credits (1.5-0-0)

**Pre-requisites:** MSL301 & MSL302

This course may expose the student to the following themes within the discipline: Introduction to Data Science and Data Scientists, Introduction to Big Data, Theories in Data Science, Big data technologies, Large query data sets and associated theories, Exploring the Hadoop Ecosystem, Information management in Big Data and Emerging Issues.

**MSL855 Electronic Commerce**
3 Credits (3-0-0)

**Pre-requisites:** MSL301 & MSL302

This course may expose the participants to the following topics: Introduction to e-commerce, B2B E-commerce models, B2C E-Commerce models, Mercantile processes, E-Commerce Infrastructure and Capacity Planning, Web Portals & Services, Trading, Pricing, Auctions, Bartering & Negotiations, Advanced and emergent topics in E-Commerce, Inter-organization information systems, e-procurement systems, e-fulfillment systems, e-SCM, Risk management in E-commerce. Hands on training may also be provided.

**MSL856 Business Intelligence**
3 Credits (3-0-0)

**Pre-requisites:** MSL301 & MSL302

The course will consist of the following: Introduction to data mining, types of data mining systems, data preprocessing and data warehouses (OLAP/OLTP), Data Cube Computation and Data Generalization, Mining Frequent Patterns, Associations, Correlations, Classification, Prediction, Clustering, time series and sequence data analysis, Graph Mining, Social Network Analysis, and Multirelational Data Mining, Mining Object, Spatial, Multimedia, Text, and Web Data, Applications and trends.

**MSL858 Business Process Management with IT**
1.5 Credits (1.5-0-0)

**Pre-requisites:** MSL301 & MSL302

This course may expose the participants to the following topics: Concepts of process and business process, Processes and workflow management systems, Concepts and evolution of BPM technologies, Impact of IT in BPM and its road map, BPM Cycle, Process deployment, Process monitoring, Process optimization using IT tools, Flowcharting and business process mapping and emergent issues in BPM/BPR technologies. Other relevant topics within the subject domain may also be explored.

**MSL859 Current and Emerging Issues in IT Management**
3 Credits (3-0-0)

**Pre-requisites:** MSL301 & MSL302

(Relevant current and Emerging Issues)

**MSL861 Market Research**
3 Credits (3-0-0)

**Pre-requisites:** MSL301 & MSL302

Module I: Research concepts; exploratory, descriptive and conclusive research. The market decision-making process and the need of different types of research. Types of marketing problems and type of marketing research activity. Sources of data; use and appraisal of existing information.

Module II : Information from respondents, sampling design, scaling techniques and questionnaire design, interviewing, mail surveys. Information from experiment, experimental design for marketing, Motivational research, Advertising research, Analysis and reporting.

Module III : Marketing information systems, Structure and design, its role in planning and control; the place of marketing research.

**MSL862 Product Management**
3 Credits (3-0-0)

**Pre-requisites:** MSL301 & MSL302

Module I : The product in corporate life, Corporate and product objective, product management role, responsibility, scope and functions, product strategy and policy, optimum product pattern/line range.


**MSL863 Advertising and Sales Promotion Management**
3 Credits (3-0-0)

**Pre-requisites:** MSL301 & MSL302

Module I : Mass communication theory and practices, marketing and promotion mix- interrelationship and interdependence advertising. Sales Promotion, Publicity and Public Relations- Scope, Objectives, activities and creative role. Advertising, objectives tasks and process, market segmentation and target audience- Message and copy development. Mass media, selection, planning, budgeting and scheduling. Integrated programme and budget planning. Implementing the programme, coordination and control. Advertising Agencies in India, their services and terms, advertisement campaign development, Agency selection and appointment; Agency Organization and operation, Getting the best of the agency services. Analysis of effectiveness of advertisement and promotional campaign.
Module II: Why and when sales promotion support, Sales promotion activities; Consumer Oriented-Sales channel Oriented-Sales staff oriented, Planning, budgeting, implementing and controlling campaigns. Advertisement development brief.

Module III: Valuation and measurement of advertising and sales promotion effectiveness, Company organization for advertising: sales manager, Sales Promotion Manager, Market Development Manager. Role of Tasks, advertising ethics, economics and social relevance. The Public Relations Activities, Public relations and mass media. Media planning and budgeting control.

MSL864 Corporate Communication
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
Corporate communications is a strategic tool that is leveraged to gain strategic advantage. Organizations use it to lead, motivate, persuade and inform both employees and outside stakeholders. How organizations set objectives, define messages and reach their employees, extended audiences, the media and customers, and how the company or group articulates its vision and brings its values to life, will all be discussed.

The course will familiarize students with some of the issues that specifically affect organisations and challenge the corporate communications function. Some of these issues include a change in CEO, mergers and acquisitions, imposition of government regulation and public pressure groups. Focus will be placed on crafting corporate messages for internal and external stakeholders. Specific subject.

MSL865 Sales Management
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
Module I: Organisational framework of the field sales force. Types and methods of field sales organisations-Career in Field Sales Management, Field Sales Manager- coordinating and controlling the Marketing mix, Tasks and responsibilities, team relations with Salesman and interaction and reporting relationship with Top Management. Operating environment for Field Sales Managers. Sales forecasting.

Module II: Sales Information and Planning, The qualities and role of a Field Sales Manager- Hierarchy of objectives and goals, concept of sales strategies and tactics; types of Planning. Marketing Intelligence and Sales Management. Relationship and contribution of Marketing Research to the sales development as decision making process. Designing and planning of sales territories, procedure for designing sales territories. Determining sales manpower requirements to establish sales territories- Recruiting salesman- selection process and system. Distribution and channel selection & Management.


MSL866 International Marketing
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302


Module III: Export credit system preshipment and post-shipment, finance, medium and long term credit financing; ECGC; Transportation and shipment of cargo; Marine insurance of cargo; procedure for claiming rebate of excise duty. Import replenishment licensing procedures. Generalized scheme of preferences. Sourcing and Transfer pricing mechanism. WTO related issues and IPR related issues impacting global trade.

MSL867 Industrial Marketing Management
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
Module I: Industrial marketing and Environment. Application of industrial buyer behaviour theories. Marketing plan to implement the marketing concept.

Module II: The new product development process. Personal selling (negotiations, systems selling, targets setting, fact finding, training); sales communications.


MSL868 Digital Research Methods
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302
The course will have the following coverage: Internet as a research medium; Research design; Sampling methods; Online surveys; Nonreactive data collection; virtual ethnography; Online focus groups; secondary qualitative data analysis; blogs & videos as source of data; data analysis approaches; tools.

MSL869 Current and Emerging Issues in Marketing
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
(Relevant current and Emerging Issues)

MSL870 Corporate Governance
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302
The course would broadly be divided into three modules. Module 1 would provide a global perspective to the students on the concept of corporate governance. Module 2 would focus on India and present the framework of corporate governance for Indian organizations. Module 3 would focus on corporate social responsibility (CSR) and its manifestations. Apart from the regular lectures and assignments, there would be a course pack provided to the students containing international and national reports, articles, studies and cases to help them build an international perspective through the self-study component.

MSL871 Banking and Financial Services
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302
The course will comprise of two broad sections; banking and financial services. Banking portion will cover banking sector reforms, bank management, financial statements of banks, sources and uses of bank funds, credit monitoring and management by banks, bank capital and Basel norms. Financial services will encompass both fund based and fee based services that are an integral part of modern financial systems; it will include lease financing, hire purchase financing, consumer credit, factoring, housing finance, investment banking, credit rating, stock broking, depository and custodial services. The course work will encompass problem solving on relevant topics and inputs from real life cases to give a practical insight to the theoretical concepts.
MSL872 Working Capital Management
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302

MSL873 Security Analysis & Portfolio Management
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302

MSL874 Indian Financial System
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302
This course is an introduction to the Indian financial system and tends to appraise students with its components, functions and integration of its sub components with each other. It covers different types of financial institutions, financial markets and financial instruments and services through which the financial system operates. Also, the students would develop an understanding of the role played by the different financial intermediaries in developing a robust financial environment for any country. The course will also give insight into the role played by financial market regulators and the challenges being faced by them in the modern internationally integrated economies.

MSL875 International Financial Management
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302

MSL876 Economics of Digital Business
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302
This course may expose the participants to the following topics: Impact of diffusion of ICTs in Business and People, Trade-offs & Network effects, Economics of Data communication including pricing, Firms, Networks, Centralization, Decentralization in 2 sided markets, Factors affecting organizational structure and size, Dynamics of Open Source and Open Innovation, Information, Search, Switching and Price dispersion, Information goods pricing and bundling. Other similar themes may also be explored.

MSL877 Electronic Government
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302
This course may expose the participants to the following topics: Introduction to E-Governance, E-Governance models and frameworks, E-Governance infrastructure and stages in evolution, Information Management in Electronic Governance. Issues in Emerging and Developing Economies, Selective Case Studies in E-Governance, Emerging initiatives in electronic governance, Role of policy. Other relevant topics within the subject domain may also be explored.

MSL878 Electronic Payments
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302
This course may expose the participants to the following topics: Different business models in electronic payments, Digital certificates and certificate chains, Automated clearing and settlement systems, Banking systems and foreign exchanges, Other players in the ecosystem, E-Payment and Card security, Micro-payments, P2P Payments, Electronic Cash, Challenges and role of policy. Other relevant topics within the subject domain may also be explored.

MSL879 Current and Emerging Issues in Finance
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
(Relevant current and Emerging Issues)

MSL880 Selected Topics in Management Methodology
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302

MSL881 Management of Public Sector Enterprises in India
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302

MSL882 Enterprise Cloud Computing
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302
This course will expose the participants to the following topics: Concepts of cloud computing and its impact, Technology Road Map to Cloud Computing, Virtualization, Practical usage of virtualization, Cloud Computing Frameworks and Deployment models. Cloud resource utilization and optimization, Cloud and Web Services, Service Model Architectures, SLA and QoS, Service Oriented Architecture and Cloud Computing.
MSL883 ICTs, Development and Business
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
The course will cover the following topics: Introduction, Development agendas and place of ICTs, ICTs as appropriate technologies, ICTs in education, health, industry & enterprises; ICT policy & regulations. Politics of open technology standards; ICT consulting for government; ICTs, Bottom of Pyramid & Business.

MSL884 Information System Strategy
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
This course may expose the participants to the following topics: IT Evolution and its implications for business, IT Productivity Paradox - Issues and Implications, Impact of IS in the Networked Economy, Reasons for success and failure of IT projects, Disaster planning, Approaches to IS Development (e.g. Portfolio approaches), Technology Justification and Alignment Models, Strategic impact of IT / IS, Role of the CIO and challenges in business continuity.

MSL885 Digital Marketing-Analytics & Optimization
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
The course may cover the following topics: Introduction and Perspectives in internet marketing, Online consumer behaviour and technology adoption theories, Managing the Word of Web, Mapping online communities & networks, Online pricing mechanisms, Social Network Analytics & Optimization, Web Analytics and Optimization, Traffic analytics, Online campaign and channel management, Managing the Web 2.0, Search Engine & Social Media Optimization, SMAC, Social CRMs, Metrics for E-Commerce Analytics, KPIs, Revenue Analytics.

MSL886 IT Consulting & Practice
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
This course may expose the participants to the following topics: Trends in the IT consulting industry, IT consulting issues and pain points, Critical IT issues and their organizational contexts, Marketing and selling IT consulting projects, Project Entry Strategies, Contracting, Proposal Writing and making the sales pitch, Frameworks for technology evaluation. Frameworks for consulting intervention, change management and project closure, Implementation Planning for IT Projects, Managing Consulting Firms and Knowledge Management. Other relevant topics may also be explored.

MSL887 Mobile Commerce
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
This course may expose the participants to the following topics: Introduction to Ubiquitous computing, Mobile communication and emerging technologies, Ubiquitous business models and challenges, Security issues and information risk management in mobile commerce. Mobile services and location based services, Interface with Social Media and Cloud, Mobile banking and payment systems, Socio-economic development with m-Commerce, Mobile based services for e-governance. Introduction to mobile apps in the context of ICT ecosystem; explaining success of apps; app entrepreneurship; app economy, challenges of entrepreneurship and economy. Business models of app stores; mobile gaming; app customer segmentation; case studies.

MSL888 Data Warehousing for Business Decisions
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302
This course may expose the participants to the following topics within this domain: Introduction to Database Management Systems, Hierarchical modelling, Multi-dimensional modeling of data, Design techniques and ETL, SQL. Data warehousing requirements for ETL; Data Warehousing Risks, OLAP and OLTP Management Issues, designing and supporting applications, Expanding a data warehouse. Other relevant topics within the subject domain may also be explored.

MSL889 Current and Emerging Issues in Public Sector management
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
(Relevant current and Emerging Issues)

MSD890 Major Project (Unique Core)
6 Credits (0-0-12)

MSD891 Major Project (Unique Core)
6 Credits (0-0-12)

MSL891 Data Analytics using SP S S
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302

MSD892 Major Project (Unique Core)
6 Credits (0-0-12)

MSL892 Predictive Analytics
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302
This course may expose the participants to the following topics: Introduction to the different predictive analytics models, using predictive analytics in decision making, types of predictive modeling, agent modeling, Case Based Reasoning and Predictive Expert Systems. Text mining, Social Network Analytics, Heuristics, Swarm algorithms, Hybrid Methods and algorithms. Other relevant topics within the subject domain may also be explored.

MSL893 Public Policy Issues in the Information Age
1.5 Credits (1.5-0-0)
Pre-requisites: MSL301 & MSL302
This course may expose the participants to the following topics within this domain: Cyber Security Policies - National Cyber Security Policy, US, UK, EU; Global cyber security norms; Cloud computing policies; ICT Supply Chain trustworthiness; Social Media, Internet freedom of expression; Security v/s Privacy - surveillance; Internet Governance; Encryption - national security v/s economic growth; International Cooperation - treaties, norms, conventions. Other relevant topics within the subject domain may also be explored.

MSL894 Social Media & Business Practices
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
Introduction, Definition, Types, and Dimensions; Status in India & the World; Different Revenue & Business Models; Situating Social Media in Business; Adoption in Organizations; Social Media & Applications: Viral marketing; Tool for SMEs, Customer Relationship Management, Researching Competitors; Digital Brand Management; Social Media Program Management; ROI; Influencers Index; and Social Media Audit & Policy in Organizations.

MSL895 Advance Data Analysis for Management
3 Credits (3-0-0)
Pre-requisites: MSL301 & MSL302
Module I : Descriptive vs. Inferential Analysis, Parametric vs. Nonparametric Analysis, Univariate, Bivariate and multivariate analysis, Hypothesis Testing and Estimation
Module II : ANCOVA, MANOVA, Logit Regression, Tobbit Regression, Panel Regression.
Module III : Factor Analysis, Cluster Analysis, Discriminant Analysis, Data Envelopment Analysis, Structural Equation Modelling.
**MSL896 International Economic Policy**  
3 Credits (3-0-0)  
Pre–requisites: MSL301 & MSL302  
World trade; The standard trade model; economies of scale and international trade; international factor movements; instruments of trade policy; exchange rates and foreign exchange markets; money, interest rates and exchange rates; price, output and exchange rates, different exchange rate regimes and policy, optimum currency area; Global capital markets; Financial crisis and contagion, Transition economies: crisis and reform.

**MSL897 Consultancy Process and Skills**  
3 Credits (3-0-0)  
Pre–requisites: MSL301 & MSL302  
Module II : The Consulting Process-Entry, Diagnosis, Action Planning, Implementation and Termination/Closing;  

**MSL898 Consultancy Professional Practice**  
3 Credits (3-0-0)  
Pre–requisites: MSL301 & MSL302  
Module I : Negotiation Skills, Professional Ethics and Code of Conduct. Managing a Consultancy firm-fundamentals of consulting firm management, consulting firms and IT in consulting firms, management of consulting assignments.  
Module II : Consulting in various areas of Management-Consulting in general and strategic management, consulting in financial management, consulting in marketing and distribution management, consulting in production and operation management, consulting in HRM, consulting in IT.  
Module III : R&D-Consultancy relationship, Careers and Compensation in Consulting, Training and development of Consultants, Future Challenges and Opportunities in Consultancy.

**MSL899 Current and Emerging Issues in Consultancy Management**  
3 Credits (3-0-0)  
Pre–requisites: MSL301 & MSL302

**MST893 Corporate Sector Attachment**  
2 Credits (0-0-4)

**MSC894 Seminar**  
3 Credits (0-0-6)

**MST894 Social Sector Attachment**  
1 Credit (3-0-0)
MTL100 Calculus
4 Credits (3-1-0)

MTL101 Linear Algebra and Differential Equations
4 Credits (3-1-0)

MTL102 Differential Equations
3 Credits (3-0-0)
Overlaps with: MTL260
Systems of differential equations, Existence and uniqueness theorems for initial value problems of semilinear and nonlinear ODEs, continuous dependence and well-posedness; Comparison theorems of Sturms, Sturm-Liouville eigenvalue problems; Phase-plane analysis, Linear and Non-linear stability, Liapunov functions and applications; First order Partial differential equations, Method of characteristics, local and global solutions, envelop of solutions, complete and general solutions; Second order equations: Heat and Wave equation, fundamental solutions, method of eigenfunctions, Duhamel's principle. Maximum principles for Heat and Laplace equation, Greens functions.

MTL103 Optimization Methods and Applications
3 Credits (3-0-0)
Overlaps with: MTL508, CLL782, MCL261

MTL104 Linear Algebra and Applications
3 Credits (3-0-0)
Pre-requisites: MTL101
Overlaps with: MTL502

MTL105 Algebra
3 Credits (3-0-0)
Overlaps with: MTL501
Preliminaries: Equivalence relations and partitions. Groups: Subgroups, Cyclic groups, Abelian groups, permutation groups; Langrange's theorem, normal subgroups, quotient groups, isomorphism theorems. Direct product of groups, structure theorem of finitely generated abelian groups, Sylow's theorems and applications. Rings: Definition and examples, units and zero divisors. Ideals and quotients, principal ideals, prime ideals, maximal ideals, integral domain, PID, Euclidean domain, UFD. Modules over a commutative ring with unity: Free module, quotient module, exact sequences. Fields: Finite fields, field extensions, splitting fields.

MTL106 Probability and Stochastic Processes
4 Credits (3-1-0)
Overlaps with: MTL108
Axioms of probability, Probability space, Conditional probability, Independence, Bayes' rule, Random variable, Some common discrete and continuous distributions, Distribution of Functions of Random Variable, Moments, Generating functions, Two and higher dimensional distributions, Functions of random variables, Order statistics, Conditional distributions, Covariance, Correlation coefficient, conditional expectation, Modes of convergences, Laws of large numbers, Central limit theorem, Definition of Stochastic process, Classification and properties of stochastic processes, Simple Markovian stochastic processes, Gaussian processes, Stationary processes, Discrete and continuous time Markov chains, Classification of states, Limiting distribution, Birth and death process, Poisson process, Steady state and transient distributions, Simple Markovian queuing models (M/M/1, M/M/1/N, M/M/c/N, M/M/N/N, M/M/∞).

MTL107 Numerical Methods and Computations
3 Credits (3-0-0)
Overlaps with: MTL509, CLL113, CVL763
MTL108 Introduction to Statistics  
3 Credits (3-0-0)  
Overlaps with: MTL106, MTL390  

MTL122 Real and Complex Analysis  
4 Credits (3-1-0)  
Pre-requisites: MTL100  
Overlaps with: MTL503, MTL506  

MTL145 Number Theory  
3 Credits (3-0-0)  
Divisibility: basic definition, properties, prime numbers, some results on distribution of primes; Congruences: basic definitions and properties, complete and reduced residue systems, theorems of Fermat, Euler & Wilson, application to RSA cryptosystem, linear congruences and Chinese Remainder theorem, quadratic congruences, and Quadratic Reciprocity law; Arithmetical functions: examples, with some properties and their rate of growth; Continued fractions, and their connections with Diophantine approximations, applications to continued fractions, and Pell's equations; Binary quadratic forms; Partition: basic properties and results; Diophantine equations: linear and quadratic, some general equations.

MTL146 Combinatorics  
3 Credits (3-0-0)  
Pre-requisites: MTL180  
Basic counting techniques; principle of inclusion and exclusion; recurrences and generating functions; Systems of Distinct Representatives & Hall’s theorem; Extremal Set theory; Projective and combinatorial geometries; Latin squares; Designs & Steiner Triple Systems; Ramsey theory.

MTL180 Discrete Mathematical Structures  
4 Credits (3-1-0)  
Overlaps with: COL202  
Logic : Propositional Logic: language of propositional logic, truth table, natural deduction, predicate logic: language of predicate logic, Logical inference with Quantifiers. Proof techniques: Introduction to different standard proof techniques. Set Theory: Review of Basic Set Operations, cardinality of a set. Relations : Types of relations, operations of relations and applications. Poset, topological ordering; Congruence arithmetic; Combinatorics: Counting techniques: Pigeon Hole principle, inclusion exclusion principle, recurrence relation and generating function; Graph Theory : Graph as a discrete structure, Modeling applications using graphs, Hamiltonian graphs, Planar graphs, Graph coloring, Matching.

MTL260 Boundary Value Problems  
3 Credits (3-0-0)  
Pre-requisites: MTL100, MTL101  

Higher Dimensions and Other Coordinates: Two-Dimensional Wave Equation: Derivation, Parabolic equation, Solution by Fourier series, Problems in Polar Coordinates, Temperature in a Cylinder, Vibrations of a Circular Membrane  
Finite dimensional approximations of solutions, piecewise linear polynomials and introduction to different methods like Galerkin and Petrov-Galerkin method.

MTL265 Mathematical Programming Techniques  
3 Credits (3-0-0)  
Pre-requisites: MTL103  
Overlaps with: COL756  
Recall of linear programming simplex algorithm and dual problem; primal-dual simplex method, linear programs with upper bounds, network optimization, network simplex method for non-capacitated and capacitated networks; dynamic programming, principle of optimality, general insight followed by in-depth examples; complexity of simplex algorithm, Karmarkar's interior point method; nonlinear programming, KKT conditions, convex programs, linear fractional programming problems, Charnes and Cooper technique, convex simplex method, Rosen projection method; multiobjective programming problems, applications to engineering and sciences, Pareto efficient solution, linear multiobjective programs, weighted sum approach, scalarization schemes, goal programming.

MTL270 Measure Integral and Probability  
3 Credits (3-0-0)  
Overlaps with: MTL510  
Measurable spaces, measurable sets, measurable functions, measure, outer measures and generation of measure, Lebesgue integration, basic integration theorem, comparison of Lebesgue and Riemann integrals, various modes of convergence of measurable functions, signed measure, Hahn and Jordan decomposition theorems, the Radon-Nikodym theorem, product measures and Fubini's theorem, probability measures and spaces, independent events, conditional probability, theorem of total probability, random variables, distribution and distribution function of a random variable, independent random variable, expectation, convergence in distribution of a sequence of random variables, weak and strong laws of large numbers, Kolmogorov's zero-one law, the central limit theorem, identically distributed summmands, the Linderberg and Lyapounov theorems.

MTP290 Computing Laboratory  
2 Credits (0-0-4)  
Pre-requisites: MTL101  
**MTL342 Analysis and Design of Algorithms**  
4 Credits (3-1-0)  
Pre-requisites: MTL180  
Overlaps with: COL351  
Models of computation: RAM and Turing Machines; Algorithm Analysis techniques; Basic techniques for designing algorithms: dynamic programming, divide-and-conquer and Greedy; DFS, BFS and their applications; Some Basic Graph Algorithms; linear time sorting algorithms; NP-Completeness and Approximation Algorithms.

**MTD350 Mini Project**  
3 Credits (0-0-6)  
Pre-requisites: EC 80  
Depends on the project topic.

**MTL390 Statistical Methods**  
4 Credits (3-1-0)  
Pre-requisites: MTL106  
Overlaps with: MTL108  
Basic concepts and Data Visualization: Measures of central tendency, Dispersion, Skewness, Kurtosis, Data Representation using Histogram, Pie Chart, Boxplot, Biplot, Multi Dimensional Scaling etc. Revision of Probability Distribution: Emphasis on Normal, Chi-Square, Student’s T, F distributions; Order Statistics: Different Order Statistics and their single and joint Distribution; Sampling Distribution of Mean, Variance; Generation of Random Numbers following certain distributions; Theory of Estimation (Point and Interval)/Properties of an estimator, MVUE, BLUE, Cramer-Rao Inequality, Rao-Blackwell Theorem; Testing of Hypothesis: Mean and Variance, Confidence Interval, Neyman-Pearson Lemma; Non-Parametric Methods Run Tests, Rank Tests, Signed Rank Tests, Kruskal Wallis Test, Kolmogorov-Smirnov Test etc.; Regression Analysis Linear Regression, Multiple Regression, Logit, Probit, Regression.

**MTL411 Functional Analysis**  
3 Credits (3-0-0)  
Pre-requisites: MTL104 and MTL122  
Overlaps with: MTL602  
Review of some basic concepts in metric spaces and topological spaces; Normed linear spaces and Banach spaces, Examples of Banach spaces, Bounded linear operators and examples, Finite dimensional Banach spaces; Introduction of Lebesgue integration on real line, Fatou’s lemma, monotone convergence theorem, dominated convergence theorem, Lp spaces; Hahn Banach extension theorem, Hahn Banach separation theorem, Uniform boundedness principle, Open mapping theorem, Closed graph theorem; Characterization of dual of certain concrete Banach spaces; Schauder basis and separability, Reflexive Banach spaces, Best approximation in Banach spaces; Hilbert spaces and their geometry; Basic operator theory.

**MTL445 computational Methods for differential Equations**  
4 Credits (3-0-2)  
Pre-requisites: MTL107  
Overlaps with: MTL712, CLL113  

**MTL458 Operating Systems**  
4 Credits (3-0-2)  
Pre-requisites: MTL342  
Overlaps with: COL331, ELL405  
Operating Systems functions, Basic Concepts, Notion of a process, concurrent processes, problem of mutual exclusion, Deadlock, process Scheduling, memory management, multiprogramming, File systems; time sharing systems and their design consideration.

**MTL501 Algebra**  
4 Credits (3-1-0)  
Groups, subgroups, Lagrange theorem, quotient groups, isomorphism theorems; cyclic groups, dihedral groups, symmetric groups, alternating groups; simple groups, simplicity of alternating groups; Group action, Sylow theorems and applications; free abelian groups, structure of finitely generated abelian groups; Solvable and nilpotent groups, composition series, Jordan-Holder theorem.  
Rings, examples: polynomial rings, formal power series, matrix rings, group rings; prime ideals, maximal ideals, quotient rings, isomorphism theorems; Integral domains, PID, UFD, Euclidean domains, division rings, field of fractions; primes and irreducibles, irreducibility criteria; product of rings, Chinese remainder theorem.  
Field extension, algebraic extension, algebraic closure, straight edge and compass constructions, splitting fields, separable and inseparable extensions, fundamental theorem of Galois theory; solvability by radicals.

**MTL502 Linear Algebra**  
4 Credits (3-1-0)  
Revision of existence-uniqueness of solutions of a system of linear equations, elementary row operations, row-reduced echelon matrices.  
Inner product spaces over $\mathbb{R}$ (real numbers) and $\mathbb{C}$ (complex numbers), Gram-Schmidt orthogonalization process, orthogonal projection, best approximation. Adjoint of a linear operator, unitary and normal operators, spectral theory of normal operators. Bilinear forms, symmetric and skew-symmetric bilinear forms.

**MTL503 Real Analysis**  
4 Credits (3-1-0)  

**MTL504 Ordinary Differential Equations**  
4 Credits (3-1-0)  

**MTL505 Computer Programming**  
4 Credits (3-1-0)  

**MTL506 Complex Analysis**  
4 Credits (3-1-0)  

**MTL507 Topology**  
4 Credits (3-1-0)  

**MTL508 Mathematical Programming**  
4 Credits (3-1-0)  
Linear programs formulation through examples from engineering/business decision making problems, preliminary theory and geometry of linear programs, basic feasible solution, simplex method, variants of simplex method, like two phase method and revised simplex method; duality and its principles, interpretation of dual variables, dual simplex method, primal-dual method; linear integer programs, their applications in real decision making problems, cutting plane and branch and bound methods, transportation problems, assignment problems, network maximum flow problems; complexity of simplex method, ellipsoid method, Karmarkar's interior point method; nonlinear programming, Lagrange multipliers, Farkas lemma, constraint qualification, KKT optimality conditions, sufficiency of KKT under convexity; quadratic programs, Wolfe method, applications of quadratic programs in some domains like portfolio optimization and support vector machines, etc.

**MTL509 Numerical Analysis**  
4 Credits (3-1-0)  

**MTL510 Measure and Integration**  
4 Credits (3-1-0)  
Outer measures, measures and measurable sets, Lebesgue measure on $\mathbb{R}$, Borel measure. Measurable functions, simple functions, Egoroff's theorem, Lebesgue integral and its properties, monotone convergence theorem, Fatou's Lemma, Dominated convergence theorem various modes of convergence and their relations. Signed measures, Hahn and Jordan decomposition theorems, Lebesgue-Radon-Nikodem theorem, Lebesgue decomposition theorem, the representation of positive linear functionals on $C(X)$. Product measures, iterated integrals, Fubini's and Tonelli's theorems. LP spaces and their completeness, conjugate space of $L^p$ for $1 < p < \infty$, conjugate space of $L_1$, for sigma-finite measure space. Differentiation of monotone functions, functions of bounded variation, differentiation of an integral, absolute continuity.

**MTL601 Probability and Statistics**  
4 Credits (3-1-0)  
Probability definition, conditional probability, Bayes theorem, random variables, expectation and variance, specific discrete and continuous distributions, e.g. uniform, Binomial, Poisson, geometric, Pascal, hypergeometric, exponential, normal, gamma, beta, moment generating function, Poisson process, Chebyshev's inequality, bivariate and multivariate distributions, joint, marginal and conditional distributions, order statistics, law of large numbers,
central limit theorem, sampling distributions - Chi-sq, Student’s t, F;
three of estimation, maximum likelihood test, testing of hypothesis,
nonparametric analysis, test of goodness of fit.

**MTL602 Functional Analysis**
4 Credits (3-1-0)
Normed linear spaces, Banach spaces and their examples, quotient
spaces, bounded linear operators, finite dimensional Banach spaces,
Lp Spaces, Lp spaces as examples for Banach spaces
Hahn Banach theorems, Uniform boundedness principle, open mapping
theorem, closed graph theorem, transpose of an operator
Characterization of the dual of certain Banach spaces
Geometry of Banach spaces - Weak and weak* convergence,
Geometry of Hilbert spaces - Inner product spaces and its properties,
Hilbert spaces and examples, best approximation in Hilbert spaces,
orthogonal complements, orthonormal basis, dual of a Hilbert space
Basic operator theory - Adjoint of an operator, self-adjoint operators,
normal and unitary operators, projections
Compact operators, examples and properties, spectral theorem for the
compact self-adjoint operator.

**MTL603 Partial Differential Equations**
4 Credits (3-1-0)
Linear and semi-linear equations, Cauchy problem, Method of
characteristics: Cauchy-Kowalewsky theorem, Holmgren’s Uniqueness
Theorem. Classification of second order equations, wave equation in
one space dimension, classical and weak solutions, Duhamel’s principle.
Laplace equation, fundamental solutions, maximum principles and
mean value formulas, Properties of harmonic functions, Green’s
function, Energy methods, Perron’s method, Parabolic equations in one
space dimension, fundamental solution, maximum principle, existence
and uniqueness theorems. Wave equation, Solutions by spherical
means, Non-Homogeneous Problems, Duhamel’s principle, Energy
Methods. Nonlinear first order PDE’s: Complete integrals, Envelopes
and singular solutions. Some special methods for finding solutions:
Similarity solutions, Hopf-Cole transformation.

**MTL625 Principles of Optimization Theory**
3 Credits (3-0-0)
Convex set, hyperplane, relative interior and closure, separation
theorems, theorems of alternatives for linear systems, convex
functions and properties of continuity, differentiability etc.,
quasiconvex and pseudoconvex functions and their properties and
interrelationships, minimax theorems for convex and quasiconvex
functions, nonlinear programming, Lagrange function, saddle point,
Fritz John optimality conditions, constraint qualifications, Karush-
Kuhn-Tucker (KKT) necessary and sufficient optimality conditions,
Wolfe and Mond-Weir duals, Wolfe method for quadratic programs,
Projection gradient method, steepest descent method, conjugate
gradient method, rank-1 methods, convergence, conjugate function,
Fenchel duality, subgradient and subdifferential, nonsmooth
optimization, tangent cone, normal cone, nonsmooth KKT conditions,
nonsmooth optimality conditions, subgradient method, proximal
method, convergence of these methods, applications to support
vector machines optimization problems.

**MTD701 Project-I**
5 Credits (0-0-10)

**MTD702 Project-II**
6 Credits (0-0-12)

**MTL704 Numerical Optimization**
3 Credits (3-0-0)
Pre-requisites: MTL103/MTL508
Unconstrained optimization techniques - one dimensional methods
like Fibonacci method, Golden section method; higher dimension
methods: pattern search method, Nelder and Mead method; gradient
based methods: Steepest descent method, Newton method, Conjugate
direction and gradient method, Quasi-Newton methods. Constrained
optimization techniques - penalty method, barrier method, cutting
plane method, projection gradient method. Heuristic technique: like
Genetic programming method to solve non-convex programs.

**MTL712 Computational Methods for Differential Equations**
4 Credits (3-0-2)
Pre-requisites: MTL107/MTL509
Numerical methods for solving ODEs: Difference equations,
Routh-Hurwitz criterion, Test Equation. Single step methods: Taylor
series method, explicit Runge-Kutta methods, convergence, order,
relative and absolute stability. Multistep methods: Development
of multi-steps, Adams method, Runge-Kutta method, Adams-Bashforth
method; Convergence, stability and consistency of difference methods.
Higher order methods. Introduction to Hyperbolic PDEs, FD methods.
Upwind schemes, Consistency, stability and convergence of schemes.
Second order schemes.

**MTL717 Fuzzy Sets and Applications**
3 Credits (3-0-0)
Fuzzy sets, fuzzy relations, matrix representation of fuzzy relations,
fuzzy numbers, fuzzy arithmetic, Zadeh’s extension principle,
ordering fuzzy numbers, ranking functions; Fuzzy aggregation,
\( \ell \)-norm, \( \ell \)-conorm, fuzzy negation, other aggregation operators, OWA
operators; Fuzzy relational equations (FRE), algorithms to solve system of
FRE; Fuzzy optimization, fuzzy linear program; Fuzzy measures,
belief and plausibility, necessity and possibility, Sugeno and Choquet
integrals on finite sets; Fuzzy logic and approximate reasoning,
If-then-else rules, Mamdani model, TSK model, SAM model; Applications
of fuzzy sets and logics in areas of image processing, control, AI,
computing with words, etc.; Generalized fuzzy sets - like type\( \alpha \) fuzzy
sets, rough sets, and Intuitionistic fuzzy sets.

**MTL720 Neurocomputing and Applications**
3 Credits (3-0-0)
Biological and Artificial Neuron, Perceptron model, Adaline model,
Multilayered feedforward networks, Activation functions, Back-
propagation algorithm and its improvements, Conjugate Gradient
Neural Network, Applications of Back-propagation algorithm to
Statistical Pattern Classification, Feature selection, Classification and
regression problems, General Regression Neural Networks, Hopfield
Network, Recurrent networks, Probabilistic Neural Networks, Kohonen’s
self-organizing maps with quadratic junctions and its applications to
character recognition, Adaptive Resonance Theory model, Applications
of ART model for knowledge acquisition.

**MTL725 Stochastic Processes and its Applications**
3 Credits (3-0-0)
Stochastic processes, specification of stochastic processes, stationary
processes, discrete time and continuous time Markov chains, birth and
death processes, applications in queueing theory. Markov processes
with continuous state space, martingales, applications in financial
mathematics. Renewal processes and theory, Markov renewal and
semi-Markov processes, branching processes.

**MTL728 Category Theory**
3 Credits (3-0-0)
Categories, functors and natural transformations, adjoints (of
functors), representable functors, Yoneda Lemma and applications.
Limits and colimits, interaction between functors and limits. Limits in
terms of representables and adjoints, limits and colimits of presheaves, interaction between adjoint functors and limits. Application to abelian category: complexes of R-modules, long exact sequence, mapping cone and cylinder, projective and injective resolution, derived functors, right and left exactness, Ext and Tor. Concept of presheaf and sheaf, group scheme and Hopf algebra.

**MTL729 Computational Algebra and its Applications**  
3 Credits (3-0-0)  

**MTL730 Cryptography**  
3 Credits (3-0-0)  
Overlaps with: COL759  

**MTL731 Introduction to Chaotic Dynamical Systems**  
3 Credits (3-0-0)  
Topics to be covered include chaos, elementary bifurcations. Sarkovskii’s theorem, recurrence and equidistribution, codes, symbolic dynamics and chaotic behaviour. Higher dimensional dynamics, including horseshoes, Henon map. Stability of systems.

**MTL732 Financial Mathematics**  
3 Credits (3-0-0)  
Pre-requisites: MTL103/MTL508  
Overlaps with: MCL363/MSL872  
Financial markets, Interest computation, value, growth and discount factors, derivative products, basic option theory: single and multi-period binomial pricing models, Cox-Ross-Rubinstein (CRR) model, volatility, Black-Scholes formula for option pricing as a limit of CRR model, Greeks and hedging, Mean-Variance portfolio theory: Markowitz model, Capital Asset Pricing Model (CAPM), factor models, interest rates and interest rate derivatives, Binomial tree models.

**MTL733 Stochastic of Finance**  
3 Credits (3-0-0)  
Pre-requisites: MTL106/MTL601  
Stochastic Processes; Brownian and Geometric Brownian Motion; Levy Processes, Jump-Diffusion Processes; Conditional Expectations and Martingales; Ito Integrals, Ito’s Formula; Stochastic Differential Equations; Change of Measure, Girsanov Theorem, Martingale Representation Theorem and Feynman-Kac Theorem; Applications of Stochastic Calculus in Finance, Option Pricing, Interest Rate Derivatives, Levy Processes in Credit Risk.

**MTL735 Advanced Number Theory**  
3 Credits (3-0-0)  
Overlaps with: MTL145  
Divisibility, prime numbers, Bertrand’s theorem, Congruences, complete & reduced residue systems, theorems of Fermat, Euler, Wilson & Wolstenholme, solutions of general congruences, study of linear and system of linear congruences, Chinese Remainder theorem, study of quadratic congruences, Quadratic, Cubic & Biquadratic Reciprocity laws, binary and ternary quadratic forms, Continued fractions, Diophantine approximations and applications to linear and Pell’s equations, Arithmetical functions, properties, rate of growth, Distribution of primes, Dirichlet’s theorem on primes in arithmetic progression, Prime Number theorem, Diophantine equations, special cases of the Fermat equation, introduction to classic and modern techniques.

**MTL737 Differential Geometry**  
3 Credits (3-0-0)  
Curves in plane and space, arc-length, reparametrization, curvature of a plane curve, curvature and torsion of a space curve. Simple closed curves, isoperimetric inequality, Four-vertex theorem. Surfaces, smooth surfaces and examples, level surfaces, quadric surfaces, surfaces of revolution, ruled surfaces smooth maps, tangent space, derivatives, orientability of surfaces. The first fundamental form, lengths of curves on surfaces, isometries, conformal mappings, equireal maps. The second fundamental form, Gauss and Weingarten maps, normal and geodesic curvatures, Gaussian and mean curvatures, principal curvatures. Surfaces of constant Gaussian curvature, surfaces of constant mean curvature, flat surfaces. Parallel transport, geodesics and their examples, properties, geodesic equations, geodesics as shortest paths, Gauss and Codazzi-Minardi equations, Theorema Egregium Gauss-Bonnet Theorem. Introduction to hyperbolic and spherical geometry.

**MTL738 Commutative Algebra**  
3 Credits (3-0-0)  
Pre-requisites: MTL105/MTL501  
Revision of Rings and Ideals: Prime and maximal ideals. Chinese remainder theorem, Nilradical, Jacobson radical, operations on ideals, extension and contraction; Module, submodule, quotient module, sums and products, Nakayama’s lemma; Homomorphism, kernel, cokernel, direct sum, direct product, universal properties, free module, exact sequences, tensor product of modules and its exactness property; Rings and modules of fractions and functorial properties of fractions; Primary decomposition; Integral dependence, going-up and going down theorems, valuation rings; Chain conditions, Noetherian rings, Artinian rings, discrete valuation ring and Dedekind domains, fractional ideals; Completion: filtration, graded rings and modules.

**MTL739 Representation of Finite Groups**  
3 Credits (3-0-0)  
Pre-requisites: MTL105/MTL501  
Revision of basic group theory, Definition and examples of representation. Subrepresentation, sum and tensor product of representations,
irreducible representations; Character Theory: Character of a representation, Schur's Lemma, Maschke's theorem, Orthogonality relations for characters, decomposition of regular representation, number of irreducible representations of a group; Representation of subgroups and product of groups, induced representations; Group Algebra: Representations and modules; Decomposition of complex algebra $\mathbb{C}[G]$ and Integrability properties of characters. Induced representations, restriction to subgroups, Reciprocity formula, Mackey's irreducibility criterion; Irreducible representations of symmetric groups $(S_n)$ and alternating groups $(A_n)$.

**MTL741 Fractal Geometry**
3 Credits (3-0-0)
Code spaces, Hausdorff metric, Hausdorff measures, fractal dimensions, Hausdorff dimension, Box-counting dimensions, groups and rings of fractal dimension, semigroups of iterated function schemes (IFS) and self-similarity, Cantor sets, Cantor dusts, Koch Snowflake, Sierpinski's triangle, Diaphantine approximation, chaos games, attractors, fractals, superfractals and multi fractal measures, Mandelbrot and Julia sets, random fractals, fractals in Brownian motion.

**MTL742 Operator Theory**
3 Credits (3-0-0)
Pre-requisites: MTL411/MTL602

**MTL743 Fourier Analysis**
3 Credits (3-0-0)
Pre-requisites: MTL122/MTL503
Fourier Series - Definition, uniqueness, convolution, summability, convergence of Fourier series, Fourier series for square integrable functions, Plancherel theorem, Riesz-Fischer theorem, Gibb's phenomenon, divergence of Fourier series

**MTL744 Mathematical Theory of Coding**
3 Credits (3-0-0)
Pre-requisites: MTL105/MTL501
Overlaps with: ELL710

**MTL745 Advanced Matrix Theory**
3 Credits (3-0-0)

**MTL746 Methods of Applied Mathematics**
3 Credits (3-0-0)
Expansion in Eigen functions, Fourier series and Fourier Integral, orthogonal expansion, mean square approximation, completeness, orthogonal polynomials and their properties.

**MTL747 Mathematical Logic**
3 Credits (3-0-0)

**MTL751 Symbolic Dynamics**
3 Credits (3-0-0)
Shift Spaces, languages, subshifts of finite type, their graph representation, sofic shifts, their presentation and characterization, entropy, its properties, conjugacy, shift equivalence and dimension groups, zeta functions.

**MTL754 Principles of Computer Graphics**
3 Credits (3-0-0)
Overlaps with: COL781, ELL792
Overview of Graphics Systems; Raster Graphics: line and circle drawing algorithms, Windowing and clipping: Cohen - Sutherland line clipping, Cyrus Beck clipping method, Polygon Clipping; 2D and 3D Geometrical Transformations: scaling, translation, rotation, reflection; 3D Object representation: Curves and Surfaces: cubic splines, Bezier curves B-splines, surface of revolution, sweep surfaces; viewing Transformations: parallel and perspective projection; Hidden line/ surface removal methods; illuminations model; shading: Gouraud, Phong; Introduction to Ray-tracing; Programming practices with standard graphics libraries like open GL.

**MTL755 Algebraic Geometry**
3 Credits (3-0-0)
Pre-requisites: MTL105/MTL501

MTL756 Lie Algebras and Lie Groups
3 Credits (3-0-0)
Pre-requisites: MTL105/MTL501
Overlaps with: MTL856
Definition and examples, solvable and nilpotent Lie algebras, the Engel's theorem, Lie's theorem, Cartan's theorem, killing form. Representation theory of finite dimensional semisimple Lie algebras. The Weyl's theorem, representations of sl(2,C), root space decomposition, Weyl group, Cartan subalgebras and classification of root systems; Definition and examples of matrix Lie groups. Exponential mapping, Baker-Campbell-Hausdorff formula. Representation theory of matrix Lie groups. Representation theory of SU(2) and SU(3).

MTL757 Introduction to Algebraic Topology
3 Credits (3-0-0)
Pre-requisites: MTL122/MTL507
Homotopy of paths, fundamental group, covering spaces, fundamental group of the circle, Retraction and application, van Kampen theorem and application. Universal cover and classification of covering spaces. Deck transformation and group actions. Simplicial and Singular homology, homotopy invariance, exact sequences- Mayer-Vietories Sequences, the equivalence of simplicial and singular homology.

MTL760 Advanced Algorithms
3 Credits (3-0-0)
Pre-requisites: MTL342
Overlaps with: COL758
MST: Fibonacci Heaps and O(m log log n) time implementation of MST, Linear time MST verification Algorithm, A linear time randomized algorithm for MST, Finding min-cost arborescences; Dynamic Graph Algorithms; Review of NP-completeness; Introduction to NP-hard optimization problems; A brief introduction to LPP; Integer Programming Problem; Primal-Dual algorithm; Approximation Algorithms: Primal-Dual Approximation Scheme; vertex cover, set cover, TSP; Hardness of Approximation; Introduction to Randomized Algorithms; Some basic Randomized algorithms; Probabilistic Method: Lovasz Local Lemma.

MTL761 Basic Ergodic Theory
3 Credits (3-0-0)

MTL762 Probability Theory
3 Credits (3-0-0)
Axiomatic definition of a probability measure, examples, properties of the probability measure, finite probability space, conditional probability and Bayes formula, countable probability space, general probability space. Random variables, examples, sigma-field generated by a random variable, tail sigma-field, probability space on R induced by a random variable, Independent events, sigma-fields and random variables, Borel 0-1 criteria, Kolmogorov 0-1 criteria. Distribution - definition and examples, properties, characterization, Jordan decomposition theorem, discrete, continuous and mixed random variables, standard discrete and continuous distributions, convolution of distributions. Two dimension random variables, joint distributions, marginal distributions, operations on random variables and their corresponding distributions, multidimensional random variables and their distributions. Expectation of a random variable, expectation of a discrete and a continuous random variable, moments and moment generating function, correlation, covariance and regression. Various modes of convergence, Weak law of large numbers, strong law of large numbers.


MTL763 Introduction to Game Theory
3 Credits (3-0-0)

MTL766 Multivariate Statistical Methods
3 Credits (3-0-0)
Pre-requisites: MTL390/MTL601
Introduction to Multivariate data, Geometry of a sample, Mean and Covariance, Generalized Variance; Sample value of Linear combination of variables; Multivariate Normal Distribution, and its properties, Sampling from a Multivariate Normal population, Sampling distribution and Large sample Behaviour of Mean and Covariance, Inference about Mean vector, Hotelling's T-square and Likelihood Ratio test, Confidence Region, Comparison of several Multivariate Populations, Multivariate Linear Regression Models, Inference about Mean Vector, Hotelling's T-square and Likelihood Ratio test, and Large sample Behaviour of Mean and Covariance, Inference about Mean Vector, Hotelling's T-square and Likelihood Ratio test, Confidence Region, Comparison of several Multivariate Populations, Multivariate Linear Regression Models, Inferences about regression models and parameters, Model checking, Principal Component Analysis, Introduction to Factor Analysis, Orthogonal Factor Models, Factor Rotation, Strategy for Factor Analysis; Canonical Correlation Analysis, Interpreting population by Canonical variables, Large Sample Inferences.

MTL768 Graph Theory
3 Credits (3-0-0)
Overlaps with: MTL776
Introduction to Graphs: Definition and basic concepts; Trees: characterizations, counting of minimum spanning tree; Paths and Distance in Graphs: Basic Definitions, center and median of a graph, activity digraph and critical path; Eulerian Graphs: Definition and Characterization; Hamiltonian Graphs: Necessary and sufficient conditions, Planar Graphs: properties, dual, genus of a graph; Graph Coloring: vertex coloring, chromatic polynomials, edge coloring, planar graph coloring; Matching and Factorizations: maximum matching in bipartite graphs, maximum matching in general graphs, Hall's marriage theorem, factorization; Networks: The Max-flow min-cut theorem, connectivity and edge connectivity, Menger's theorem; Graph and Matrices.
**MTL773 Wavelets and Applications**
*3 Credits (3-0-0)*

**Pre-requisites:** MTL411/MTL602


**MTL781 Finite Element Theory and Applications**
*3 Credits (3-0-0)*

**Pre-requisites:** MTL107/MTL509 and MTL411/MTL602

Variational formulation of elliptic boundary value problems; Lax Milgram Lemma; Existence and uniqueness of solutions; equivalence of Galerkin and Ritz variational formulations; Triangulation of ordinary domains-rectangles, polygons, circles, ellipses, etc. Finite element problems; conforming and non-conforming methods, Ce-a's Lemma, Interpolation on simplexes in Rn, different Lagrange and Hermite finite elements, Affine, isoparametric, sub-parametric, super parametric finite elements; Triangulation using isoparametric mapping; approximation of boundary; Numerical Integration, construction of element stiffness matrices and assembly into global stiffness matrix, Skyline method of solution of finite element equations; Solution of model problems and computer implementation procedures; Asymptotic error estimate results; Eigenvalue problems of Laplace operator.

**MTL785 Natural Language Processing**
*3 Credits (3-0-0)*

Overlaps with: COL772


**MTV791 Special Module in Dynamical System**
*1 Credit (1-0-0)*


**MTL792 Modern Methods in Partial Differential equations**
*3 Credits (3-0-0)*

**Pre-requisites:** MTL411/MTL602


**MTL793 Numerical Methods for Hyperbolic PDEs**
*3 Credits (3-0-0)*


**MTL794 Advanced Probability Theory**
*3 Credits (3-0-0)*


**MTL795 Numerical Method for Partial Differential Equations**
*4 Credits (3-1-0)*


**MTL843 Mathematical Modeling of Credit Risk**
*3 Credits (3-0-0)*

**Pre-requisites:** MTL106/MTL601


**MTL851 Applied Numerical Analysis**
*3 Credits (3-0-0)*


**MTL854 Interpolation and Approximation**  
3 Credits (3-0-0)  

**MTL855 Multiple Decision Procedures in Ranking and Selection**  
3 Credits (3-0-0)  
The problem of ranking and selection, different approaches to the solution of problem. Indifference zone formulation: Ranking normal population in terms of means single and two stage procedures. Ranking normal population in terms of variances. Ranking binomial population-fixed sample size and multistage procedures, play the winner rules and vector at a time sampling. Ranking Gamma population with largest (smallest) scale parameter. Optimal properties of fixed subset size procedures Bayes, minimax and admissibilities properties, subset selection formulation: Decision theoretical formulation, best invariant rules. Restricted subset selection. Subset selection of normal population w.r.t. means and variances, selection of t-best. Subset selection in binomial and gamma populations. Comparison of population with a control. Normal and exponential populations.

**MTL856 Lie Algebras**  
3 Credits (3-0-0)  
Overlaps with: MTL756  

**MTL860 Linear Algebra**  
3 Credits (3-0-0)  

**MTL863 Algebraic Number Theory**  
3 Credits (3-0-0)  
Algebraic number fields, cyclotomic fields, quadratic and cubic fields, integral extensions, conjugate elements and conjugate fields, norms and traces. The discriminant. Noetherian rings and Dedekind domains. Finiteness of the class group. Dirichlet's unit theorem and its applications.

**MTL874 Analysis**  
3 Credits (3-0-0)  

**MTL882 Applied Analysis**  
3 Credits (3-0-0)  

**MTL883 Physical Fluid Mechanics**  
3 Credits (3-0-0)  
Description of principles of flow phenomena: pipe and channel flow laminar flow, transition, turbulence; flow past an object; boundary layer, wake, separation, vortices, drag, convection in horizontal layers, transition from periodic to chaotic behaviour; equations of motion; dynamical scaling, sample viscous flows; inviscid flows. Flow in rotating fluids; hydrodynamic stability.

**MTL888 Boundary Elements Methods with Computer Implementation**  
3 Credits (3-0-0)  
MCP100 Introduction to Engineering Visualization
2 Credits (0-0-4)
Sketching of engineering objects and interpretation of drawings as a visualisation and communication tool. Creating 3D components through the use of a CAD package. Simple assemblies, generation of assembly views from part drawings, animation of simple assemblies.

MCP101 Product Realization through Manufacturing
2 Credits (0-0-4)
Exposing role of manufacturing processes in product realization; Understanding product realization by endeavouring hands on activities; Experience of product realization by undertaking manufacturing exercises and assembly activity in teams.

MCL111 Kinematics and Dynamics of Machines
4 Credits (3-0-2)
Pre-requisites: APL100
Free and forced vibration of SDOF system. Introduction to 2 DOF systems, vibration absorbers.

MCL131 Manufacturing Processes-I
3 Credits (3-0-0)
Pre-requisites: MCP101
Overlaps with: With three core courses of ME2 (30% each)
CASTING: Sand casting, Gating system and its design, Riser design and its placement, Melting, Pouring and Fluidity, Solidification of pure metals and alloys, Casting defects, Inspection and testing. Other casting processes, advantages and applications.
WELDING: Shielded metal arc welding, other arc welding processes like TIG, MIG and SAW processes, Types of metal transfer in arc welding, Gas welding and Gas cutting, Resistance welding, Solid state welding processes, Brazing, Soldering and their applications, Surfacing and its applications.

MCL132 Metal Forming and Press Tools
3 Credits (3-0-0)
Pre-requisites: MCP101
Overlaps with: 30% with MCL131
Mechanical behaviour of metals and alloys in plastic deformation, Stress-strain relationships, Yield criteria, Fundamentals of plasticity, Tensile properties, Flow stress and flow curves, Fundamentals of metal forming processes, Strain rate and temperature in metal working, Hot working, Cold working and annealing, Analysis of forming processes like forging, rolling, extrusion, wire drawing and sheet metal forming by slab method, Equipment and tools used in metal forming operations, Types of presses, different types of dies and their design aspects, Unconventional forming processes.

MCL133 Near Net Shape Manufacturing
3 Credits (3-0-0)
Pre-requisites: MCP101
Introduction and fundamentals of Casting of complicated shapes: automotive components, casting of light alloys – Aluminum, Magnesium and Titanium alloys.
Injection moulding: Thermoplastics, thermoset plastics and composites – processing methodologies.
Powder Metallurgy: fabrication routes, powder size determination – micro and nano level, powder consolidation routes, compacting, sintering, hot pressing, sintering, hot isostatic pressing, field assisted sintering technologies.
Advances in near net shape manufacturing: Metal Injection moulding, Laser engineered net shaping.

MCL134 Metrology and Quality Assurance
3.5 Credits (3-0-1)
Pre-requisites: MCP101
Overlaps with: MCL231
Introduction to Metrology and its relevance, standardization, dimensional measurement, limits, fits and tolerances, limit gauging, linear and angular measurements and their applications, surface roughness-quantification & measurement, Feature Inspection, Online inspection, Calibration.
Design of sampling plans, Economics of product inspection, Quality costs, Problems and illustrations in Quality Assurance.

MCL135 Welding and Allied Processes
3 Credits (3-0-0)
Pre-requisites: MCP101
Overlaps with: MCP101
Principles of arc welding, basic physics of arc and flame, Gas welding and Gas cutting, manual metal arc welding, GTAW, GMAW. Metal transfer mechanisms in arc welding, Weld bead characterization, Electrodes and electroslag welding, Resistance welding, Heat flow characteristics and metallurgical changes in fusion welding, Solid state welding processes, Radiant energy welding processes, Brazing, Soldering and their applications, Joint design, welding symbols and Joint evaluation through destructive and non destructive testing methods, welding defects, causes and remedies, residual stress and distortion. Plasma cutting, surfacing and plasma spray forming, surfacing applications. Advances in welding.

MCL136 Material Removal Processes
3 Credits (3-0-0)
Pre-requisites: MCP101
Overlaps with: MCP101
Introduction to various material removal processes, Nomenclature and geometry of cutting tools, Mechanics of Conventional and Non Conventional Machining including force, temperature, surface integrity.
Methods of measurement of forces, temperature and surface finish (experimentally and analytically), Tool wear mechanisms and tool life criteria, Basic concepts of cost and economics of machining.
Various types of machine tools and their structures, Workholding and tool holding devices for machine tools.
Ultraprecision machining and grinding methods and the machine tools used for such processes. Manufacturing of micro tools, Nano-finishing of materials using advanced machining methods.

MCL137 Composite Materials
3 Credits (3-0-0)
Pre-requisites: MCP101
Introduction to various material removal processes, Nomenclature and geometry of cutting tools, Mechanics of Conventional and Non Conventional Machining including force, temperature, surface integrity.
Methods of measurement of forces, temperature and surface finish (experimentally and analytically), Tool wear mechanisms and tool life criteria, Basic concepts of cost and economics of machining.
Various types of machine tools and their structures, Workholding and tool holding devices for machine tools.
Mechanical Engineering

Ultraprecision machining and grinding methods and the machine tools used for such processes. Manufacturing of micro tools, Nano-finishing of materials using advanced machining methods.

MCL140 Engineering Thermodynamics
4 Credits (3-1-0)

MCL141 Thermal Science for Manufacturing
4 Credits (3-1-0)
Overlaps with: MCL140, MCL242 (50%), CLL110 (50%)

MCL142 Thermal Science for Electrical Engineers
3 Credits (3-0-0)
Overlaps with: MCL140, MCL141, CLL121

Introduction to Metal Machining and Machine Tools, Geometry of cutting tools, Mechanics of Machining including force and temperature generation, Methods of measurement of forces and temperature (experimentally and analytically), Tool wear mechanisms and tool life criteria, Basic concepts of cost and economics of machining. Various types of machine tools and their development with regard to productivity & accuracy requirements, Workholding and tool holding devices for machine tools.
Introduction to non conventional machining processes and understanding basic mechanisms of material removal in such processes. Introduction to metrology, Dimensional Inspection, Inspection by measurement, Limit gauging, Design of Limit gauges; Surface quality inspection, Feature inspection.

MCL211 Design of Machines
4 Credits (3-0-2)
Pre-requisites: APL104, MCL100, MCL201
Conceptualization of a machine in terms of geometrical requirements specified in terms of functional degrees of freedom, degrees of constraints and stiffness. Synthesis of an assembly from machine components to meet the functional requirements. Sizing machine components and selecting material through use of free body diagrams, failure theories in static and repeated loading. Design and selection of certain machine elements (i.e. cams, gears, belts, pulleys, bearings, springs, shaft/ axle, plates, nuts and bolts, brake/ clutch) as exemplars. Case studies (like Gearbox driven by motor using belt drive) through use of parametric software to carry out iteration in the design space.

MCL212 Control theory and applications
4 Credits (3-0-2)
Pre-requisites: MTL100, MTL101
Overlaps with: 50-60% with ELL301 and CLL261
Introduction; Fourier and Laplace transforms; Mathematical Modeling of simple physical systems; Transfer function; Block diagrams; Signal flow graph; Transient response analysis using Laplace transform; Frequency response; Design/performance specifications in time and frequency domain; Steady state error and error constants; Proportional, integral, derivative, PD and PID control; Sensors and actuators for temperature, pressure, flow and motion control systems; Realization of standard controllers using hydraulic, pneumatic, electronic, electro-hydraulic and electro-pneumatic systems; Stability; Routh's criterion; Nyquist stability criterion, Bode plots; Control system design using Root Locus and Frequency response; Lead and lag compensation; Gain margin, Phase margin; Introduction to Modern control: State space representation; Control with state feedback; Review of applications of control in: Machine tools, Aerospace, Boiler, Engine Governing, Active vibration control.

MCL231 Manufacturing Processes-II
3 Credits (3-0-0)
Pre-requisites: MCL131
Overlaps with: MCL134, MCL136
Introduction to Metal Machining and Machine Tools, Geometry of cutting tools, Mechanics of Machining including force and temperature generation, Methods of measurement of forces and temperature (experimentally and analytically), Tool wear mechanisms and tool life criteria, Basic concepts of cost and economics of machining. Various types of machine tools and their development with regard to productivity & accuracy requirements, Workholding and tool holding devices for machine tools.
Introduction to non conventional machining processes and understanding basic mechanisms of material removal in such processes. Introduction to metrology, Dimensional Inspection, Inspection by measurement, Limit gauging, Design of Limit gauges; Surface quality inspection, Feature inspection.

MCP231 Manufacturing Laboratory-I
1 Credit (0-0-2)
Pre-requisites: MCL131
Overlaps with: MCP223 (60%)
Experiments on casting, joining, forming, injection molding and powder metallurgical processes.
MCP232 Production Engineering Laboratory-I
1 Credit (0-0-2)
Pre-requisites: MCL132, MCL133, MCL134
Overlaps with: MCP231 (60%)
Experiments on casting, forming, injection molding and powder
metallurgical processes.

MCL241 Energy systems and Technologies
4 Credits (3-0.5-1)
Pre-requisites: MCL140
Overlaps with: ESL714 (>50%)
Energy sources:
Fuels: Fossil fuels, Nuclear fuels, Direct Solar, Indirect solar - Biomass,
Ocean, Tidal, Hydro, Wind etc. Energy demand/ Growth/ economics;
Fuel upgradation: gasification of coal and biomass; biogas
Energy conversion: Direct Conversion: Solar PV, Fuel Cells,
Thermoelectric Conversion. Thermal to electric: IC Engines, Gas and
Steam Turbines; Electromechanical conversion; Hydraulic turbines.
Chemical to Thermal: Combustion and stoichiometry.
Energy utilization: Refrigeration, HVAC, Desalination, Polygeneration;
pumps and compressors
Energy storage: Thermal/Mechanical/Electric/Chemical

MCL242 Heat and Mass Transfer
4 Credits (3-1-0)
Pre-requisites: MCL140 & APL106
Overlaps with: CLL251
Modes of heat transfer, energy carriers and continuum approximation.
Mechanisms of mass transfer. Unified view of momentum, heat and
mass transfer.
Conduction: Fourier's law, heat diffusion equation, 1-D steady state
conduction in extended surfaces, heat generation, lumped capacitance
and 1D transient models, semi-infinite wall. Diffusion mass transfer
in 1D: steady state and transient.
Convection: Forced and free convection - mass, momentum and
energy conservation equations, scaling analysis and significance of
non-dimensional numbers, thermal boundary layers, heat transfer
in external and internal laminar and turbulent flows, and use of
correlations. Convective mass transfer. Boiling and condensation:
physical phenomena and correlations.
Heat exchanger types and analysis: LMTD and effectiveness-NTU method.
Radiation: properties, Laws, view factor; 3-surface network for diffuse-
gray surfaces. Gas radiation.

MCL261 Introduction to Operations Research
3 Credits (3-0-0)
Pre-requisites: MTL108
Introduction to Modeling, Linear Programming - Formulation, Solution
methods including Simplex, Primal-Dual, Integer Programming-
Formulation, Solution methods, Introduction to Dynamic Programming,
Software Tools and Case Studies.

MCP261 Industrial Engineering Laboratory-I
1 Credit (0-0-2)
Pre-requisites: MCL261, MCL262
Deterministic optimization problem formulation, solution using CPLEX,
sensitivity analysis; Conceptualization/Visualization of problem situation,
formulation of simulation model, simulation runs and output analysis.

MCL262 Stochastic Modelling and Simulation
3 Credits (3-0-0)
Pre-requisites: MTL108
Overview of Probability Basics, Introduction to Discrete Time
Markov Chains (DTMC), Transient and Limiting analysis of DTMC,
Introduction to Continuous Time Markov Chains (CTMC), Transient
and Limiting analysis of DTMC, Applications, Discrete Event Simulation
- Introduction, Generation of Random Variables, Simulation modeling
through case studies.

MCP301 Mechanical Engineering Laboratory-I
1.5 Credits (0-0-3)
Pre-requisites: APL104, APL106, MCL111, MCL140, MCL241
Experiments pertaining to applications of the concepts learnt in the
theory courses of Fluid Mech, Solid Mech, Thermodynamics, Kinematics
and dynamics and Energy Systems.

MCL311 CAD and Finite Element Analysis
4 Credits (3-0-2)
Pre-requisites: APL104, MCL211
Overlaps with: AML705, 706, 710 (course should be mutually
exclusive w.r.t these courses)
Introduction and overview. Need and Scope of Computer Aided
Machine Design. Role of Geometric Modelling, FE and Optimization;
2D and 3D Geometric transformations and projections. The Viewing
pipeline; Geometric modeling; Modelling of curves, cubics, splines,
beziers and b-splines, NURBS; Modeling of surfaces; Modeling of
solids–b-rep, CSG, octree, feature based modeling; Introduction to
the Finite Element Method, principle of potential energy; 1D elements,
Derivation of Stiffness and Mass matrices for a bar, a beam and a shaft,
FEA using 2D and 3D elements; Plain strain and plain stress problems,
plates/shell elements; Importance of Finite element mesh, Automatic
meshing techniques; Interfacing with CAD software.
Introduction to Thermal analysis, Dynamic analysis using eigen values,
and Non linear analysis; Limitations of FEM.

MCL314 Acoustics and Noise Control
4 Credits (3-0-2)
Pre-requisites: APL100
Overlaps with: MEL733 (20%), MEL746 (50%), ITL 760 (60%)
Fundamentals of acoustics, Reflection and transmission of waves,
Sound sources and generation mechanisms, Human physiological
response to noise, Sound measurement, Sound in enclosed
spaces, Sound absorption, Acoustic enclosures and barriers; Sound
propagation in ducts, Vibration control, Active noise control, Overview
of Numerical acoustics.

MCL321 Automotive Systems
4 Credits (3-0-2)
Overlaps with: MEL311 (10%),
Review of basic engine management systems, alternative fuel systems,
fuel ignition systems, hybrid electric vehicles, exhaust emission
systems, drivetrain systems, chassis, environmental management
and service information systems. Introduction of torque converters,
planetary gears, clutches, differentials, all-wheel drive, heating and
air conditioning systems, and interaction of tyre and road interface.
History of engine technology. Detail of starting and charging systems.
Details of steering and suspension systems. Details of bearing and
lubrication systems.

MCL322 Power Train Design
3 Credits (3-0-0)
Pre-requisites: MCL211
Overlaps with: MEL311 (10%)
Introduction of components of automotive powertrain system, viz.,
engines, transmission, clutches and brakes. Engine characteristics.
Throttle system, Turbochargers, History and design of valve train.
Design of variable valve timing system, Exhaust gas recirculation.
Materials in powertrain components. Lubrication systems to minimize
life cycle costs. Modelling and design of gearbox. Role of control
system in advanced (i.e., direct injection, active boosting, camless)
powertrain system.
MCL330 Special Topics Production Engineering  
3 Credits (3-0-0)  
Pre-requisites: To be defined by the course coordinator at the time of offering the course if required  
Specialized topics in Production Engineering. The detailed contents will be decided by the faculty who will reach the course.

MCL331 Micro and Nano Manufacturing  
3 Credits (3-0-0)  
Pre-requisites: for ME1: MCL131, MCL231  
for ME2: MCL136  
An overview of micro and nano mechanical systems and their applications in Mechanical Engineering, MEMS Microfabrication methods, Silicon Micromachining methods, Laser, Electron and Ion beam micromachining methods, Mechanical Micromachining techniques, Nanomanufacturing methods, nanomaterials and nano metrology.

MCP331 Manufacturing Laboratory-II  
1 Credit (0-0-2)  
Pre-requisites: for ME1: MCL131, MCL231  
for ME2: MCL136  
Experiments on machining and metrology.

MCP332 Production Engineering Laboratory-II  
1 Credit (0-0-2)  
Pre-requisites: MCL135, MCL136, MCP232  
Experiments on machining and welding processes.

MCL334 Industrial Automation  
4 Credits (3-0-2)  
Pre-requisites: ELL100 and APL106 or MCL141  
Overlaps with: 5% with MEL312  
Introduction to Automation technologies, applications around us and in manufacturing. Types of systems - mechanical, electrical, electronics; Sensors, Factory Automation Sensors, Electrical sensors, Process Automation Sensors and their interfaces; Hydraulics & Pneumatic Systems and components; Circuit design approach and examples; Sequence operation of more than two cylinders and motors; Electro Pneumatic & Electro Hydraulic Systems, Relay Logic circuits, Feedback control systems; Programmable Logic Controllers, programming languages & instruction set, ladder logic, functional blocks, structured text, and applications. Human Machine Interface & SCADA; Motion controller, stepper & servo motors, multi axes coordinated motion, CNC control; RFID technology and its application; Machine vision and control applications.  
Laboratory work will be hands-on design and operation of automatic systems.

MCL335 Advances in Welding  
4 Credits (3-0-2)  
Pre-requisites: MCL131 or MCL135  
Introduction to joining technology, General survey and classification of Welding processes, importance of advanced materials and joining technologies, welding technologies related to industries: automotive, aerospace, nuclear, oil and gas industries.

MCL336 Advanced Machining Processes  
3 Credits (3-0-0)  
Prerequisites: MCL231 or MCL136  
Overlaps with: ~20% overlap with MCL231 and MCL136  
Introduction to advanced machining processes – need for such processes and application areas.  
Mechanical Energy utilized advanced machining processes like ultrasonic machining, abrasive flow machining, magnetic abrasive finishing, magneto-rheological finishing, abrasive water jet machining – mechanics of cutting, process parametric analysis, process capabilities, applications.  
Thermolectric based advanced machining processes like electro discharge machining, wire EDM, Plasma Arc Machining, Laser Beam Machining, Focussed Ion Beam Machining – working principles, material removal mechanisms, process capabilities and applications.  
Electrochemical and Chemical Advanced Machining – ECG, Electrostream Drilling, Chemical Machining – process characteristics, numerical modelling of the processes, applications and limitations.

MCL337 Advanced Machining Processes - 4 Credits (3-0-2)  
Pre-requisites: ELL100  
Overlaps with: MEL749, EEL482  
Introduction to mechatronic systems and components, Review of manufacturing and need and integration of mechatronics at different levels, Principles of basic electronics, Digital electronics review: number system, gates, flip-flops, registers, counters, tri-state concept, TTL and CMOS circuits, memories. Embedded electronics, Basics of Microcontroller & Microprocessors architecture and instruction set, machine cycles, interrupts, instruction set, memory and I/O interfacing, programming techniques, Timer/Counters, Serial Interfacing and communications, Interfacing to keyboards and displays, Standard busses. Microcontrollers and their applications, integrated circuits, sensors, actuators, and other electrical/electronic hardware in mechatronic systems. Microprocessor based measurement and control: D/A and A/D conversion, data acquisition systems, encoders, interfacing of motors and transducers. Selection of mechatronic components, namely sensors like encoders and resolvers. Stepper and servomotors; Solenoid like actuators; Transmission elements like Ball screw and Controllers. Analysis of mechatronic systems with applications to motion control, robotics, CNC systems, and others.  
Case studies of applications in process and discrete manufacturing.  
Laboratory work will be hands-on Microcontroller & Microprocessor interfacing and programming, Motion controller, motors, sensors, and actuators.

MCL341 Gas Dynamics and Propulsion  
4 Credits (3-0-2)  
Pre-requisites: MCL140 & MCL241  

MCL343 Introduction to Combustion  
3 Credits (3-0-0)  
Pre-requisites: (MCL140 and MCL242) or MCL141  
MCL344 Refrigeration and Air-conditioning
4 Credits (3-0-2)
Pre-requisites: (MCL140 and MCL242) or MCL141
Overlaps with: ESL850

MCL345 Reciprocating Internal Combustion Engines
4 Credits (3-0-2)
Pre-requisites: MCL140 or MCL141
Overlaps with: <10% with PG I.C. Engine course
Introduction, Engine design and operating parameters, Ideal properties, Models of engine processes and cycles, combustion thermodynamics, fuel/air cycle analysis, Spark-Ignition engine combustion, SI and Diesel engine emissions, IC Engines: the future.

MCL347 Intermediate Heat Transfer
3 Credits (3-0-0)
Pre-requisites: MTL100, MTL101, MCL242
Overlaps with: MCL441 (~20%)

MCL348 Thermal Management of Electronics
3 Credits (3-0-0)
Pre-requisites: APL106 and (MCL242 or MCL141)
Electronics packaging and cooling technologies; Heat sinks: principle, types, modelling, and design; Contact resistance; Heat pipes and two phase systems: principle, types, modelling and design; Microchannel heat exchangers: single phase and two phase; Radiative heat transfer and importance in space applications; Thermoelectric devices; Measurement and characterisation techniques; Case studies of thermal management of electronics.

MCL350 Mechanical Engineering Product Synthesis
2 Credits (1-0-2)
Pre-requisites: Product-related core courses, as specified by the instructor

MCL361 Manufacturing System Design
3 Credits (3-0-0)
Pre-requisites: MTL108, MCL261
Manufacturing strategy, Manufacturing flexibility, Manufacturing complexity, Investment decisions using life cycle costing, System reliability and maintenance models, Economic design of quality control plans, Single and mixed model assembly line balancing, Shop floor scheduling algorithms, Lot sizing and inventory control models, Performance modeling of manufacturing systems, Production control mechanisms like Kanban, CONWIP and POL2.

MCP361 Industrial Engineering Laboratory-II
1 Credit (0-0-2)
Pre-requisites: MCP261, MCL361
Design of optimal acceptance sampling plans, Design of optimal control charts, Simulation of process failures, Simulation of machine failures and Simulation of job shops and production lines with various production control mechanisms.

MCL363 Investment Planning
3 Credits (3-0-0)
Pre-requisites: MCL261 & MCL262
Introduction to investment and rate of return, Markowitz theory and its applications to optimal portfolio management, Introduction to Bonds, Introduction to Derivatives and Options, Concept of Risk Neutral Pricing, Single period and multiple period binomial models for option pricing, Introduction to Black Scholes model and the formula.

MCL364 Value Engineering
4 Credits (3-0-2)
Overlaps with: MEL671

MCL366 OR Methods in Policy Governance
3 Credits (3-0-0)
Pre-requisites: MCL261
Mixed Integer Linear Programming, Markov Decision Processes, Applications of OR techniques to aviation security, resource allocation, energy policy, railways systems, management of natural resources, Public Service Delivery.

MCL368 Quality and Reliability Engineering
3 Credits (3-0-0)
Pre-requisites: MTL108
Process capability analysis, Process quality improvement approaches, Economics of quality control, Reliability data analysis, Component and system reliability models, Reliability test plans, Warranty analysis, Maintenance models.

MCL370 Special Topics in Industrial Engineering
3 Credits (3-0-0)
Pre-requisites: To be defined by the course coordinator at the time of offering the course if required
Specialized topics in Industrial Engineering, The detailed contents will be decided by the faculty who will teach the course.
MCL380 Special Topics in Mechanical Engineering  
3 Credits (3-0-0)  
Pre-requisites: courses as specified by the instructor and EC 50  
Course details shall be announced at the time of offering of the course. The assessment will be based on a combination of assignments, quizzes, and term paper and tests.

MCV390 Special module in Mechanical Engineering  
1 Credit (1-0-0)  
Pre-requisites: courses as specified by the instructor and EC 50  
Course details shall be announced at the time of offering of the course. The lectures will be supplemented by reading materials. The assessment will be based on a combination of assignments, quizzes, and term papers (to be announced by the instructor) and tests.

MCP401 Mechanical Engineering Laboratory-II  
2 Credits (0-0-4)  
Pre-requisites: MCL211, MCL212, MCL242, MCP301  
The experiments would involve full or partial fabrication of setups and then taking readings and analysis of its behavior, instead of using ready made setups. The knowledge gained in control engineering course would also be used for setting up computerised measurements using Data acquisition cards.

MC411 B.Tech. Project-I  
4 Credits (0-0-8)  
Pre-requisites: EC 100  
A broad outline of the contents is as follows and a project may include some or all of these activities:  
Team formation for designing, manufacturing and operating a selected product, formulating project management procedures. Need identification, assessment of alternative designs, selection of design for development, defining design and performance specifications, and testing procedure. Detailed mechanical, thermal and manufacturing-related design of systems, assemblies, sub-assemblies and components culminating in engineering drawings and material specifications; preparing bill of materials and identification of standard components and bought-out parts.  
Using engineering drawings, the process sheets are developed based on available materials, machine tools and other fabrication facilities. Materials and standard components are procured and manufacturing is carried out. After inspection, parts are accepted. Assembly procedure is finalized and the machine is assembled. Acceptance tests are carried out vis-à-vis specifications. Professional quality documentation of all designs, data, drawings, and results, change history, overall assessment, etc. is mandatory, along with a final presentation.

MC412 B.Tech. Project-II  
7 Credits (0-0-14)  
Pre-requisites: EC 100  

MCL421 Automotive Structural Design  
3 Credits (2-0-2)  
Pre-requisites: MCL211, MCL321  
Overlaps with: MELT36 (40% - Students should be allowed to do only one of the two courses)  
History of automotive design, Design cycle for an Automobile, Styling, Loads on the chassis, Chassis and structural Design for static loads, Dynamic and Impact loads, Energy absorption in the vehicle, Designing for NVH, Designing the suspension system, Designing the brake system.

MCL422 Design of Brake Systems  
3 Credits (2-0-2)  
Pre-requisites: APL104, MCL111, MCL321  
Types of brakes, Friction materials in brakes and their characteristics, Design of brakes in passenger cars/ vans: weight transfer, effect of tyre/road adhesion, wheel lock, brake efficiency/adhesion utilization; Design of brakes in vehicle – trailer combinations: in light trailers, overrun brakes, center axle trailer, chassis trailer; Brake-design analysis: Brake and shoe factors in different types of brakes, Comparison of estimation by analytical and FE methods; Thermal effects in friction brakes (thermal analysis and heat dissipation); Issues in electronic control of brakes: features of anti-lock brake system, Traction Control System, Electronic Stability Control, Adaptive Cruise Control, trailer Sway Control; Brake Noise: Sources, its analysis (using analytical and FE based approaches) and control.

MCL431 CAM and Automation  
3 Credits (2-0-2)  
Pre-requisites: for ME1: MCL131, MCL231  
for ME2: MCL136  
Automation need and types of automation, economics of automation, FMS, CIM. Basics of electro-mechanical automation technologies, Circuit design and applications of hydraulic, pneumatic, electro-pneumatic, electro-hydraulic and programmable logic control (PLC) systems. Numerical control, NC and CNC hardware and programming, Machine controls, HMI design and implementation, DNC system, Control engineering in production systems: open loop and closed loop control systems, Automated material handling technologies, Group technology, Computer aided process planning, Inspection automation and reverse engineering, Rapid prototyping and tooling concepts and applications, virtual manufacturing.

MCL441 Modelling and Experiments in Heat Transfer  
4 Credits (2-0-4)  
Pre-requisites: (MCL242 or MCL141) and MCP301  

MCL442 Thermofluid Analysis of Biosystems  
3 Credits (3-0-0)  
Pre-requisites: APL106 and [(MCL140 & MCL242) or MCL141] and EC 80  
Applications of fluid mechanics, heat transfer, and thermodynamics to biological processes, including blood flow in the circulatory system, heart function, effects of heating and cooling on cells, tissues, and proteins.

MCL443 Electrochemical Energy Systems  
3 Credits (3-0-0)  
Pre-requisites: MCL140 & MCL242 or MCL141 and EC 80  
Overlaps with: CL722 (30%), CL720 (10%), CL721 (15%)  
MCL701 Advanced Thermodynamics
3 Credits (3-0-0)
Review of basic fundamentals, closed system and open system formulations, laws of thermodynamics, the maximum entropy principle, concept of equations of state, ideal gas, van der Waals equations and other variants, compressibility, maximum work theorem, exergy, energy minimum principle, thermodynamic potentials and relationships for compressible, elastic, electric and magnetic systems, stability conditions of potentials, multicomponent systems, entropy of mixing, chemical potential, mixtures, conditions of equilibrium and stability of multicomponent systems, thermodynamics of reactive mixtures.

MCL702 Advanced Fluid Mechanics
3 Credits (3-0-0)
Formulation of Navier-Stokes equations. Exact solutions of the Navier-Stokes equations for select unsteady/steady flows, potential flows, boundary layer theory and its applications, turbulent flows; special topics in fluid mechanics such as capillary and electrokinetic flows.

MCL703 Advanced Heat and Mass Transfer
3 Credits (3-0-0)


MCL704 Applied Mathematics for Thermofluids
3 Credits (3-0-0)
Initial-boundary value problems, Linear and Non-linear systems; Theory of linear homogeneous and nonhomogeneous equations; Non-linear systems; Series solutions of linear ordinary differential equations; special functions; 1st order PDEs, classification of PDEs: 2nd order PDE - Planar, cylindrical and spherical geometries, Homogeneous and non homogeneous PDEs, Strum-Liouville theory; Stability and instability of regular system.

MCL705 Experimental Methods
4 Credits (3-0-2)

MCL721 Automotive Prime Movers
3 Credits (3-0-0)

MCL722 Mechanical Design of Prime Mover Elements
3 Credits (3-0-0)

MCL723 Vehicle Dynamics
3 Credits (2-0-2)

MCL724 Biomechanics in Trauma and Automotive Design
3 Credits (3-0-0)

MCL725 Design Electronic Assist Systems in Automobiles
3 Credits (3-0-0)

MCL726 Design of Steering Systems
3 Credits (3-0-0)
Introduction of steering requirements and system; steady-state cornering – slip angle effects, steady-state turns, calculating steady-state steering characteristics, lateral weight transfer effect, traction effect, neutral steer point and static margin, swing axle; steady-state cornering – steer effects, roll effects, wheel control, understeer and oversteer effects, torque steer, lateral deflection steer, straight running, suspension geometry effects, effect of road surface, wind handling; transient cornering, steering when moving forward, steering when moving reverse, boat steering and truck in reverse; examples of steering system; conclusion.
Mechanical Engineering

MCL728 Nanotribology
3 Credits (3-0-0)
Topics will include surface force and adhesion models for soft and hard solids; friction laws for nano, micro and macro contacts; atomic-scale stick-slip phenomenon; the roles of surface energy and surface forces on friction and wear; molecular structure effects on friction; nano-lubrication and design of nano-lubricants (self-assembled monolayers, ultra-thin films of functionalized polymers); nano-texturing and surface roughness effects; surface chemisorptions and physisorption effects; friction-induced effects such as wear, molecular alignments, tribocharging, surface oxidation, third-body generation etc. The above principles would be applied to modern technologies such as data storage (head-disk interface) tribology, various micromachines such as micro-electromechanical systems (MEMS) tribology and nature's solutions to tribological problems through a few case studies.

MCL729 Nanomechanics
3 Credits (2-0-2)
Introduction to nanomechanics, need for studying nanomechanics, its scope and limitations: Dynamics of 2-atom, 3-atom molecules, and an N-atom chain; Crystal Lattice and Reciprocal Lattice; Dynamic Interaction Potentials and Periodic Boundary Conditions in molecular dynamics simulations; Role of different ensembles; Evaluation of atomic stresses and strains, Evaluation of Specific Heat, Dissipation of Energy in nano-mechanical Systems; Solutions for classical Nano scale structural components such as Carbon Nanotubes, Nano rods, Nanowires and Polymers; Correlations between Nano-mechanics and classical continuum theory of solids; Size effect; Introduction to multiscale modeling.

MCL730 Designing with advanced materials
4 Credits (3-0-2)
Introduction to polymers, composites and smart materials. Polymer microstructure and mechanical properties. Thermosets and thermoplastics. Viscoelastic creep and relaxaion behavior, mechanical models, and polymer failure. Design considerations and practices for polymeric components with case studies. Composite materials and their applications. Micro and macro mechanics of lamina, failure criteria of lamina, classical laminate theory, strength of laminates. Design considerations and practices for composite structures with case studies. Structure, applications and design considerations of smart materials such as shape memory alloys and piezoelectric materials.

MCL731 Analytical Dynamics
3 Credits (3-0-0)
Review of Newtonian dynamics; Degrees of freedom; Generalized coordinates and constraints; Holonomic and nonholonomic systems; Principle of Virtual work; D'Alembert's principle; Euler-Lagrange equations of motion; Hamilton's principle; Rotating coordinate systems; Euler angles; Coordinate transformation; Kinematics of a rigid body; Euler's equations of rotation; Computer-oriented dynamic modeling; Orthogonal-complement based formulation of dynamic equations; Geometric theory; Stability; Lyapunov's direct method; Introduction to flexible-body dynamics.

MCL733 Vibration and Noise Engineering
3 Credits (3-0-0)

MCL735 CAD and Finite Element Analysis
4 Credits (3-0-2)

MCL736 Automotive Design
4 Credits (3-0-2)
History of automotive design, Design cycle for an Automobile, Styling, Loads on the chassis, Chassis and structural Design for static loads, Dynamic and impact loads, Energy absorption in the vehicle, Computational tools for structural design, vehicle occupant system analysis, biomechanics of the human body and its implications for structural design, Designing for NVH, Designing the suspension system, Designing the brake system, Design of engine characteristics, Design requirements of the transmission and the driveline.

MCL738 Dynamics of Multibody Systems
3 Credits (2-0-2)
Overview of kinematic descriptions of serial, tree, and closed-loop chains, Degrees of freedom, and Kinematic constraints of rigid and flexible systems; Basics of Euler-Lagrange and other classical dynamic formulations, and those with orthogonal complements; Dynamic algorithms (inverse and forward dynamics); Efficiency and numerical stability aspects of the algorithms; Introduction to commercial software like RecurDyn.

MCL740 Advanced Lubrication
4 Credits (3-0-2)
Introduction: surface topography and its 2-D and 3-D characterizations, interactions of surfaces, friction, wear, lubrication; Regimes of lubrication: hydrodynamic, elastohydrodynamic, mixed, boundary, Strubeck curve; Lubrication: mineral oil, synthetic oil, grease, emulsions, gases, properties of lubricants, various rheology models; Derivation of governing equations: conservations of mass, momentum, energy, establishing 3-D Reynolds equation and energy equation for lubrication simulations; Cavitation and turbulence models; Contact mechanics: 2-D and 3-D contacts, surface and subsurface stresses, asperity contact models, elastic deformation at contacts; Applications of governing equations in design and performance analysis of journal bearings, thrust bearings, squeeze film bearings, hydrostatic bearings, rolling bearings, gear sets, seals, and piston rings; Lubrication in metal forming; Dynamic coefficients: stiffness and damping calculations, rotor vibrations, oil-whirl instability, and friction instabilities; Failure analysis of lubricated contacts/interfaces, Immersing technology: surface textures and bionic surfaces.

MCL741 Control
4 Credits (3-0-2)
An introduction to control systems; transfer function representation of mechanical and mechatronic systems; stability analysis, gain setting for stability; transient and steady-state response analyses; control system analysis and design by the Root-Locus method and the Frequency-Response method; PID controllers design and realization; State-Space representation, controllability and observability; control system design in State Space; digital implementation of classical controllers.
MCL742 Design & Optimization
4 Credits (3-0-2)
Review of machine element design based on strength and distortion criterion; review of choice of materials and their treatment: Designing for fatigue, creep; Design criterion for fracture; Application of advanced design criterion to machine elements (like shafts, spur/bevel/worm gears); Design of structures, machines and equipment; Classical methods of unconstrained optimization (single variable and multi variable), classical methods of constrained optimization, Numerical optimisation techniques including i. genetic algorithms, (binary and real coded) ii. Simulated annealing. Case studies of Optimum Design (Gear Box, Power Transmission, shape and topology using FE).

MCL743 Plant Equipment Design
3 Credits (3-0-0)
Introduction to various kinds of plant equipment, and technological considerations in their design. Special considerations for typical industries such as petrochemicals, food-processing, power plants, and for mass production. Pressure vessel types and shapes. Design analysis of thin walled vessel for low pressure applications. Design analysis of thick walled vessels for high pressures and special applications. Vessel opening, closures and seals. Manufacturing considerations for pressure vessels. Configuration of various kinds of pumps used in process plants. Pump design considerations. Centrifugal pump selection. Design of pipes and piping joints, Layout of piping systems. Material Handling Equipment, Types and use. Design considerations for hoisting equipment, Surface and Overhead equipment Stackers and elevators, and conveyors. Design consideration in rotating machinery, bearing characteristics and selection, placement of critical speeds, effect of seals and foundation effects. Materials and manufacturing considerations in various plant equipment systems, and use of applicable standards, and available software packages.

MCL744 Design for Manufacture and Assembly
3 Credits (2-0-2)
Product design for life-cycle, concurrent engineering, dfx, design for manufacture, rule-based and plan based DFM, automated manufacturability assessment, Automated manufacturability assessment, Commonly used dfx tools including, QFD, POKA YOKE, FMEA, Design for manual assembly and automated assembly, design for environment, Industrial and real life case studies of dfx.

MCL745 Robotics
4 Credits (3-0-2)
Type and components of robots; Classification of closed- and open-loop kinematic systems; Definition of mechanisms and manipulators; Kinematic constraints; Degrees of freedom and mobility; Rotation representation; Coordinate transformation; DH parameters; Matrix methods for forward and inverse kinematics analyses; Jacobian and singularity; Dynamic modeling; Euler-Lagrange and Newton-Euler equations of motion for serial type manipulators; DeNOC-based dynamic formulation; Inverse and forward dynamics algorithms; Parallel robots; Inverse and forward kinematics of parallel robots; Gain singularity of parallel robots; Introduction to control of robotic systems.

MCL746 Design for Noise Vibration and Harshness
4 Credits (3-0-2)

MCL747 Design of Precision Machines
3 Credits (2-0-2)
Pre-requisites: For UG:AML140, MCL111, MCL211
Fundamental concepts in precision design; design for stiffness; controlling Degrees-of-Freedom, exact-constrained design; design of elastic mechanisms/flexures/compliant mechanisms; friction, hysteresis and micro-slip; actuators and sensors for precision motion; materials selection in precision machine design; slideways for long range precision motion; and dynamics of precision mechanisms.

MCL748 Tribological Systems Design
4 Credits (3-0-2)

MCL749 Mechatronic Product Design
4 Credits (3-0-2)
Pre-requisites: For UG : ELL100, MCL338
Overlaps with: EEL482
Introduction tokey elements of Mechatronic products - Physical Systems Modeling, Sensors and Actuators, Signals and Systems, Computers and Logic Systems, Software and Data Acquisition; Mechatronic Design Approach, System Interfacing, Instrumentation and Control Systems; Microprocessor-Based Controllers and Microelectronics; Product functional block diagram, schematic and PCB Design, Product enclosure design, Microcontroller interfacing and programming, Interfacing with sensors and actuators, driver circuits, motion control, Stepper and servo motion control. Software and hardware tools to build mechatronic systems. Design and selection of mechatronic elements namely sensors like encoders and resolvers; stepper and servomotors, ball screws, solenoid like actuators, and controllers with applications to CNC systems, robotics, consumer electronic products etc. Design of a mechatronic product using available software CAD packages. Laboratory work will be hands-on Microcontroller & Microprocessor interfacing and programming, Motion controller, motors, sensors, and actuators.

MCL750 Product design and Manufacturing
3 Credits (1-0-4)
Product design for a given need or identified need, Development and evaluation of multiple solutions and concepts, Manufacturability assessments of given design, Product Costing and Bill of Materials, Process planning for components and assembly, Product manufacturing and Testing.

MCL751 Industrial Engineering Systems
3 Credits (1-0-4)
Overview of IE methods and tools such as decision making under uncertainty (Pay-off tables, decision trees, utility theory etc.), Probability based methods for outcome prediction (Logistic regression, Bayesian belief networks, Monte Carlo simulation etc.), Multicriteria decision making (AHP, ANP, Graph theory etc.), System Simulation (through games like the Beer game for supply chain), Queuing theory games, Economic analysis (NPV, IRR etc. for deterministic and stochastic scenarios), Algorithems (branch and bound, Metahueristics etc.). Formulation of bigger optimization problems and solving using available solvers (eg. CPLEX), Shop-floor scheduling.

MCL753 Manufacturing Informatics
4 Credits (3-0-2)
Pre-requisites: MCL361
Introduction to manufacturing analytics (manufacturing analytics concepts, contemporary issues in high-value manufacturing, and
opportunities provided by analytics and big data technologies), data types and applications (point of sale data, service touch point data, service centre data, warranty data, machine condition data, machine failure history, machine utilisation data, work in process data and online quality control data), optimisation of manufacturing processes (optimisation concepts, evolutionary computing, multi-objective optimisation, and applications of optimisation for sequential and assembly processes), and latest advancements in manufacturing analytics (virtual reality, augmented reality, and motion capture capturing technologies for manufacturing).

MCL754 Operations Planning and Control
3 Credits (3-0-0)
Evolution of Scientific Management and Buzzwords, Inventory Management and Control, MRP and ERP, JIT, Modeling of Processes and Systems, Measuring and Improving Performance, Scheduling, Aggregate Production Planning, Facility Location.

MCL755 Service System Design
3 Credits (2-0-2)
Pre-requisites: MTL108
Need for servitzation, Service system types, Key dimensions of service systems, Frameworks for service system design, tools for service system design, Value co-creation, Service quality models, Economics of service systems, Service contract design, OMNI-SVC model for service systems, Case studies on service system design.

MCL756 Supply Chain Management
3 Credits (3-0-0)
Pre-requisites: MCL361
Supply Chain Orientation and Management, Various flows in a typical supply chain, Supply chain strategy – its context, components and structure, Location Decisions, Inventory Decisions, Information Decisions – Bull whip effect and its ramifications, remedies, Transportation Decisions - including planning techniques, Supply chain modeling and analysis, Performance measurement; Various frameworks including Balanced Score Card, SCOR etc., Customer Service level selection and supply chain vulnerabilities, Reverse Logistics and decision making involved, Supply chain integration and web enabled supply management.

MCL757 Logistics
3 Credits (3-0-0)
Logistics Management is the part of supply chain management that plans, implements, and controls the efficient, effective forward and reverse flow and storage of goods, services, and related information between the point of origin and the point of consumption in order to meet customers' requirements.

This course provides a practical, management perspective of the following areas of logistics: distribution, transportation, international logistics, inventory control, sustainable logistics practices, key performance indicators, supply chain finance, leadership in a supply chain role, and an introduction to logistics technology including RFID and ERP systems.

MCL758 OPTIMIZATION
3 Credits (3-0-0)
Optimization Theory in single and multiple dimensions, Karush-Kuhn-Tucker Conditions, Non Linear Programming, Solution Methods, Stochastic Programming, Applications and case studies.

MCL759 Entrepreneurship
3 Credits (3-0-0)
Ideaation, Team Building, Making of a Business Plan, Securing Funding, Legal Procedures, Case studies of successful and failed attempts.

MCL760 Project Management
3 Credits (3-0-0)
Pre-requisites: MTL108
The nature of projects, the project as a non-repetitive unit production system, the project as an agent of change. Project Identification considering objectives and SWOT analysis, Screening of project ideas, Technical, Market, Financial, Socio-economic and Ecological Appraisal of a project. Work break down structure and network development. Basic Scheduling, Critical Path and four kinds of floats, Scheduling under probabilistic durations, Time Cost tradeoffs, Project Monitoring with PERT/Cost, Organizational aspects, Computer packages and project completion.

MCL761 Probability and Statistics
3 Credits (3-0-0)

MCL765 Operations Research
3 Credits (3-0-0)
The art and science of modeling, Linear Programming, Solution methods including Simplex, Sensitivity Analysis, Shadow Pricing and Duality Theory, Integer Programming and Solution methods, Dynamic Programming with applications, Large Canonical problems such as Transportation Problem, Traveling Salesman Problem, Network Flow Problem, Case Studies.

MCL769 Metal Forming Analysis
4 Credits (3-0-2)
Revision of fundamentals of plastic deformation and metal forming, Constitutive equations for plastic deformation, effect of strain, strain rate and temperature, Theory of plasticity, Analysis of important bulk forming processes and sheet metal forming processes, Workability, Upper and lower bound methods, Slipline field theory, Defects in sheet metal forming, Introduction to FE analysis of forming processes.

MCL770 Stochastic Modeling and Simulation
3 Credits (3-0-0)

MCL771 Value Engineering and Life Cycle Costing
3 Credits (3-0-0)

MCL772 Reliability Engineering
3 Credits (3-0-0)
Time to failure distributions; Parameter estimation for non-repairable systems; Reliability models for series, parallel and mixed configurations; Reliability models for active/passive redundancy,
load sharing systems, mixed population, competing failure modes; Stress-Strength models; Conditional reliability models and residual life calculation; Reliability models for multiple operational phases; Shock based reliability models; Reliability models for non-repairable systems; Parameter estimation for repairable systems, Failure Mode and Effects Analysis, Fault Tree Analysis; Failure simulation; Warranty cost analysis; Reliability allocation; Reliability of production systems; Test plan design for non-accelerated life tests; Accelerated life testing models; Burn-in test plans.

**MCL773 Quality Systems**  
3 Credits (3-0-0)  
Introduction to quality systems through approaches proposed by Juran, Deming, Baldrige, Taguchi, Crossby etc., Quality costs, Requirements analysis using methods like Kano's analysis, Requirement mapping using QFD, Product and process analysis using Design and Process FMEA, Robust design and process improvement using online and offline methods for design and analysis of experiments, Shainin's tools for variability reduction, Process capability analysis and loss functions, Statistical tolerancing, Design of control charts and acceptance sampling plans, Quality standards like ISO 9000, ISO 14000, CMMI etc.; Service quality models and Service blueprints and Service FMEA, Case studies.

**MCL775 Special Topics in Industrial Engineering**  
3 Credits (3-0-0)  
To be decided by the instructor at the time of offering.

**MCL776 Advances in Metal Forming**  
3 Credits (3-0-0)  
Pre-requisites: For UG: MCL131 or MCL132; for PG MCL769  
Advanced metal forming processes such as tube and sheet hydroforming, High energy rate forming processes such as EMF, EHF and explosive forming. Design of dies for forging, extrusion and wire drawing, Die design for sheet metal forming processes such as single and multi-stage deep drawing, bending and stretch forming. Materials used for making forming tools, Lubrication mechanisms, Metal forming equipment, Formability testing of sheet metals, Determination of Forming Limit Diagrams and their applications, Warm forming, Micro forming.

**MCL777 Machine Tool Design**  
4 Credits (3-0-2)  
Pre-requisites: MCL231 or MCL136  
Course will cover machine tool design process which will include machine tool specifications, conceptual design, configuration design, mechanical structure design, design of drives & controls. Methods of achieving required mechanical accuracies considering static, dynamic and thermal loads, geometric, kinematic and thermal error compensation. Machine tool acceptance tests and characterization of machine tools for no-load and load conditions.

**MCL778 Design and Metallurgy of Welded Joints**  
4 Credits (3-0-2)  
Importance of welding in fabrication, Problems and difficulties in welded structures, service and fabrication tests and their importance, weld testing and qualification, causes and remedies for weld defects, weld symbols, weld joint design for strength and quality and automation in welding.

**MCL780 Casting Technology**  
4 Credits (3-0-2)  
Sand casting: sand molding techniques, Core sand and core fabrication. Other casting: Permanent mold, pressure die casting, squeeze casting, centrifugal casting, continuous casting, stir casting, defects and inspection. Gating system, risering system, casting design: Metallurgical consideration, design consideration, economical consideration. Fluidity testing, Application of CAD/CAM in foundry.  
Casting of complicated shapes: automotive components, casting of light alloys – Aluminum, magnesium and Titanium alloys.  
Advances in near net shape manufacturing: Metal Injection moulding, Laser engineered net shaping.

**MCL781 Machining Processes and Analysis**  
4 Credits (3-0-2)  
Introduction to basic traditional machining processes – the need and requirements for such processes and their brief application areas. Specifications and geometry of various cutting tools such as turning tools, drills, milling cutters in different referencing systems such as work reference, tool reference and machine reference systems. Methods and techniques used for sharpening/resharpening of these cutting tools.  
Mechanisms of chip formation by single point, drilling and milling tools. Different types of chips obtained during machining. Concept of effective rake angle during machining.  
Mechanics of machining of single point cutting tool, drill and milling cutter – estimation of cutting forces using analytical models, Experimental methods and instruments used for cutting force determination during machining processes, essential design features of the dynamometers used for such measurement.  
Heat transfer during machining processes, identification of the different sources of heat generation and development of suitable models for analytical estimation of the cutting temperature, Experimental methods used for estimating cutting temperature. Use of cutting fluids in machining – purposes, proper selection and methods of application of such cutting fluids. Advanced cutting tool materials and processes used for development of such tools.  
Mechanics of cutting tool wear and development of models for assessing the tool life. Economics of machining – identifying the major parameters in machining and their roles on cutting force, surface finish and cutting temperature, selection of optimal conditions of process parameters to reduce machining costs through suitable models.  
Introduction to Grinding processes and understanding of the differences between machining and grinding.  
Grinding for bulk material removal – creep feed grinding – fast feed grinding.  
Superabrasive grinding wheels – both monolayer and multilayer, advantages of the monolayer wheel and its applications.  
Grinding Geometry and Kinematics – contact length – measurement of contact length definition of active grits and methods used for estimating active grits, use of single grit experiments to develop models for estimating forces and specific energy requirement in grinding.  
Wheel Conditioning – truing and dressing techniques and parameters – effect of dressing on grinding wheel parameters – dressing of super-abrasive wheels.  
Temperature generation during grinding process and thermal modelling of the process.  
Special Machining and grinding processes such as • Ductile Regime Grinding • Diamond Turning.

**MCL782 Computational Methods**  
2 Credits (2-0-0)  
Errors in numerical calculations and series approximations, Solution of algebraic and transcendental equations, Interpolation of data, finite differences, Curve fitting, Numerical differentiation and integration, Matrices and linear system of equations, Numerical solution of ordinary differential and partial differential equations, Solution of integral equations, Numerical solution of important production engineering problems.
MCL783 Automation in Manufacturing
4 Credits (3-0-2)
Introduction to Automation of different manufacturing processes. Types of systems - mechanical, electrical, electronics; Data conversion devices, transducers, signal processing devices, relays, contactors and timers. Sensors and their interfaces; Hydraulics & Pneumatic Systems design and their applications to manufacturing equipment; Sequence operation of hydraulic and pneumatic cylinders and motors; Electro Pneumatic & Electro Hydraulic Systems design, Relay Logic circuits, Feedback control systems, PID Controller; Drives and mechanisms of an automated system: stepper motors, servo drives. Ball screws, linear motion bearings, electronic camming and gearing, indexing mechanisms, tool magazines, and transfer systems. Programmable Logic Controllers, I/Os, system interfacing, ladder logic, functional blocks, structured text, and applications. Human Machine Interface & SCADA; Motion controller and their programming, PLC/Open Motion Control blocks, multi axes coordinated motion, CNC control; RFID technology and its application; Machine vision and control applications. Modular Production Systems – Distribution, Conveying, Pick & Place etc. Laboratory work will be hands-on design and operation of automatic systems.

MCL784 Computer Aided Manufacturing
4 Credits (3-0-2)
An overview of Computer Aided Manufacturing, Use and Programming of Computer Controlled Machines such as CNC, 3D Printing, CMM, Robots etc. Constructional aspects of computer controlled machines. Geometric modeling and computational geometry for manufacturing. Product Life-cycle modeling. Virtual and Distributed Manufacturing.

MCL785 Advanced Machining Processes
3 Credits (3-0-0)
Introduction to advanced machining processes – need for such processes and application areas
Mechanical Energy utilized advanced machining processes like ultrasonic machining, abrasive flow machining, magnetic abrasive finishing, magneto-rheological finishing, abrasive water jet machining – mechanics of cutting, process parametric analysis, process capabilities, applications.
Thermoelectric based advanced machining processes like electro discharge machining, wire EDM, Plasma Arc Machining, Laser Beam Machining, Focussed Ion Beam Machining – working principles, material removal mechanisms, process capabilities and applications.
Electrochemical and Chemical Advanced Machining – ECG, Electrostream Drilling, Chemical Machining – process characteristics, numerical modelling of the processes, applications and limitations.

MCL786 Metrology
3 Credits (2-0-2)

MCL787 Welding Science and Technology
4 Credits (3-0-2)
General survey and classification of welding processes, importance of advanced materials and joining technologies, weld arc physics, power sources and their characteristics, welding technologies related to industries: automotive, aerospace, nuclear, oil and gas industries.

MCL788 Surface Engineering
4 Credits (3-0-2)
Introduction to surface engineering – importance and scope of surface engineering, conventional surface engineering practices like pickling, grinding, buffing etc., surface engineering by material addition like electroplating, surface modification of ferrous and non-ferrous materials like nitriding, cyaniding, aluminizing etc. Advanced surface engineering practices like laser assisted surface modification, electron beam assisted modification, spraying techniques like flame and plasma spraying, high velocity oxyfuel, cold spray techniques. Sputter deposition processes, PVD and CVD methods of surface coatings, surface modification by ion implantation and ion beam mixing Characterisation of the engineered surface and coatings like thickness, porosity and adhesion of coatings, surface microscopy and spectroscopic analysis of the modified surfaces. Functional coatings and their applications.

MCP790 Process Engineering
4 Credits (2-0-4)

MCL791 Processing and Mechanics of Composite Materials
4 Credits (3-0-2)

MCL792 Injection Molding and Mold Design
3 Credits (2-0-2)
Introduction to Injection molding fundamentals, flow of non-Newtonian fluids, flow of various polymer melts in a cavity, molding cycle, injection molding machine characteristics- injection unit design, clamping unit design, shrinkage, warpage, defect free product. Moldflow analysis – fundamentals of FE analysis for fill, cool, warp, stress, DOE, results interpretation. Mold design fundamentals, type of molds - two plate, three plate, feeding system – sprue, runner, gate design, ejection system - pin, sleeve, stripper plate, air ejection design. Moldings with undercuts – internal, external, threads, split cavity, split core designs. Advances in injection molding process- microcellular, gas assisted, insert, outset, pull-push, multi-cavity, vibration assisted, micro lamellar, lost core. Designing with plastics, applications and future research.

MCL796 Additive Manufacturing
4 Credits (3-0-2)
surface finish, build time, support structure, cost etc. Various Rapid
tooling techniques. Introduction to Reverse Engineering. Reverse
engineering and Additive Manufacturing.

MCD800 Professional Project Activity
3 Credits (0-0-6)
Project Work.

MCD810 Major Project Part-I (Thermal Engineering)
12 Credits (0-0-24)

MCD811 Major Project Part-I (Thermal Engineering)
6 Credits (0-0-12)

MCL811 Advanced Power Generation Systems
3 Credits (3-0-0)
General Introduction to current power generation technology and
need for advances systems. Analysis of Advanced Ultra super-critical
power plants, Organic Rankine Cycle based systems, Power systems
using mixtures as working fluids. Sizing of components for the selected
systems. Design of power systems for solar, biomass and geothermal
sources. Thermo-fluid analysis of solar PV systems. Hybrid solar
PV-thermal systems. Recent developments in hydro power systems.

MCD812 Major Project Part 2 (Thermal Engineering)
12 Credits (0-0-24)

MCL812 Combustion
3 Credits (3-0-0)
Introduction - importance of combustion. Chemical thermodynamics
and chemical kinetics. Important chemical mechanisms. Coupling
chemical and thermal analysis of reacting systems. Premixed systems:
detonation and deflagration, laminar flames, burning velocity,
flammability limits, quenching and ignition. Turbulent premixed flames.
Non-premixed systems: laminar diffusion flame jet, droplet burning.
Combustion of solids: drying, devolatilization and char combustion.
Practical aspects of coal combustion, woodstove combustion.

MCL813 Computational Heat Transfer
4 Credits (3-0-2)
Mathematical Description of the Physical Phenomena- Governing
equations—mass, momentum, energy, species, General form of the
scalar transport equation, Elliptic, parabolic and hyperbolic equations.
Discretization Methods- Introduction to finite difference and finite
volume method, Consistency, stability and convergence.
Diffusion Equation- 1D-2D steady diffusion, Source terms, non-linearity,
Boundary conditions, interface diffusion coefficient, Under-relaxation,
Solution of linear equations (preliminary), Unsteady diffusion, Explicit,
Implicit and Crank-Nicolson scheme.
Convection and Diffusion- Steady one-dimensional convection and
diffusion, Upwind, exponential, hybrid, power, QUICK scheme, Two-
dimensional convection-diffusion.
Flow Field Calculation- Incompressibility issues and pressure-velocity
coupling, Primitive variable versus other methods, Vorticity-stream
function formulation, Staggered grid, SIMPLE family of algorithms.
Radiative heat transfer - Computation of surface radiation using zone
method, Solution of radiative transfer equation using discrete transfer,
discrete ordinates and finite volume methods.

MCL814 Convective Heat Transfer
3 Credits (3-0-0)
Derivation of energy equation-Similarity solutions for laminar
external flows-Laminar internal flows-Transition flow-Heat transfer
in transition flow-Reynolds averaged equations of motion, Averaged
energy equations-Turbulent flow and heat transfer over a flat
plate-Turbulent flow and heat transfer in pipes and channels-
Laminar and turbulent natural convection-laminar and turbulent
mixed convection - Pool boiling : nucleate boiling-film boiling, flow
boiling-condensation : dropwise condensation-film condensation
Nusselt theory-Special topics-Convective heat transfer in rotating
systems, Microscale convective heat transfer, Convective heat
transfer with nano-fluids, Combined convection and radiation,
Double diffusive convection.

MCL815 Fire Dynamics and Engineering
4 Credits (2-0-4)
Basics of Conservation equations, Turbulence, radiation and
thermochemistry. Ignition of solids- Burning and heat release rates.
Properties of fire plumes- buoyant plumes and interactions with
surfaces. Turbulent diffusion flames- structure, modeling, soot
formation and radiation effects. Toxic products. Fire chemistry, thermal
decomposition of bulk fuel, pyrolysis, nitrogen and halogen chemistry.
Fire growth- ignition, initial conditions, flame and fire spread theory,
feedback to fuel. Compartment zone models. Flashover, post-flashover
and control. Fire detection, suppression methods, codes, standards
and laws. Case studies of real fires- buildings, transport, industries,
shamiana and jhuggi-jhopodi etc.

MCL816 Gas Dynamics
4 Credits (3-0-2)
Revision of fundamentals. Thermodynamics of compressible flow
- wave motion in compressible medium, Mach number and cone,
properties. Steady one-dimensional compressible flow through
variable area ducts. Converging and converging-diverging nozzles
and diffusers. Effects of heating and friction in duct flow, Rayleigh
and Fanno lines. Flows with normal shocks. Oblique shocks and
Measurements and applications. Jet propulsion – types of engines,
propulsion fundamentals. Compressor, combustor and turbines
combustion and performance. Rocket propulsion – basics, solid and
liquid propelled engines, parametric studies, construction features,
single and multi-stage rockets. Thrust chamber and nozzle models.
Studies of in-use engines. Environmental aspects.

MCL817 Heat Exchangers
3 Credits (3-0-0)
Applications. Basic design methodologies – LMTD and effectiveness-
NTU methods. Overall heat transfer coefficient, fouling, Correlations for
heat transfer coefficient and friction factor. Classification and types of
heat exchangers and construction details. Design and rating of double
pipe heat exchangers, shell and tube heat exchangers, compact heat
exchangers, plate and heat pipe type, condensers, cooling towers.
Heat exchanger standards and testing,Heat transfer enhancement
and efficient surfaces.

MCL818 Heating, Ventilating and Air-conditioning
3 Credits (3-0-0)
Introduction, psychrometry of air conditioning processes. HVAC
technologies. Thermal comfort - factors influencing thermal comfort.
Cooling and Heating load calculations. Room air distribution principles.
Design of air duct systems.
Indoor air quality. Ventilation - need, principles. Various types of air
conditioning systems. Cooling, dehumidification and humidification
equipment. Temperature, pressure and humidity controllers. Various
types of controls and control strategies.

MCL819 Lattice Boltzmann method
3 Credits (3-0-0)
Introduction, Kinetic theory and statistical mechanics, Lattice gas
cellular automata, LBM, Thermal LBM, Boundary conditions, Body forces,
Multiple relaxation time model, Single component multiphase models,
Multicomponent models single phase models, Applications of LBM.

MCL820 Micro/nano scale heat transfer
4 Credits (3-0-2)
Introduction to micro/ nano scale transport phenomena, size effect
behaviour, overview of engg. applications, fundamentals of micro/
nano scale fluid mechanics and heat transfer – kinetic theory, quantum mechanics considerations, Boltzmann transport equation, molecular dynamics modelling, microfluidics, Knudsen number, slip theory, micro/nano scale heat conduction - classical/ quantum size effects, thermal conductivity models, specific heat, thin films, convection in microtubes and channels, nanoparticles and nanofluids – preparation & transport properties, microfluidics - electrokinetic flows, microscale radiative heat transfer – modelling, properties, measurements at microscale.

MCL821 Radiative Heat Transfer
3 Credits (3-0-0)
Introduction to Radiation- Recapitulation: Radiative properties of opaque surfaces, Intensity, emissive power, radiosity, Planck’s law, Wien’s displacement law, Black and Gray surfaces, View factors.
Enclosure with Transparent Medium- Enclosure analysis for diffuse-gray surfaces and non-diffuse, non-gray surfaces, net radiation method.
Radiative heat transfer in Participating Medium- Radiation in absorbing, emitting and scattering media. Absorption, scattering and extinction coefficients, Radiative transfer equation. Analytical solution of radiative transfer equation.

MCL822 Steam and Gas Turbines
4 Credits (3-0-2)
Introduction, Recapitulation of heat cycles of steam power plants and gas turbine engines, Thermodynamics and fluid dynamics of compressible flow through turbines, meanline analysis and design of axial flow turbines, Three dimensional flows in axial flow turbines, Partial admission turbines, Turbines for nuclear power plants, Steam turbines for co-generation, turbine for super critical thermal power plant, operation of turbine plants- start up and shut-down of a turbine, steady state operation.

MCL823 Thermal Design
4 Credits (3-0-2)
System design:
Design of thermal systems: System identification and description with mathematical modelling: Examples with Power plant, refrigeration plant, HVAC systems, pump pipe network, electric space heaters, wind tunnel.
Development of a numerical model, mathematical techniques, solution of non-linear equations, numerical model for a system, system simulation, methods of numerical simulation.
Optimization - basic concepts, optimization of thermal systems, Lagrange multiplier, optimization of unconstrained problems, search based methods, Genetic algorithm, Differential Evolution method.
Thermal design based on inverse methods - Definition, estimation of boundary condition, conjugate gradient method.

MCL824 Turbocompressors
3 Credits (3-0-0)
Introduction, Fluid mechanics and thermodynamics of axial and radial flow compressors, operation and performance of compressors, compressor cascades, blade to blade flow for axial compressors with subsonic inlet flow, blade-to-blade flow for axial flow compressors with supersonic inlet flow, loss correlations, performance analysis of axial flow compressors, Centrifugal compressor - the centrifugal impeller, diffuser of centrifugal compressor, stall and surge, supersonic compressors, compressor instrumentation and testing.

MCL825 Design of Wind Power Farms
4 Credits (3-0-2)

MCL826 Rotor Dynamics
4 Credits (3-0-2)
Importance of dynamics of rotors, issues involved in rotor vibration analysis, Rigid rotor and flexible rotor analysis, Lateral and Torsional vibration analysis, Response to steady state and transient excitations, bending critical speeds and response to unbalance for simple and complex rotor bearing system, orbital analysis and cascade plots, critical speed map, Campbell diagram. Disc gyroscopics, synchronous and nonsynchronous whirl, forward and backward whirl, Role of fluid film bearings and seals, analysis of rotors mounted on rolling element bearings, hydrodynamic bearings, two spool and multi-spool rotors, Dynamics of rotors with stiffness asymmetry, bend, crack and misalignment, etc.
Parametric excitations, instabilities due to fluid film forces and hysteresis, influence of nonlinear supports. Balancing techniques, such as rigid rotor balancing, modal balancing, etc. Introduction to smart rotor systems. Use of finite element based approach for solving rotor dynamic problems.
Application of vibration based condition monitoring, signal processing for rotor fault identification, application of expert systems for automated condition monitoring and rotor fault diagnosis, remote monitoring and other commercial systems.
The course involves extensive coding in Matlab for dynamic response analysis of a general rotor bearing system. It involves exercises on vibration signal processing and analysis. The course involves experimentation on Machinery Fault Simulator.
MCL840 Experimental Modal Analysis and Dynamic Design
3 Credits (2-0-2)
Introduction to modal testing. Dynamic test data measurement and processing methods including Laser vibrometry. Frequency response functions for multi-degree of freedoms systems, forced response. Experimental and theoretical modal analysis - algorithms and codes. Applications of modal testing in system and force identification, structural dynamic modification, sensitivity analysis and frequency response coupling of substructure etc. Introduction to non-linear vibration analysis. Introduction to discrete systems and finite element modeling. Approaches to Joint modeling. Numerical model correlation; Introduction to FE model updating; Direct and iterative methods of FE model updating including optimization based updating; Brief idea of operational Modal Analysis, frequency and time domain methods of Operational Modal Analysis; Dynamic design of structures of products, machines and equipment via model testing, structural dynamic modification and FE model updating.

MCL845 Advanced Robotics
3 Credits (2-0-2)
Review of different robotic systems; Types of wheeled mobile robots and walking machines; Jacobian; Forward and inverse kinematic algorithms; Non-recursive and recursive dynamic algorithms; Dynamics of mobile robots and walking machines; Kinematic design of robotic systems based on singularity, manipulability, etc.; Control of robots. Mechanical design of links.

MCL848 Special topics in Systems Design-I
2 Credits (2-0-0)
Some sample topics are given below and depending upon the availability of experts, the department will decide the topic for a given semester:
1. Design of aircraft fuselage and wing
2. Engineering materials selection in mechanical design: Stages of design, stiffness/strength based design, damage tolerant design, life cycle design, systems approach to materials selection etc.
3. Tribo-systems design
4. Electro-mechanical machines etc.

MCL849 Special topics in Systems Design-II
3 Credits (3-0-0)
The course topic(s) will be decided by the department for each semester this course will be offered depending on the expertise available. Generally, each time a theme topic will be selected and students will work on all aspects of system design for that theme topic. Theme topic can be parts of aircraft design, automotive design, robotic design, energy system, biomedical equipment etc.

MCV849 Special Module in Systems Design
1 Credit (1-0-0)
Content will be decided by department based on the availability of experts in a particular semester. Topics will be related to systems design on the theme selected by the department.

MCD861 M.Tech. Project Part-I
12 Credits (0-0-24)

MCD862 M.Tech. Project Part-II
12 Credits (0-0-24)

MCL865 Advanced Operations Research
3 Credits (3-0-0)

MCL866 Maintenance management
3 Credits (3-0-0)
Introduction to maintenance management, Reliability basics, Asset criticality analysis, Reliability centered maintenance, Basic maintenance models for age and time based replacement, block and group replacement, inspection and shock based replacement, imperfect maintenance models, Maintainability models, Availability models, Life cycle cost models, Simulation based approach for maintenance planning, Queuing models for maintenance planning, Models for condition monitoring, Models for Maintenance scheduling, Maintenance performance measurement, Asset management practices, Case studies.

MCD881 Major Project Part-I
6 Credits (0-0-12)

MCD882 Major Project Part-II
12 Credits (0-0-24)

MCD895 MS Research Project
36 Credits (0-0-72)
Department of Physics

PYL100 Electromagnetic Waves and Quantum Mechanics
3 Credits (3-0-0)
Electric and magnetic fields in a medium, Susceptibility and Conductivity, Maxwell's equations, Boundary conditions; EM wave equation, Plane wave solutions, Polarization of the EM waves, Poynting vector and intensity of the EM wave; Wave packet, Phase and Group velocities; Reflection and refraction of EM waves at a dielectric interface; Brewster angle; Total internal reflection at a dielectric interface; EM waves in a conducting medium and plasma.

Wave-particle duality, de-Broglie waves; Quantum mechanical operators; Schroedinger equation, Wave function, Statistical interpretation, Superposition Principle, Continuity equation for probability density; Stationary states, Bound states, Free-particle solution, 1-D infinite potential well, Expectation values and uncertainty relations; 1-D finite potential well, Quantum mechanical tunneling and alpha-decay, Kronig-Penny model and emergence of bands.

PYP101 Physics Laboratory
2 Credits (0-0-4)
Experiments based on Design and Study of Power sources, Charging and discharging of a capacitor, Electromagnetic Induction, Phase Measurement. Experiments on geometrical and wave optics including interference, diffraction, dispersion and polarization. Experiments based on mechanics, heat, sound, fluids, resonance, like linear air track, coupled pendulum and oscillators, thermal conductivity, elasticity. Experiments in the area of modern physics, like Planck's constant, lasers, semiconductor band gap, wave motion, mechanical transmission lines.

PYL102 Principles of Electronic Materials
3 Credits (3-0-0)
Pre-requisites: PYL100
(Program Linked Course: Not available to B.Tech. (Engineering Physics) students)
Energy bands in solids(KP model), Classification of electronic materials: metals, semiconductors and insulators. Free electron model, Conductivity in metals and Concepts of Fermi level, effective mass and holes, Concept of phonons, Thermelectricity, Intrinsic, extrinsic and degenerate semiconductors, Fermi level variation by carrier concentration and temperature, Metal-semiconductor junction, p-n junction, Diffusion and drift transport, carrier life time and diffusion length; Direct and indirect band gaps, Optical transition, photon absorption, Exciton, photovoltaic effect, Dielectrics and electrical polarization, Depolarization field, Clausius-Mossotti relation; Drude model, Electronic polarization and its mechanisms, Dielectric breakdown; Piezoelectricity, Pyroelectricity and Ferroelectricity; Magnetism in materials – types of interactions, Magnetic susceptibility, Curie and Neel temperatures; Domains, Magnetic anisotropies, Spin-orbit interaction.

PYL103 Physics of Nanomaterials
3 Credits (3-0-0)
Pre-requisites: PYL100
(Program linked course: Not available to B.Tech. (Engineering Physics) students)
Basics semiconductor concepts; Quantum dot, nanoparticle and clusters; critical size for low dimensional effects and magic numbers; Size induced modifications in band gap; Tight binding and effective mass approximations; Density of states of 0-D, 1-D, 2-D, superlattice and monolayer structures; Quantum Hall effect; Thermoelectrical properties of nanostructured materials. Optical properties of bulk, metal nanoparticles, Core-shell nanoparticles; Size, shape and matrix effects; surface plasmon resonance; intrinsic and extrinsic effects; Applications of surface plasmon resonance in sensor devices; Magnetic properties of bulk and nanostructured materials; Single domain and multiple domain super paramagnetic phases; ZFC and FC measurements; Giant magnetoresistance effect. Chemical and Physical methods of synthesis of nano-particles and nano-structures, size selection methods; Measurements of size and its distribution; Characterization by AFM, STM and STS; Applications - Single electron effect and resonant tunneling devices. QW lasers, CNT and Graphene, GMR magnetic sensor, Nanostructured solar cell, Thermoelectric devices.

PYL104 Advanced Mechanics and Thermodynamics
3 Credits (3-0-0)
Pre-requisites: PYL100
(Program linked course: Not available to B.Tech. (Engineering Physics) students)
Dynamics of a single and system of particles through energy approach, Hamilton's principle, the principle of least action, Canonical transformation, implication to mechanical systems, Poission, bracket, Concepts of phase space, Lioviile's theorem, principle of stochastic cooling. Concepts of non linear dynamics, contraction of phase space volume, attractors, classical chaos, periodic motion, chaotic trajectories, bifurcations, driven damped harmonic oscillator, fractals and dimensionalities, various examples of nature, transition from discrete to continuous systems and fields. Laws of thermodynamics, Carnot's cycle, adiabatic and isothermal processes, principle of ideal engine and refrigeration, Definition of entropy, enthalpy, free energy, Maxwell's relations, Concepts of transport of heat and mass, Heat diffusion equations with and without heat source in one and three dimension based on thermal circuit concepts, Applications in nuclear reactors and Fourier transform based analysis of heat exchange process.

PYL105 Optics and Lasers
3 Credits (3-0-0)
Pre-requisites: PYL100
(Program linked course: Not available to B.Tech. (Engineering Physics) students)
Basic optics: Interference and interferometers, phase change on reflection, anti-reflection film; Fresnel and Fraunhofer diffraction and examples, limit of resolution, diffraction grating, resolving power. Polarization optics, examples and applications. Lasers: Laser principles, interaction of radiation and matter, amplification and resonator conditions for laser oscillation, modes of laser, some laser systems and applications. Fiber optics: Light propagation in optical fibers, fiber communication, attenuation and dispersion, single and multi-mode fibers, fiber amplifiers and lasers, fiber optic sensors. Fourier Optics and Holography: Basics of Fourier transformation, spatial frequency, spatial filtering and some applications; Holographic principles, on-axis and off-axis holograms, types of holograms and some applications.

PYL111 Electrodynamics
4 Credits (3-1-0)

PYP111 Engineering Physics Laboratory-I
3 Credits (0-0-6)
Experiments with various Lasers, Optical spectrometer, Microwaves, Fundamentals of Quantum Mechanics, Atomic spectroscopy and Tunnelling.
PYL112 Quantum Mechanics
4 Credits (3-1-0)
Dirac's bra-ket algebra, projection operator. Matrix representation of
vectors and operators. Reformulating postulates in bra-ket language,
Examples. 1D harmonic oscillator, ladder operators and construction of
the stationary state wave functions, number operator and its
eigenstates. Quantum mechanics in 2 and 3 dimensions in Cartesian
coordinates. Quantum theory of angular momentum, eigenvalues and
eigenfunctions. Quantum theory of spin angular momentum, addition
of angular momenta and Clebsch-Gordan coefficients. Schroedinger
equation in spherical coordinates, Free particle solution and solutions for
spherically symmetric potentials, Hydrogen atom. Many particle
Schroedinger equation, independent particles and reduction to the
system of single-particle equations. Identical particles, exchange
symmetry and degeneracy, Pauli principle and its applications. EPR
paradox, Entangled states, hidden variables, Bell's inequality.

PYL113 Mathematical Physics
4 Credits (3-1-0)
Linear algebra, complex variables, partial differential equations, special
functions, Fourier and Laplace transforms, integral equations, vector
tensor analysis, brief introduction to group theory.

PYL114 Solid State Physics
4 Credits (3-1-0)
Crystal Structure, concepts of reciprocal lattice and Brillouin zones,
Defects in Crystals, Phonons, Crystal Vibrations with monoatomic
and diatomic basis, Phonon Heat Capacity: Density of states in
one dimension, Debye and Einstein models, thermal expansion,
Free Electron Fermi Gas, Effect of temperature on the Fermi-Dirac
Distribution, E-k diagrams, Effective Mass, Nearly free electron model,
Bloch function, Kronig Penny Model, Atomic origin of magnetism:
Diamagnetism, Langevin theory of paramagnetism, Curie-Weiss
Law, Pauli paramagnetism, Ferromagnetism, Weiss molecular theory,
Ferromagnetic domains, magnetic anisotropy, Superconductivity,
types of superconductors, Heat capacity, energy gap, Thermodynamics
of the superconducting transition, London equation, coherence length,
BCS theory of superconductivity (qualitative), Brief introduction to
high temperature superconductors.

PYL115 Applied Optics
4 Credits (3-1-0)
Geometrical and Wave Optics: Fermat's Principle, Solution of ray
equation, and applications. Review of Maxwell's equations and
propagation of e. m. waves, reflection and refraction, total internal
reflection and evanescent waves. Surface plasmons, Meta-materials.
Plane waves in anisotropic media, Wave refractive index, Uniaxial
crystals, some polarization devices. Interference and Diffraction:
Concept of Coherence, Interference by division of wavefront and
division of amplitude; Stokes relations; Non-reflecting films; Michelson
interferometer; Fabry-Perot interferometer and etalon. Fraunhofer
diffraction: Single slit, circular aperture; limit of resolution. Diffraction
grating, Resolving power. Fresnel diffraction: Half-period zones and
diffraction: Single slit, circular aperture; limit of resolution. Diffraction
grating, Resolving power. Fresnel diffraction: Half-period zones and
the zone plate. Diffraction of a Gaussian beam. Lasers and Fiber
Optics: Interaction of radiation and matter, Einstein coefficients,
condition for amplification. Optical resonators, Condition for laser
oscillation. Some Laser Systems. Light propagation in optical fibers,
Attenuation and dispersion; Single-mode fibers, material dispersion,
Fiber amplifiers and lasers. Fiber optic sensors. Introduction to Fourier
Optics and Holography

PYL116 Elements of Materials Processing
4 Credits (3-1-0)
Fundamentals of thermodynamic and kinetic aspects during nucleation
and growth processes, Film growth modes, 2-D growth, Epitaxy and
lattice misfits, Molecular beam epitaxy, Basics of vacuum, plasma
discharge and sputtering, importance for material growth, Energy
enhanced processes for low temperature processing, Reactive
sputtering, Ion-beam deposition, Pulsed Laser Deposition, Plasma
etching, E-beam and Ion-beam patterning, Chemical Vapor Deposition,
Chemical Bath Deposition and Electro deposition, Chemical epitaxy,
PYL 301 Vacuum Technology and Surface Science
3 Credits (3-0-0)
Need of Vacuum and basic concepts; Mean free path, Particle flux; Monolayer formation, Gas Flow regimes; Gas release from Solids: Vaporization, Thermal Desorption, Permeation, Surface diffusion, Physisorption and Chemisorption; Measurement of Pressure: Gauges, Residual Gas Analyses; Production of Vacuum: Roughting - Rotary pumps, Oil free pumps; HV & UHV - Turbulomolecular pumps, Cryopumps, Getter and Sputter Ion pumps; Materials and components in vacuum; Bulk versus surface; Electronic properties of surfaces: Contact potential and work function, Surface Plasmons; Atomic motion: Surface lattice dynamics, Surface melting and chemisorption; Adsorption of atoms and molecules; Experimental techniques for surface analysis: XPS, AES, SEXAFS, TEM, SEM, STM, AFM and RHEED.

PYL302 Nuclear Science and Engineering
3 Credits (3-0-0)
Pre-requisites: PYL112
Introduction to nuclear structure, Radioactivity and applications, Nuclear detection and acceleration technology, Nuclear reactors engineering, Nuclear techniques for composition analysis, Nuclear radiation in biology.

PYL303 Materials Science and Engineering
3 Credits (3-0-0)
Pre-requisites: PYL114
Elementary materials science concepts, thermally activated processes, diffusion in solids, phase diagram of pure substances, Gibbs phase rule, binary isomorphous systems, the Lever rule, zone refining, homogeneous and heterogeneous nucleation, martensitic transformation & spinodal decomposition, Temperature dependence of resistivity, Matthiessen’s rule, TCR, Nordheim’s rule, mixture rules and electrical switches, high frequency resistance of a conductor, thin metal films and integrated circuit inter-connections, thermoelectricity, seebeck, Thomson and Peltier effects, thermoelectric heating and refrigeration, thermoelectric generators, the figure of merit, Bonding characteristics and elastic modulii, anelasticity, thermoelasticity, anelasticity energy losses, viscoelastic deformation, displacement models, Corrosion and Degradation of Materials: Electrochemical considerations, corrosion rates and their prediction, passivity environmental effects, forms of corrosion, corrosion environments, corrosion prevention, oxidation, protective and non-protective oxides, PB ratio, mechanisms of oxide growth, Materials Selection and Design Considerations.

PYL304 Superconductivity and Applications
3 Credits (3-0-0)
Pre-requisites: PYL114
Basic properties: zero resistance, perfect diamagnetism, difference from perfect conductors; Critical temperature, Basic Introduction to High Temperature superconductors, Meissner effect, London equations, penetration depth, flux quantization, critical current and critical magnetic field, Thermodynamics of superconducting state, Type I and Type II superconductors, BCS theory, electron pairs; coherence length; energy gap; Isotope effect, Ginzburg-Landau Theory, tunneling of electron in M/VS, tunneling of electron pairs in S/VS: DC and AC Josephson effect, Some applications: Electromagnet, SQUID, Oscillators, basics of superconducting electronics and superconducting quantum computing.

PYL305 Engineering Applications of Plasmas
3 Credits (3-0-0)
Pre-requisites: PYL111
Plasma processing of materials, surface cleaning, etching, power fusion energy, coherent radiation generation, plasma processing of textiles, nitrudging, surface modification, plasma based charged particle accelerators, Hall thrusters.

PYL306 Microelectronic Devices
3 Credits (3-0-0)
Pre-requisites: PYL201
Brief overview of semiconductor fundamentals; pn junction diode - energy-band diagrams, electrostatics, current - voltage relationship, junction-breakdown mechanisms. Metal-semiconductor contacts: Schottky barrier diode, C-V and I-V characteristics of Schottky diode; ohmic contacts in semiconductors. MOS structure: Accumulation, depletion and inversion modes of operation, charge - voltage and capacitance - voltage behaviour, threshold and flatband voltages, fixed oxide and interface charge effects. MOSFET: Output and transfer characteristics, I-V relations, nonideal effects, MOSFET scaling. BJT: BJT action, current gain factors, modes of operation, I-V characteristics of a BJT, non-ideal effects, cutoff frequency of a BJT.

PYL311 Lasers
3 Credits (3-0-0)
Pre-requisites: PYL115
Interaction of Radiation with Matter: Einstein coefficients; Line shape function, Line-broadening mechanisms, Condition for amplification by stimulated emission, the meta-stable state and laser action. 3-level and 4-level pumping schemes. Laser Rate Equations: Two-, three- and four-level laser systems, condition for population inversion, gain saturation, Laser amplifiers; Rare earth doped fiber amplifiers. Optical Resonators: Modes of a rectangular cavity, Plane mirror resonators, spherical mirror resonators, ray paths in the resonator, stable and unstable resonators, resonator stability condition; ring resonators; Transverse modes of laser resonators. Gaussian beams in laser resonators. Laser Oscillation: Optical feedback, threshold condition, variation of laser power near threshold, optimum output coupling, Characteristics of the laser output, oscillation frequency, frequency pulling, hole burning and the Lamb dip; Mode selection, single-frequency lasers; Methods of pulsing lasers, Q-switching, mode-locking. Some Laser Systems: Ruby, Nd: YAG, He-Ne, CO2 and excimer lasers, Tunable lasers: Ti Sapphire and dye lasers, Fiber lasers, Semiconductor lasers; Laser safety.

PYL312 Semiconductor Optoelectronics
3 Credits (3-0-0)
Pre-requisites: PYL201
Energy bands in solids, density of states, occupation probability, Fermi level and quasi Fermi levels, p-n junctions, Semiconductor optoelectronic materials, bandgap modification, Heterostructures and Quantum Wells. Rates of emission and absorption, condition for amplification by stimulated emission, the laser amplifier. Semiconductor Photon Sources: Electroluminescence. The LED, Semiconductor Laser, Single-frequency lasers; DBF and DBR lasers, VCSEL; Quantum-well lasers and quantum cascade lasers. Laser diode arrays. Semiconductor optical amplifiers (SOA), Electro-absorption modulators based on FKE and QCSE. Semiconductor Photodetectors: Types of photodetectors, Photodiodes, PIN diodes and APDs. Quantum well infrared photodetectors (QWIP); Noise in photodetection; Photonic integrated circuits (PICs).

PYL313 Fourier Optics and Holography
3 Credits (3-0-0)
Pre-requisites: PYL115
Signals and systems, Fourier transform (FT), FT theorems, sampling theorem, Space-bandwidth product; Review of diffraction theory: Fresnel-Kirchhoff formulation, Fresnel and Fraunhofer Diffraction and angular spectrum method, FT properties of lenses and image formation by a lens; Frequency response of a diffraction-limited system under coherent and incoherent illumination. Basics of holography, in-line and off-axis holography, plane and volume holograms, diffraction efficiency; Recording medium for holograms; Applications of holography: display, microscopy; memories, interferometry, NDT of engineering objects, Digital Holography etc.; Holographic optical elements. Analog optical information processing: Abbe-Porter experiment, phase contrast microscopy and other simple applications; Coherent image processing: vander Lugt filter; joint-transform correlator; pattern recognition, image restoration.

PYL321 Low Dimensional Physics
3 Credits (3-0-0)
Pre-requisites: PYL201 (Only for students opting for Minor Area)
Brief overview of band structure and density of states function for 0D, 1D and 2D systems, band gap engineering and semiconductor heterostructures. Quantum wells and their optical properties, multiple quantum wells and superlattices, Bloch oscillations. Two dimensional electron gas, modulation doped heterostructures, Quantum Hall effect. Quantum wires and nanowires, electronic transport, properties and applications. Quantum dots and their optical properties, Coulomb blockade. Device applications of low dimensional systems: Double heterostructure laser, quantum cascade laser, high electron mobility transistors. 2D materials: Graphene, topological insulators, WS2 / MoS2 and their properties.

**PYL322 Nanoscale Fabrication**  
3 Credits (3-0-0)  
**Pre-requisites:** PYL201  

**PYL323 Nanoscale Microscopy**  
2 Credits (2-0-0)  
**Pre-requisites:** PYL201  
Scanning probe microscopy such as scanning electron microscope, atomic force microscope, scanning electron microscope. Transmission electron microscope with high resolution and near field optical microscopy.

**PYL324 Spectroscopy of Nanomaterials**  
2 Credits (2-0-0)  
**Pre-requisites:** PYL201  

**PYL331 Applied Quantum Mechanics**  
3 Credits (3-0-0)  
**Pre-requisites:** PYL112  

**PYL332 General Theory of Relativity & Cosmology**  
3 Credits (3-0-0)  
**Pre-requisites:** PYL203  
Revision of special relativity, Notations, Equivalence principle, Introduction to tensor calculus, Metric, Parallel transport, covariant derivative and Christoffel symbols, Geodesic, Riemann curvature tensor, Ricci tensor, Geodesic deviation equation, Stress-Energy tensor, Einstein equation, Meaning of Einstein equation, Schwarzschild solution, Trajectories in Schwarzschild space-time, Perihelion shift, Binary pulsars, Gravitational deflection of light, Gravitational lensing, Gravitational collapse, Black holes, Hawking Radiation, Gravitational waves, Cosmology: Models of the universe and the cosmological principle, Cosmological metrics, Types of universe, Robertson-Walker universes, Big Bang, Dark energy.

**PYD411 Project-I**  
4 Credits (0-0-8)  
To set the objectives, deliverables, work plan, logistics planning and milestones with discernible outputs, and to demonstrate the feasibility through some specific aspects of a project.

**PYL411 Quantum Electronics**  
3 Credits (3-0-0)  
**Pre-requisites:** PYL112  
Light propagation through anisotropic media, nonlinear effects, nonlinear polarization, Second harmonic generation, sum and difference frequency generation, parametric amplification, parametric fluorescence and oscillation, concept of quasi-phase matching; periodically poled materials and their applications. Third-order effects: self-phase modulations, temporal and spatial solitons, cross-phase modulation, stimulated Raman and Brillouin scattering, four-wave mixing, phase conjugation. Quantization of the electromagnetic field; number states, coherent states and their properties: squeezed states of light and their properties, application of optical parametric processes to generate squeezed states of light, entangled states and their properties; Generation of entangled states; Quantum eraser, Ghost interference effects; Applications in quantum information science. Ultra-intense laser-matter interactions.

**PYD412 Project-II**  
8 Credits (0-0-16)  
**Pre-requisites:** PYD 411  
Open to only those students opting for Departmental Specialization. The Project can be a continuation of the project undertaken for PYD 411. The students will be eligible to do this project, if he/she secures a grade not below B in PYD411.

**PYL412 Ultrafast Laser Systems and Applications**  
3 Credits (3-0-0)  
**Pre-requisites:** PYL311  
PYL413 Fiber and Integrated Optics
3 Credits (3-0-0)
Pre-requisites: PYL115

PYD414 Project III
4 Credits (0-0-8)
Pre-requisites: PYD411
Working out the detailed work plan and implementation of the project. The Project can be a continuation of the project undertaken for PYD 411.

PYL414 Engineering Optics
3 Credits (3-0-0)
Pre-requisites: PYL115
Lens systems and basic concepts in their design; Optical components: Mirrors, prisms, gratings and filters; Sources, detectors and their characteristics; Optical systems: Telescopes, microscopes, projection systems, photographic systems, interferometers and spectrometers; Concepts in design of optical systems; Applications in industry, defense, space and medicine; CCD, compact disc, scanner, laser printer, photography, laser shows, satellite cameras, IR imagers, LCD, Spatial Light modulators.

PYV418 Selected Topics in Photonics
2 Credits (2-0-0)
Pre-requisites: PYL115
Topics from the emerging areas of Photonics will form the basics, and the faculty offering the course will provide the detailed course contents.

PYV419 Special Topics in Photonics
1 Credit (1-0-0)
Pre-requisites: PYL115
Topics from the emerging areas of Photonics will form the basics, and the faculty offering the course will provide the detailed course contents.

PYL421 Functional Nanostructures
3 Credits (3-0-0)
Pre-requisites: PYL201
Basics of low dimensional structures, QD, QW, nanostructures for optical and electronic applications, QD lasers, detectors, SET, Carbon based nanostructures, CNT, CNT optical, electrical, mechanical, chemical properties, sensors, drug delivery, photonic crystals, GMR, nanostructured magnetism, hydrogen storage, nanoclays, colloids, nanomachines, organic and biological nanostructures.

PYL422 Spintronics
3 Credits (3-0-0)
Pre-requisites: PYL112
Spintronics, Its need and future vision; Basics of magnetic materials, spin orbit interaction, spin polarized current and their injection, accumulation and detection, Magnetoresistance and concepts of spin detection and magnetic memory; Spin valves & GMR, CIP and CPP transport, Semisclassical transport models; Basics of spin valve and magnetic tunnel junctions, Tunnel magneto resistance, Quantum mechanical model of coherent tunneling and Giant TMR; Magnetic anisotropies and exchange bias, Spin valves with AF and SAF layers, Magnetization switching in AF and SAF layers, Magnetic domains and domain walls, single domain nano-particles; Pure spin and chage currents, spin-Hall effect and inverse spin-Hall effect, spin Seebeck effect, magneto-calaric effect, generation of spin current by charge and thermal current; Current induced magnetization switching, Spin torque effect and spin torque oscillators of tunable GHz frequency; High density data storage: MRAM, two stable states, half-select problem, Savtchenko switching and Toggle MRAM; Ultra high density devices: Current & STT driven DW motion, Race track memory, Shift resistor; Q-bits and spin logic.

PYL423 Nanoscale Energy Materials and Devices
3 Credits (3-0-0)
Pre-requisites: PYL201
Basics of photovoltaics, Quantum confinement and plasmonics in photovoltaic devices, Nanorod solar cells, Principle of operation of hybrid and dye-sensitized solar cells, Nanoscale materials for improving thermoelectric figure of merit, Photobleachmocleotherochemical cells.

PYV428 Selected Topics in Nanotechnology
2 Credits (2-0-0)
Topics from the emerging areas of Nanotechnology will form the basics and the faculty offering the course will provide the detailed course contents.

PYV429 Special Topics in Nanotechnology
1 Credit (1-0-0)
Topics from the emerging areas of nanotechnology will form the basics and the faculty offering the course will provide the detailed course contents.

PYL431 Relativistic Quantum Mechanics
2 Credits (2-0-0)
Pre-requisites: PYL331

PYL432 Quantum Electrodynamics
3 Credits (3-0-0)
Pre-requisites: PYL331

PYL433 Introduction to Gauge Field Theories
2 Credits (2-0-0)
Pre-requisites: PYL111 & PYL12
Maxwell's equations and Gauge invariance, Quantum mechanics of a charged particle as a gauge theory, Vector potential as phase, Aharonov-Bohm Effect, Superconductivity and Magnetic flux quantization in superconductors, Introduction to continuous symmetry groups, U(1) and SU(2) symmetry groups, Classical field
theories, Local gauge invariance and the gauge fields, Yang-Mills gauge theories, Spontaneous symmetry breaking, Goldstone bosons, Higgs mechanism, Weinberg-Salam Model.

**PYL434 Particle Accelerators**  
2 Credits (2-0-0)  
*Pre-requisites:* PYL111 & PYL112  
Electrostatic and electromagnetic accelerators: Van de Graaf, Tandem acceleration, Linear accelerators, Synchrocyclotron, Storage ring, Free electron laser, High energy colliders.

**PYV438 Selected Topics in Theoretical Physics**  
2 Credits (2-0-0)  
*Pre-requisites:* PYL112  
Topics from the emerging areas of Theoretical Physics will form the basics, and the faculty offering the course will provide the detailed course contents.

**PYV439 Special Topics in Theoretical Physics**  
1 Credit (1-0-0)  
*Pre-requisites:* PYL112  
Topics from the emerging areas of Theoretical Physics will form the basics, and the faculty offering the course will provide the detailed course contents.

**PYL551 Classical Mechanics**  
4 Credits (3-1-0)  
Constraints, generalized coordinates, action principle, symmetries and conservation laws, Hamilton's equations, Poisson brackets, canonical transformations, central potentials, small oscillations, normal modes, rigid body dynamics.

**PYL552 Electrodynamics**  
4 Credits (3-1-0)  
Electrostatics, conductors, dielectrics, magnetostatics, boundary value problems, time dependent fields, waves in a medium, relativistic formulation of Maxwell's equations, radiation from accelerating charges, scattering of electromagnetic waves.

**PYL553 Mathematical Physics**  
4 Credits (3-1-0)  
Linear Algebra, complex analysis, Fourier transform, Sturm-Liouville's theorem and orthogonal functions, Ordinary differential equations, Green Functions/old methods.

**PYL555 Quantum Mechanics-I**  
4 Credits (3-1-0)  
Introduction, quantum mechanical wave function, Born interpretation, basic formalism (Dirac bra-ket formalism), state vectors, operators and their representation, review of one dimensional examples, one dimensional harmonic oscillator, creation and annihilation operators, Landau problem, symmetries in quantum mechanics, hydrogen atom, entanglement.

**PYL556 Quantum Mechanics-II**  
3 Credits (3-0-0)  
Time independent perturbation theory, time dependent perturbation theory, cross-section, scattering theory, approximation techniques, identical particles, interaction of atoms with radiation, relativistic equations.

**PYL557 Electronics**  
4 Credits (3-1-0)  
Basics of semiconductor devices such as diode, transistor, FET and MOSFET; BJT and FET based amplifiers, oscillators, switches, circuit analysis by hybrid and r-parameters, operational amplifiers and their applications, timer circuit, dc power supplies, filters and digital circuits, counters, registers, ADC, DAC and microprocessor.

**PYL558 Statistical Mechanics**  
4 Credits (3-1-0)  

**PYL560 Applied Optics**  
4 Credits (3-1-0)  

**PYD561 Project-I**  
3 Credits (0-0-6)

**PYP561 Laboratory-I**  
4 Credits (0-0-8)

**PYD562 Project-II**  
6 Credits (0-0-12)

**PYP562 Laboratory-II**  
4 Credits (0-0-8)

**PYL563 Solid State Physics**  
4 Credits (3-1-0)  
PYP563 Advanced Laboratory
4 Credits (0-0-8)

PYL567 Atomic and Molecular Physics
3 Credits (3-0-0)
Hydrogen and alkali metals, double fine structure of atoms, two electron atom, Zeeman and Paschen-Back effect, X-ray spectra, general factors influencing spectral line width (Collision, Doppler effect, Heisenberg) and line intensities (transition probability, population of states, Beer-Lambert law), Molecular symmetry, irreducible representations, Rotational and vibrational spectra of diatomic molecules, FTIR and Laser Raman spectroscopy, electronic spectra, Franck-Condon principle, bond dissociation energies, Molecular orbital and models, laser cooling of atom.

PYL569 Nuclear and Particle Physics
3 Credits (3-0-0)
N-N interaction, iso-spin symmetry, nuclear models, beta decay, detectors and particle accelerators, Quark model, Deep inelastic scattering, Basics of nuclear astrophysics, Fundamental particles and their properties.

PYL650 Fiber and Integrated Optics
3 Credits (3-0-0)

PYL651 Advanced Solid State Physics
3 Credits (3-0-0)
Pre-requisites: PYL563

PYL652 Magnetism and Spintronics
3 Credits (3-0-0)
Pre-requisites: PYL563
Magnetism of metals, Spontaneous spin split bands, Magnetic anisotropy, Competing interactions, One and two-dimensional magnets, Spin dependent transport in magnetic metals - Anisotropic magnetoresistance, Giant magnetoresistance, Spin dependent tunneling, Tunneling magnetoresistance, Spin-Orbit interaction and Hall effects –Spin Hall Effect and Inverse Spin Hall Effect; Spin injection phenomena - Spin Transfer Torque, Spin injection magnetization reversal; High frequency phenomena.

PYL653 Semiconductor Electronics
3 Credits (3-0-0)
Pre-requisites: PYL563 or equivalent
Semiconductors junction review; charge storage and transient behavior, equivalent circuit of diode, p-n hetero-structure: band discontinuity and its effect on junction properties; Junction breakdown mechanisms; Static characteristics of Bipolar transistor; Frequency response and switching behavior, Non-ideal effects: base width modulation, early effect, current crowding and high injection effect; Hetero-Junction transistor; SCR, M-S junctions: Basic structure, Energy band relation, I-V characteristics; Ohmic contacts; MOS capacitors, JFET and MESFET basic principles, MOSFET: structure and operation, basic characteristics and analysis; linear quadrature model; equivalent circuit; Threshold voltage calculation; Substrate biasing effect; LED, Laser, Photodiode and solar cells, Tunnel, IMPATT & Gunn diodes and comparison of microwave devices.

PYL655 Laser Physics
3 Credits (3-0-0)
Pre-requisites: PYL560

PYL656 Microwaves
3 Credits (3-0-0)
Pre-requisites: PYL552
Maswell’s equations, Wave equation, Boundary conditions, Ideal transmission line, Terminated line, Wave solutions, TEM, TE, and TM waves, Rectangular and circular wave guides, power and attenuation, Smith chart, Impedance matching, Double and triple stub tuners, Quarter wave and half wave transforms, Equivalent voltage and currents, Impedance description, Impedance admittance and scattering matrix formulation, Signal flow graph, Attenuators, Phase shifters, Directional couplers, Junctions, Power dividers, Isolators and circulators, Resonant circuits, Transmission line resonators, Rectangular and circular wave guide resonators, Electron beams, Velocity modulation, Klystron, Magnetron, Traveling wave tubes, Gunn oscillator, Transistor and FET amplifiers, biasing, stability, power gain, noise, Mixers.

PYL657 Plasma Physics
3 Credits (3-0-0)
Pre-requisites: PYL552

PYD658 Mini Project
3 Credits (0-0-6)

PYL658 Advanced Plasma Physics
3 Credits (3-0-0)
Pre-requisites: PYL657
PYL659 Laser Spectroscopy
3 Credits (3-0-0)

PYL701 Physical Foundations of Materials Science
3 Credits (3-0-0)
Overlap with : PYL303

PPY701 Solid State Materials Laboratory-I
3 Credits (0-0-6)
This laboratory course is designed to make the students familiar with fundamental experiments related with materials synthesis and their primary characterization. Experiments are based on materials synthesis by various reaction route, Spray-pyrolysis, spin and dip coating, thermal evaporation and sputtering, Dry and Wet Oxidation of Silicon, Understanding of binary eutectic phase diagrams, phase transitions, etc. and study of the optical, electrical, semiconducting and dielectric properties of the synthesized materials. Simulation experiments to understand the properties of solid state materials (e.g. ion-matter interaction, properties of low dimensional materials and band structure estimation) are also included.

PYL702 Physics of Semiconductor Devices
3 Credits (3-0-0)
Overlap with : PYL201
Charge carriers in semiconductors: Intrinsic and extrinsic semiconductors, position of Fermi energy level. Carrier transport phenomenon: Carrier drift and diffusion, Hall effect, Carrier generation and recombination. PN Junction: Energy band diagram, electrostatics of pn junction, PN junction current, ideal current-voltage relationship, junction breakdown mechanisms, heterojunctions. Metal-semiconductor contacts: Schottky barrier diodes, current transport in Schottky diodes, I-V characteristics, Ohmic contacts. MOS structure: Ideal MOS structure, energy band diagrams under accumulation, depletion and inversion conditions, C-V characteristics, various oxide charges in Si/Ox, MOS and their effect on C-V graph, MOSFET, basics about the operation of a MOSFET, I-V relationships of a MOSFET, non ideal effects. Optical devices: Basics of Solar cells and photodetectors.

PYL703 Electronic Properties of Materials
3 Credits (3-0-0)
Overlap with : PYL102

PYL704 Science and Technology of Thin Films
3 Credits (3-0-0)
Overlap with : PYL116
Kinetic Theory of Gases and basics of vacuum science and technology, Physical Vapor Deposition - Hertz Knudsen equation; mass evaporation rate; Knudsen cell, Directional distribution of evaporating species, Evaporation of elements, compounds, alloys, Raoul’s law, Homogenous and Heterogenous Nucleation, capillarity theory, atomistic and kinetic models of nucleation, basic modes of thin film growth, stages of film growth & cluster coalescence. E-beam beam evaporation, Molecular beam epitaxy and Pulsed Laser Deposition, Epitaxy–homo, hetero and coherent epilayers, lattice misfit and imperfections, epitaxy of compound semiconductors, scope of devices and applications, Glow Discharge and Plasma, Sputtering–mechanisms and yield, dc and rf sputtering, Bias sputtering, magnetically enhanced sputtering systems, reactive sputtering, Hybrid and Modified PVD- Ion plating, reactive evaporation, ion beam assisted deposition, Chemical Vapor Deposition - reaction chemistry and thermodynamics of CVD; Thermal CVD, Laser & plasma enhanced CVD, Atomic layer deposition, Electrodeposition, Spray pyrolysis.

PYL705 Nanostructured Materials
3 Credits (3-0-0)

PYL707 Characterization Techniques for Materials
3 Credits (3-0-0)
Pre-requisites: PYL563 (for MSc), PYL114 (for UG)
Introduction to structure property correlation in materials, basic crystallography basic revision in 2-3 classes, k-space, X-ray diffraction, Reitveld refinement method and its fundamentals, Ewald sphere, Transmission electron microscopy in patterns, Microstructural investigations using Scanning electron microscope
and Transmission electron microscopes, Kinetics of phase transformations in solids - Thermal analysis using differential thermal analysis and Differential scanning calorimetry, other techniques like Thermogravimetric analysis, Dynamic mechanical thermal analysis, Thin film DSC, Modulate DSC, Raman and Micro Raman spectroscopy, Photoluminescence spectroscopy, Material compositional analysis like Energy dispersive x-ray (EDX) and Electron probe micro analysis (EPMA).

PYL723 Vacuum Science and Cryogenics
3 Credits (3-0-0)
Overlapping with: PYL301

PYL724 Advances in Spintronics
3 Credits (3-0-0)
Overlapping with: PYL422 and PYL552
Spin dependent transport in magnetic metals - Anisotropic Magnetoresistance, Giant Magnetoresistance, Spin dependent tunneling, Tunneling magnetoresistance, Spin-Orbit interaction and Hall effects –Spin Hall Effect and Inverse Spin Hall Effect; Spin injection phenomena and applications - Spin Transfer Torque, Spin injection magnetization reversal; High frequency phenomena; Spin Transfer Torque applications, Dilute magnetic semiconductors, Spintronics properties of ferromagnetic semiconductors, Materials for Spin Electronics, Spintronic devices and their applications.

PYL725 Surface Physics and Analysis
3 Credits (3-0-0)
Surface structure, stability and reactivity, surface crystallography, surface stress, reconstructions and relaxation, surface sensitivity, clean surface preparation, physisorption, chemisorption, Langmuir kinematics and dynamics of surface processes, properties of interfaces, adhesion and segregation, surface diffusion, chemical shift in electronic structure, surface states, plasmons, chemical potential/work function, experimental methods for surface structure: photoemission spectroscopy (PES), inverse photoemission spectroscopy (IPES), low energy electron diffraction (LEED), Reflection high energy electron diffraction (RHEED), Auger electron spectroscopy (AES), Secondary ion mass spectroscopy (SIMS), scanning tunneling microscopy (STM), Grazing incidence XRD, x-reflectivity (XRR), scanning electron microscope (SEM), electron energy loss spectroscopy (EELS), etc.

PYL726 Semiconductor Device Technology
3 Credits (3-0-0)
Silicon wafer fabrication and oxidation techniques, Growth kinetics and oxide measurement techniques, defects in silicon and silicon dioxide, interface defects, polysilicon, silicon nitride and silicide formation, Lithography and etching techniques, diffusion and ion implantation, modeling and measurement of dopant profile, Thick and thin film device technology, Processes involved in ink preparation, screen printing, laser trimming, mounting, mask making and packaging, Thin film deposition, metallization etc.

PYL727 Energy Materials and Devices
3 Credits (3-0-0)
Importance of energy materials and devices in present technology, PV materials and devices: Definition and basic physical quantities; Energy band diagram and operation of Schottky, homojunction and heterojunction solar cells. Amorphous silicon and thin film based solar cell devices. Physics of tandem solar cell devices. New generation up conversion and down conversion devices. Materials for Si based solar cell, thin film solar cells, role of nanomaterials, dye sensitized solar cells. Introduction to PV panels, domestic and industrial applications. Materials and device concept for thermoelectric devices, Methods for improving the thermoelectrical properties, application for heating and cooling applications. Operation of photoelectrochemical cell for hydrogen production, Energy band and materials requirements.

PYL728 Quantum Heterostructures
2 Credits (2-0-0)
Semiconductor heterostructures, Quantum confined systems, Electron transport in quantum structures, D2EG, Excitons in quantum structures, Quantum confined Stark effect, Integer Quantum Hall effect, quantum well and quantum cascade lasers, quantum well infrared photodetectors (QWIPD), resonant tunneling devices (RTD), high electron mobility transistors (HEMT), quantum interference transistors (QIT) and hot electron transistors (HET).

PYL729 Nanoprobe Techniques
1 Credit (1-0-0)

PYL739 Computational Techniques for Solid State Materials
3 Credits (3-0-0)
Pre-requisites: PYL563/PYL114 or equivalent

PYL740 Advanced Condensed Matter Theory
3 Credits (3-0-0)
Pre-requisites: PYL563/PYL114 or equivalent
Quantum Fields and their roles in describing collective modes. Particle creation and annihilation operators: Commutation relations for Bosons and Fermions. Second quantization. Equivalence with the many body Schroedinger Equation. Identical Conserved particles in equilibrium and thermodynamic properties, Simple Examples of Second Quantization, Bosonic and Fermionic systems. Cooper instability and BCS Hamiltonian, Mean field description of BCS condensate, Quasiparticle excitation and Bogoliubov de-Gennes theory. Phase transition and broken symmetry, Order parameter concept, Landau theory and Landau Ginzburg theory and some examples from condensed matter Spin systems and magnetism, Heitler London theory and Heisenberg model, Ferromagnets, Spin waves, Antiferromagnets, Spin-chains.

PYL741 Field Theory and Quantum Electrodynamics
3 Credits (3-0-0)
Quantization of free fields; Discrete symmetries; Gauge symmetries; QED; Elementary processes; Higher order effects; Renormalization; Novel effects of QED.
PYL742 General Relativity
3 Credits (3-0-0)
Overlaps with : PYL332
Brief review of special Relativity, Principle of equivalence: weak, strong and Einstein, Experimental evidence for equivalence principle of covariance, Curvilinear coordinates, Tensor algebra and tensor analysis, Parallel transport, Curvature tensor, Ricci and Einstein tensors, Einstein equation, The Schwarzschild metric, Shift in perihelion of planets, Bending of light ray, Modern tests with light delay, Gravitational lensing, Gravitational waves, and their detection, Friedman-Robertston-Walker metric, the Hubble expansion.

PYL743 Group Theory and its Applications
3 Credits (3-0-0)
Concept of a group, multiplication tables, cyclic and permutation groups, subgroups, cosets, Isomorphism and Homomorphism, conjugate elements and classes, normal sub-groups and factor group, direct product of groups, Group representations, Unitary and Irreducible, representations, Schur's Lemmas, orthonormality theorems, Character tables, Basis functions for irreducible representations. Continuous groups, Lie groups, The rotation group, Special orthogonal and unitary groups, crystallographic point groups and their representations. Applications in quantum mechanics and solid state physics.

PYL744 High Energy Physics
3 Credits (3-0-0)
Overlaps with : PYL433
Fundamental interactions; QED; QCD; Marshak-Sudarshan theory of weak interactions; Parity violation; Higgs mechanism; Glashow-Salam-Weinberg model; The standard model of particle physics; Open problems.

PYL745 Advanced Statistical Mechanics
3 Credits (3-0-0)
Pre-requisites: PYL558/PYL202/equivalent

PYL746 Non-equilibrium Statistical Mechanics with Interdisciplinary Applications
3 Credits (3-0-0)
Pre-requisites: PYL558/PYL202/equivalent

PYL747 Non-linear Optics
3 Credits (3-0-0)
Pre-requisites: PYL560
Wave propagation in anisotropic media. Origin of optical nonlinearity, Nonlinear optical polarization; Second order and third order processes; Nonlinear optical wave equation; Second order nonlinear processes; Second harmonic generation, difference and sum frequency generation, Phase insensitive and phase sensitive optical parametric amplifiers, Spontaneous parametric down conversion; Birefringence and quasi phase matching; Optical parametric oscillators. Third order nonlinear processes; Third harmonic generation, Self phase modulation, Cross phase modulation and four wave mixing; Impact of nonlinear effects in lightwave communication systems; supercontinuum generation; Phase conjugation and applications, Stimulated Raman and Brillouin scattering; Applications of stimulated processes. Electro optic, photorefractive and acousto optic effects and their applications, Ultrafast and intense field nonlinear optics. Special topics.

PYL748 Quantum Optics
3 Credits (3-0-0)
Pre-requisites: PYL556/PYL112
HBT effect, Quantization of the EM field, Quantum states of light, correlation functions, Detection of quantum light and techniques, coincidence-counting, Phase-sensitive detection, Quantum treatment of linear optics, Quantum light by non-linear optical processes, SPDC, Signatures of quantum behaviour, Landmark experiments in quantum optics, Applications: Laser cooling and BEC, Ion trapping, CPT, EIT, Slow light, Introduction to quantum communication: Quantum teleportation, Entanglement swapping, Quantum repeaters, Quantum cryptography.

PYL749 Quantum Information and Computation
3 Credits (3-0-0)
Pre-requisites: PYL556/PYL112
Basic classical and Quantum mechanics; Basic information theory; Bits, Qubits and ebits; Non-locality and entanglement; Quantum gates and circuits; Teleportation, Superdense coding, Quantum oracles; Quantum algoritms; Quantum encryption; Quantum error correction; Quantum computers.

PYL751 Optical sources, photometry and metrology
3 Credits (3-0-0)
Eye and vision: Visual system, Sensitivity, Acuity; Radiometry and Photometry: Radiometric quantities and their measurements, Photometric quantities, Radiation from a surface; Brightness and luminous intensity distribution; Integrating sphere; Illumination from a line, Surface and volume sources; Colorimetry: Fundamentals, Trichromatic specifications, Colorimeters, CIE system; Conventional light sources: Point and extended sources; Incandescent, fluorescent, discharge lamps; LEDs; Lighting fundamentals, Optical detectors; Detector characteristics, Noise considerations, Single & multi-element detectors, CCDs.

Optical metrology: Surface inspection, Optical gauging and profiling, Techniques for non-destructive testing, Moire self imaging and Speckle metrology, Sensing elements.

PYL752 Laser systems and applications
3 Credits (3-0-0)
**PYL753 Optical systems design**  
3 Credits (3-0-0)  
Gaussian theory of optical system; Aberrations: Transverse ray and wave aberrations; Chromatic aberration; Third order aberrations; Position and shape factors; Meridional ray tracing; Paraxial rays and first order optics; Primary chromatic aberration: Achromat doublet, Triplets and duality, tolerances, Chromatic aberration at finite aperture; Spherical aberration: Surface contribution formulas; Spherically corrected achronom; Oblique pencils: Tracings of oblique meridional and skew rays; Coma and sine condition; Image evaluation: Geometric OTF, Strehl ratio, Spot diagram; definition of Merit function; Cooks Triplet and its derivatives; Double Gauss lens, Introduction to Zoom lenses and Aspherics; Examples of modern optical, GRIN optics.

**PYL755 Basic optics and optical instrumentation**  
3 Credits (3-0-0)  
Reflection and refraction of plane waves and by spherical surfaces; Lens aberrations; Polarization and Polarizing components; Diffraction: Diffraction by single and multiple slits and circular aperture, Gaussian beams, Interference: Two beam and multiple beam interference. Interferometers: Shearing and Scanning interferometers, Interferometric instruments and diaphragming, Polarization interferometers; Spectroscopic instrumentation, Fourier transform spectroscopy; Imaging and super-resolution imaging, near-field imaging techniques; Adaptive optics; Wavefront sensing and correction, reconstruction, Opto-medical instruments; Optical coherence tomography, Infrared instrumentation; I.R. telescopes, Focal plane arrays; Light field camera, Space optics; Satellite cameras, High-resolution radiometers, Space telescopes, Space based sensors.

**PYL756 Fourier optics and holography**  
3 Credits (3-0-0)  
Signals and systems, Fourier Transform (FT), Sampling theorem; Diffraction theory; Fresnel-Kirchhoff formulation and angular spectrum method, brief discussion of Fresnel and Fraunhofer diffraction, FT Properties of lenses and Image formation by a lens; Frequency response of a diffraction-limited system under coherent and incoherent illumination, OTF-effects of aberration and apodization, Comparison of coherent and incoherent imaging, Super-resolution; Techniques for measurement of OTF; Analog optical information processing: Abbe-Porter experiment, phase contrast microscopy and other simple applications; Coherent image processing: Vander Lugt filter; Joint transform correlator; Pattern recognition, Synthetic Aperture Radar. Basics of holography, in-line and off-axis holography; transmission and reflection holograms, Amplitude and phase holograms, Recording materials. Thick and thin holograms.

**PYL757 Statistical and Quantum optics**  
3 Credits (3-0-0)  
Overlaps with: PYL748  
Probability theory, Generating function, Characteristic function; Analytic signal representation, Correlation and spectral properties, Temporal, spatial and partial coherence, Law of interference, spectral interference, Coherent mode representation, Propagation of coherence; Higher order correlations; Photodetection probability, Mendel's photon counting formula; Intensity interferometry, Speckle statistics and applications, Field quantization, Number states, Coherent states, Glauber-Sudarshan representation, Tests for non-classicality, Quantum correlations, Two photon coherence function and coincidence count rate, Quantum treatment of beamsplitter and simple interferometers.

**PYL758 Advanced Quantum optics and applications**  
3 Credits (3-0-0)  
Pre-requisites: PYL757  
Quantization of the EM field, Quantum states of light, Correlation functions, Photodetection techniques, Generation of quantum light, Detection of quantum light, coincidence-counting, Phase-sensitive detection, Quantum treatment of linear optics, Quantum light by non-linear optical processes, Signatures of quantum behaviour, Squeezed states and applications, Landmark experiments in quantum optics, Light-matter interaction, Quantum memories, Experimental quantum communications: Quantum teleportation, Entanglement swapping, Quantum repeaters.

**PYL759 Computational optical imaging**  
3 Credits (3-0-0)  
Revision of Fourier optics and basic concepts in optical imaging, Mathematical preliminaries on inverse problems in imaging, Compressive imaging, Multi-view imaging systems, Point-spread function engineering, Phase retrieval, Interferometric imaging methods such as digital holography and optical coherence tomography. Imaging through turbulent media, Super-resolution through structured illumination, Correlation/Ghost imaging.

**PYL760 Biomedical optics and Bio-photronics**  
3 Credits (3-0-0)  

**PYL761 Liquid Crystals**  
3 Credits (3-0-0)  

**PYP761 Optical fabrication and metrology laboratory**  
3 Credits (0-0-6)  

**PYL762 Statistical Optics and Optical coherence theory**  
3 Credits (3-0-0)  

**PYLP762 Advanced optics laboratory**  
3 Credits (0-0-6)  

**PYLP763 Computational Optics laboratory**  
3 Credits (0-0-6)  
Pre-requisites: PYL756  
Ray tracing in optical systems with commercial software, Image handling in Matlab or similar environment for optics experiments, Simulation of Fresnel and Fraunhofer diffraction, Fourier transforms and applications in optics, Simulation of spatial filtering, Matched filtering and pattern recognition, Simulation of Joint Transform and Vander Lugt correlators, Synthesis of computer generated hologram and optical reconstruction, Simulation of recording and reconstruction of digital holograms, Interferogram analysis using Fourier and Phase shifting methods, Stokes' parameters of optical beams and plotting of polarization ellipse, Simulation of multi-beam interference for photonic crystal designs, Simulation of multi-beam interference for photonic crystal designs, Design Project.

**PYLP764 Advanced Optical Workshop**  
3 Credits (0-0-6)  
Development of metal optics, Infrared imaging, Fabrication of Total Internal Reflection Prisms, Measurement of thin coating, Fabrication of Shearing plate, Shearing interferometer, Talbot interferometry, Moire interferometry.

**PYLP770 Ultra-fast optics and applications**  
3 Credits (3-0-0)  
Overlaps with: PYL412  

**PYLP771 Green Photonics**  
3 Credits (3-0-0)  
Need for green photonics, Overview of solid-state lighting technologies and their advantages. Inorganic and Organic LEDs: Fundamentals, Device Physics, Diode structures and operating principles. Materials for LEDs, OLEDs and PLEDs: Phosphor materials and their characterisation. LEDs and OLED fabrication, encapsulation and Packaging techniques. Electro-optical properties of LEDs and OLEDs, Electric drive circuits, internal, external and power efficiency, Spectral distribution, and encasulants. Design and development of light out-coupling techniques. Photometry and colorometry of LEDs and OLEDs. Free-form optics and design of LEDs and OLEDs based illumination systems: General lighting, Traffic lights, Automotive, Street & flood lighting, and Backlights for displays.


**PYLP772 Plasmonic sensors**  
3 Credits (3-0-0)  
Optical fiber, optical fiber sensors, characteristics and components of optical fiber sensors, Spectroscopic techniques, Modulation schemes, Physics of plasmons, Surface plasmons at semi-infinite metal-dielectric interface, Excitation of Surface plasmons, surface plasmon resonance (SPR) condition, Interrogation techniques; Theory of SPR based optical fiber sensors, N-layer model, excitation by meridional rays: on-axis excitation, performance parameters: sensitivity, detection accuracy and figure of merit; SPR based sensing applications, refractive index and other analytes sensing, multichannel sensing, multianalyte sensing; Factors affecting performance of the sensor: fiber parameters, change of metal, high index dielectric material, probe design, Temperature and ionic fluid.

**PYLP780 Diffusive and micro optics**  
3 Credits (3-0-0)  

**PYLP790 Integrated Optics**  
3 Credits (3-0-0)  

**JOP791 Laboratory-I (Fiber Optics and Opt. Comm. Lab)**  
3 Credits (0-0-6)  
Experiments on characterisation of optical fibers, sources, detectors and modulators, in the Physics Department and experiments on electronics and communication in the Electrical Engineering Department.

**PYLP791 Fiber Optics**  
3 Credits (3-0-0)  
Overlaps with: PYL413 and PYLE50  
Ray and ray paths in optical fibers; Numerical aperture; Step index and graded index fibers; Attenuation in optical fibers; Modal analysis of symmetric planar waveguides; TE and TM modes, mode cutoff, power flow: Linearly polarized (LP) modes in step-index optical fibers; Mode cutoff, single mode operation; Mode field diameter in single mode fibers, LP modes of infinitely extended parabolic medium, Intermodal dispersion in multimode fibers; Optimum profile fibers; Dispersion and chirping of pulses in single mode fibers, Dispersion compensation and dispersion tailoring; Birefringence in optical fibers, Polarization mode dispersion; Specialty fibers: Birefringent fibers, Photonic crystal fibers;
Erbium doped fiber amplifiers and lasers; Fiber optic components: fiber Bragg gratings, directional couplers; Fiber fabrication and characterization techniques; OTO, connectors and splices.

**JOP792 Laboratory-II (Fiber Optics and Opt. Comm. Lab)**
3 Credits (0-0-6)
Experiments on characterisation of optical fibers, sources, detectors and modulators, in the Physics Department and experiments on electronics and communication in the Electrical Engineering Department.

**PYL792 Optical Electronics**
3 Credits (3-0-0)
Light propagation through anisotropic media, Electro optic effect and electro optic modulators and switches, Liquid crystal devices and spatial light modulators, Acousto optic effect, acousto optic tunable filter, acousto optic deflector, scanner and spectrum analyser, Basics of nonlinear optical effects, Second harmonic generation, phase matching, quasi phase matching, Sum and difference frequency generation, parametric amplification and parametric oscillation, Third order nonlinear optical effects, Self phase modulation and soliton formation, Cross phase modulation and four wave mixing, Stimulated Raman and Brillouin scattering. Nonlinear effects in optical fibers.

**JOL793 Selected Topics-I**
3 Credits (3-0-0)

**PYL793 Photonic Devices**
3 Credits (3-0-0)
Overlaps with : PYL312
Review of Semiconductor Physics for Photonics: The Density of States \( p(K) \) and \( p(E) \); Density of States in a Quantum Well Structure; Carrier Concentration & Fermi Level; Quasi Fermi Levels. Semiconductor Optoelectronic Materials; Heterostructures, Strained-Layers, Bandgap Engineering; p-n junctions; Schottky Junctions & Ohmic Contact.

**JOL794 Selected Topics-II**
3 Credits (3-0-0)

**JOS795 Independent Study**
3 Credits (0-3-0)
Detailed study on a contemporary topic in the area of Optoelectronics/ Optical Communication, as suggested by the Course Coordinator.

**PYL795 Optics and Lasers**
3 Credits (3-0-0)
Overlaps with : PYL115, PYL311, PYL560 and PYL655
Review of basic optics: Reflection and refraction of plane waves; Polarization and polarizing devices; Diffraction: diffraction due to single slit and circular aperture, grating, Gaussian beam; Interference: two beam and multiple beam interference, Fabry-Perot interferometer, Michelson interferometer; Fourier optics and its applications, spatial frequency filters.
Interaction of light with matter, light amplification and oscillation, Laser rate equations, three level and four level systems, Line broadening mechanisms, Laser power around threshold, Optical resonators and resonator stability, Modes of a spherical mirror resonator, mode selection, Q-switching, mode locking in lasers, properties of laser radiation, laser systems and some applications of lasers.

**JOV796 Selected Topics in Photonics**
1 Credit (1-0-0)

**PYL800 Numerical and Computational Methods in Research**
3 Credits (3-0-0)
Solution of polynomial and transcendental equations, ordinary differential equations with initial conditions, matrix algebra and simultaneous equations, eigenvalues and eigenvectors of a real symmetry matrix, least square curve fittings, numerical integration, integral equations, ordinary differential equation with boundary conditions, Monte Carlo methods and random numbers.

**JOD801 Major Project Part-I**
6 Credits (0-0-12)
Analysis/Design/Simulation/Experimental study on topics in the board area of Optoelectronics and Optical Communication, offered by the faculty.

**PYD801 Major Project Part-I**
6 Credits (0-0-12)
Study on topics in the board area of Solid State Materials, offered by the faculty.

**JOD802 Major Project Part-II**
12 Credits (0-0-24)
Detailed investigations on the study of contemporary topics in the board area of Optoelectronics and Optical Communication. Normally this is a follow-up of the study carried out under Part-1 of the Major Project.

**PYD802 Major Project Part-II**
12 Credits (0-0-24)
Detailed investigations on the study of contemporary topics in the board area of Solid State Materials. Normally this is a follow-up of the study carried out under Part-1 of the Major Project.

**PYD801 Major Project Part-I**
6 Credits (0-0-12)
Study on topics in the board area of Applied Optics, offered by the faculty.

**PYD802 Major Project Part-II**
12 Credits (0-0-24)
Detailed investigations on the study of contemporary topics in the board area of Applied Optics. Normally this is a follow-up of the study carried out under Part-1 of the Major Project.

**PYS855 Independent Study**
3 Credits (0-3-0)

**PYL858 Advanced Holographic techniques**
3 Credits (3-0-0)
PYL879 Selected Topics in Applied Optics
3 Credits (3-0-0)

PYV881 Selected Topics-I
1 Credit (1-0-0)

PYV882 Selected Topics-II
1 Credit (1-0-0)

PYD883 Minor Project
3 Credits (0-0-6)

PYL891 Fiber Optic Components and Devices
3 Credits (3-0-0)
Pre-requisites: PYL413 or PYL650 or PYL791
Review of optical fiber properties: step and graded index fibers, multimode, single mode, birefringent, photonic crystal and holey fiber: Directional couplers: Analysis, fabrication and characterization: Fused and polished fiber couplers application in power dividers, wavelength division multiplexing, interleavers and loop mirrors: Fiber half-block devices and application in polarizers, and wavelength filters. Fiber grating: Short and Long period gratings, Analysis, fabrication and characterization: application in add-drop multiplexing, gain flattening, dispersion compensation and wavelength locking and sensing. Polarization effects in Optical fibers, Fiber polarization components: Fiber optic wave-plates, polarization controllers and associated micropolar optic components like isolators and circulators; Optical fiber sensors: Intensity, phase, polarization and wavelength-shift based sensors, applications in various disciplines.

PYL892 Guided Wave Photonic Sensors
3 credits (3-0-0)
Pre-requisites: PYL413 or PYL650 or PYL790 or PYL791
Department of Textile Technology

TXL110 Polymer Chemistry
3 Credits (3-0-0)
Pre-requisites: CML100
The course will deal with chain and step growth polymerization methods, polymer's macromolecular architecture, molecular weight of polymers, copolymerization, cross-linked polymers, general structure and characteristics of polymers, properties of fiber forming polymers and their applications.

TXL111 Textile Fibres
3 Credits (2-0-2)
Pre-requisites: PYL100/MTL100/CML100
Laboratory exercises would include experiments on fibre identification through physical appearance, microscopic (optical, SEM), and burning behaviour. Chemical identification through solvent treatment and elemental analysis.

TXL211 Structure and Physical Properties of Fibres
3 Credits (3-0-0)
Pre-requisites: TXL110/TXL111/TXN100

TXL212 Manufactured Fibre Technology
3 Credits (3-0-0)
Pre-requisites: TXL110/TXL111/TXN100

TXP212 Manufactured Fibre Technology Lab
1 Credit (0-0-2)
Pre-requisites: TXL110/TXL111/TXN100
The laboratory experiments are planned to provide knowledge on fibre formation of selected synthetic polymers and the characterization of fibres/tapes produced. Melt-spinning, extrusion, wet spinning and dry-jet wet spinning techniques is used to produce fibres or tapes. The evaluation of structure through thermo-mechanical properties, polymer solution rheology and microscopic analysis of materials is carried out using established methods.

TXL221 Yarn Manufacture-I
3 Credits (3-0-0)
Pre-requisites: TXL110/TXL111/TXN100

TXP221 Yarn Manufacture Laboratory-I
1 Credit (0-0-2)
Pre-requisites: TXL110/TXL111/TXN100
Experiments related to the lecture course entitled "Yarn Manufacture I (TXL221)".

TXL222 Yarn Manufacture-II
3 Credits (3-0-0)
Pre-requisites: TXL110/TXL111/TXN100

TXP222 Yarn Manufacture Laboratory-II
1 Credit (0-0-2)
Pre-requisites: TXL110/TXL111/TXN100
Experiments related to the lecture course entitled "Yarn Manufacture II (TXL222)".

TXL231 Fabric Manufacture-I
3 Credits (3-0-0)
Pre-requisites: TXL110/TXL111/TXN100

TXP231 Fabric Manufacture Laboratory-I
1 Credit (0-0-2)
Pre-requisites: TXL110/TXL111/TXN100
Experiments related to the theoretical paper TXL231.

TXL232 Fabric Manufacture-II
3 Credits (3-0-0)
Pre-requisites: TXL110/TXL111/TXN100
and warp knitted constructions, cams and needles, different weft and warp knitted structures and their properties, weft and warp knitting machines. Nonwovens: Definitions and classifications, production technology, selection criteria and important properties of fibres used, different types of webs and bonding techniques, production and properties of needle punched, adhesive bonded, thermally bonded, hydroentangled, spun bonded and meltblown fabrics. Braided structures: Types of braiding processes, classification of braids, braid geometry, structure-property relationship, over braiding.

**TXP232 Fabric Manufacture Laboratory-II**
1 Credit (0-0-2)
Pre-requisites: TXL110/TXL111/TXN100
Experiments related to the theoretical paper TXL232.

**TXL241 Technology of Textile Preparation & Finishing**
3 Credits (3-0-0)
Pre-requisites: TXL110/TXL111/TXN100

**TXP241 Technology of Textile Preparation & Finishing Lab**
1.5 Credits (0-0-3)
Pre-requisites: TXL110/TXL111/TXN100

**TXL242 Technology of Textile Coloration**
3 Credits (3-0-0)
Pre-requisites: TXL110/TXL111/TXN100
The principles of dyeing and printing of textile materials. Basic characteristics of dyes, chemical structure of dyes, and classification of dyes. Dyeing equipment and the specific dyes and procedures used to dye textiles. Evaluation of Fastness. Methods of printing namely, roller, screen, transfer, ink jet and the preparation of printing paste. Direct, discharge and resist printing styles. Physical chemistry of fibre/fabric dyeing. Physicochemical theories of the application of dyestuffs to textile and related materials, including the thermodynamics and kinetic principles involved.

**TXP242 Technology of Textile Coloration Lab**
1.5 Credits (0-0-3)
Pre-requisites: TXL110/TXL111/TXN100
The principles of dyeing and printing of textile materials. Dyeing equipment and the specific dyes and procedures used to dye textiles. Evaluation of Fastness. Methods of printing namely, screen, transfer, ink jet and the preparation of printing paste. Direct, discharge and resist printing styles.

**TXD301 Mini Project**
3 Credits (0-0-6)
Pre-requisites: TXL211/TXL221/TXL222/TXL231/TXL232 and EC65

**TXR301 Professional Practices**
2 Credits (0-1-2)
Pre-requisites: TXL211/TXL221/TXL222/TXL231/TXL232 and EC65

**TXS301 Independent Study**
3 Credits (0-3-0)
Pre-requisites: EC65

**TXL321 Multi and Long Fibre Spinning**
3 Credits (3-0-0)
Pre-requisites: TXL221/TXL222 and EC50

**TXL331 Woven Textile Design**
3 Credits (3-0-0)
Pre-requisites: TXL231/TXL232 and EC50

**TXL341 Colour Science**
2 Credits (2-0-0)
Pre-requisites: TXL241/TXL242 and EC50
The course will deal with aspects of colour science that are important to the colour technologist in the day-to-day manufacture and control of coloured products in textile applications.

**TXL361 Evaluation of Textile Materials**
3 Credits (3-0-0)
Pre-requisites: TXL211/TXL221/TXL222/TXL231/TXL232 and EC50
Introduction to textile testing: Sampling and basic statistics: Selection of samples for testing; Random and biased samples; Different types of sampling of textile materials; The estimation of population characteristics from samples and the use of confidence intervals; Determination of number of tests to be carried out to give chosen degree of accuracy; Test of significance of means and variance; Related numerical; Quality control charts and their interpretation; Standard tests, analysis of data and test reports, Correlation and coefficient of determination; Analysis of variance (ANOVA).
Testing methods: Measurement of length, fineness and crisp of fibres; Determination of maturity, foreign matter, and moisture content of cotton; Principles of AFIS, HVI etc.; Measurement of twist, linear density and hairiness of yarn; Evenness testing of spinners, rovings and yarns; Analysis of periodic variations in mass per unit length; Uster classimat; Spectrogram and V-L curve analysis; Tensile testing of fibres, yarns and fabrics; Automation in tensile testers; Tearing, bursting and abrasion resistance tests for fabrics; Pilling resistance of fabrics; Bending, shear and compressional properties of fabrics, fabric drape and handle (KEST, FAST etc); Crease and wrinkle behavior; Fastness characteristics of textiles; Matching of shade; Air, water and water-
vapour transmission through fabrics; Thermal resistance of fabrics; Testing of interlaced and textured yarns; Special tests for carpets and nonwoven fabrics. Testing of special yarns (textured yarns, core yarn, ropes, braids etc). Testing of special fabrics (different types of nonwovens, carpets, different types of technical textiles like bullet proof fabrics, UV protective fabrics, EMS fabrics etc.).

**TXL370 Modelling and Simulation in Fibrous Assemblies**
3 Credits (2-0-2)

Pre-requisites: TXL211/TXL221/TXL222/TXL231/TXL232 and EC 75

Introduction to Textile Modelling and Simulation, types of model. Curve Fitting Techniques: Prediction of mechanical properties of fibrous assemblies.


Stochastic and Stereological Methods: Random fibrous assemblies, anisotropy characteristics, two and three-dimensional fibrous assemblies. Statistical Mechanics: Monte Carlo simulation of random fibrous assemblies.

Multiscale Modelling: Geometrical modelling of textile structures, modelling of properties of fibrous assemblies.

Computational Fluid Dynamics: Newtonian and Non-Newtonian Fluids and their applications in extrusion processes, Computer simulation of fluid flows through porous materials, heat and mass transfer in fibrous assemblies.

**TXV701 Process Cont. and Econ. in Manmade Fibre Prod.**
1 Credit (1-0-0)

Pre-requisites: TXL211/TXL221/TXL222/TXL231/TXL232 and EC 75


**TXV702 Management of Textile Business**
1 Credit (1-0-0)

Pre-requisites: TXL211/TXL221/TXL222/TXL231/TXL232 and EC 75


**TXV703 Special Module in Textile Technology**
1 Credit (1-0-0)

Pre-requisites: TXL211/TXL221/TXL222/TXL231/TXL232 and EC 75

The course aims at introducing special topics in textile technology. The course topics and content are likely to change with each offering depending upon the current requirement and expertise available with the department including that of the visiting professionals.

**TXV704 Special Module in Yarn Manufacture**
1 Credit (1-0-0)

Pre-requisites: TXL211/TXL221/TXL222/TXL231/TXL232 and EC 75
The course aims at introducing new or highly specialized technological aspects in yarn manufacture. The course topics and content are likely to change with each offering depending upon the current requirement and expertise available with the department including that of the visiting professionals.

**TXV705 Special Module in Fabric Manufacture**
1 Credit (1-0-0)
Pre-requisites: TXL211/TXL221/TXL222/TXL231/TXL232 and EC 75
The course aims at introducing new or highly specialized technological aspects in fabric manufacture. The course topics and content are likely to change with each offering depending upon the current requirement and expertise available with the department including that of the visiting professionals.

**TXV706 Special Module in Fibre Science**
1 Credit (1-0-0)
Pre-requisites: TXL211/TXL221/TXL222/TXL231/TXL232 and EC 75
The course aims at introducing new or highly specialized technological aspects in fibre science. The course topics and content are likely to change with each offering depending upon the current requirement and expertise available with the department including that of the visiting professionals.

**TXV707 Special Module in Textile Chemical Processing**
1 Credit (1-0-0)
Pre-requisites: TXL211/TXL221/TXL222/TXL231/TXL232 and EC 75
The course aims at introducing new or highly specialized technological aspects in textile chemical processing. The course topics and content are likely to change with each offering depending upon the current requirement and expertise available with the department including that of the visiting professionals.

**TXL710 High Performance and Specialty Fibres**
3 Credits (3-0-0)
Pre-requisites: TXL212 and EC75
Definition, classification and structural requirements of high performance and specialty fibres, Polymerization, spinning and properties of arams, aromatic polyesters, rigid rod and ladder polymers such as PBZT, PBO, PBI, PPD, Manufacture of carbon fibres from polyacrylonitrile, viscose and pitch precursors, Concept of gel spinning and spinning of UHMPE fibres, Elastomeric polymers and fibres, Lyocell fibre production, Conducting fibres, Thermally and chemically resistant polymers and fibres, Methods of synthesis, production and properties of: glass and ceramic fibres. Specialty fibres: profile fibres, optical fibres, bicomponent fibres and hybrid fibres, Superabsorbent polymers and fibres.

**TXL711 Polymer and Fibre Chemistry**
3 Credits (3-0-0)
The course will deal with chain and step growth polymerization methods, polymer's macromolecular architecture, molecular weight of polymers, copolymerization, cross-linked polymers, general structure and characteristics of polymers, spectroscopic analysis of polymers, properties of fiber forming polymers and their applications.

**TXP711 Polymer and Fibre Chemistry Laboratory**
1 Credit (0-0-2)
Identification of fibres by chemical and burning tests, polymerization of vinyl monomers such as styrene, acrylamide using bulk polymerization, solution polymerization, emulsion polymerization, radiation induced polymerization. Condensation polymerization and interfacial polymerization of nylon-6, Molecular weight measurement. Intrinsic viscosity and end group analysis, preparation of phenol-formaldehyde resin. Analysis of chemical structure by FTIR, UV spectroscopy.

**TXL712 Polymer and Fibre Physics**
3 Credits (3-0-0)
Molecular architecture, configuration, conformation of ideal and real chains, Random Walk models of polymer conformations, Gaussian chain, Self-avoiding walks and excluded-volume interaction, the amorphous phase and its chemical-physical aspects, the glass transition phenomenon, the WLF-equation, crystalline state and its chemical-physical aspect, cross-linked polymers and rubber elasticity, behaviour of polymers in solutions and mixtures, viscoelasticity and rheology of polymers, mechanical properties, physical properties of fibres: moisture absorption properties, mechanical properties, optical properties, thermal properties.

**TXP712 Polymer and Fibre Physics Laboratory**
1 Credit (0-0-2)
Laboratory Experiments on Characterization of fibres by Infrared spectroscopy, Density measurements; Thermal analysis: Thermogravimetric Analysis (TGA), Differential Scanning calorimetry (DSC) and Thermo-Mechanical Analysis (TMA); Dynamic Mechanical Analysis (DMA); Sonic modulus; X-ray diffraction studies; Birefringence measurement; Optical microscopy studies; Scanning Electron Microscope (SEM) of fibres: Creep and Stress Relaxation study, Mechanical property testing such as tensile and flexural rigidity.

**TXL713 Technology of Melt Spun Fibres**
4 Credits (3-1-0)
Importance of transport phenomena in fibre manufacturing; Fundamentals of momentum transfer, heat transfer, mass transfer, building differential equations using shell balance and generalized equations; Polymer rheology- shear flow, elongational flow; Melt spinning lines for filament and staple fibre; Role of spin finish; Necessary conditions for fibre formation, elasticity versus plasticity of melts; Melt instabilities; Thermodynamic limitations; Force balance and heat balance in melt spinning; Low speed melt spinning; Necking and stress induced crystallization in high speed melt spinning; Effect of process parameters on fibre spinning and structure of nylon 6, PET and PP; Drawing Process and its necessity; Neck or flow deformational drawing; Drawing machines; Effect of parameters on structure development in nylon 6, PET, PP; Types of heat setting, Effect of setting parameters on structure and properties; Concept of bulking/texturing.

**TXL714 Advanced Materials Characterization Techniques**
1 Credit (1-0-0)
Relevance of advanced characterization techniques in material development; scattering techniques (SAXS/WAXS); advanced surface characterization techniques (X-ray photoelectron spectroscopy (XPS), Auger electron spectroscopy (AES), secondary ion mass spectroscopy (SIMS)); microscopy techniques: basics of electron-materials interaction; SEM combined with FIB techniques; TEM and cryo-TEM; chemical analysis utilizing microscopy techniques; AFM; confocal laser microscopy.

**TXL715 Technology of Solution Spun Fibres**
3 Credits (3-0-0)
Pre-requisites: TXL711/TXL713
PAN properties; Solution rheology and its dependence on parameters. Effect of parameterization entanglement density, fibre spinning and subsequent drawing; Various solvent systems; Dope preparation; Wet and dry spinning processes; Effect of process parameters such as dope concentration, bath concentration, temperature and jet stretch ratio on coagulation rate, fibre breakage and fibre structure; Modeling of coagulation process; properties and structure of dry and wet spun fibres; Dry jet wet spinning. Solution spinning of PAN.
Bicomponent and bulk acrylic fibres. Acrylic fibre line, crimping and annealing, tow to top conversion systems; Viscose rayon process, Spinning with and without zinc sulfate; Polyamids and high performance cellulosic fibre; Non viscose processes, Lyocell spinning process, structure and properties; Gel spinning of PE, Gel spinning of PAN and PVA. Introduction to high performance fibres and their spinning systems such as rigid rod polymer, liquid crystalline polymers, polyactic acid and spandex fibre manufacturing.
TXP716 Fibre Production and Post Spinning Operation Laboratory
2 Credits (0-0-4)
Experiments related to fibres production processes. Effect of moisture and temperature on MFI of PET and PP. Melt spinning of PET, PP & nylon-6 filament yarns on laboratory spinning machines. Single and two stage drawing of the as-spun yarns or industrial POY. Demonstration of high speed spinning machine. Wet and dry heat setting of PET and nylon drawn yarns. Effect of temperature and tension on heat setting. Determination of structure and mechanical properties of as spun, POY, drawn and heat set yarns using DSC, X-ray, FTIR, density, sonic modulus. Effect of shear rate, temperature on polymer solution viscosity using Brookfield Rheometer and ball-fall method. Wet spinning or dry jet wet spinning of PAN copolymers. False twist and air jet texturing processes. Determination of structure of textured yarn under microscope.

TXL719 Functional and Smart Textiles
3 Credits (3-0-0)
Pre-requisites: TXL221/TXL222 and EC75
Definition and Classification of Functional and Smart textiles ; Introduction to Composites : Theory, Types, Properties ; High Performance fibers, thermoplastic and thermosetting Resins; Composite Manufacturing and Applications; Coated and laminated Textiles: materials, formulations, techniques and applications ; Protective Textiles- Materials, design, principles and evaluation for protection against fire, harmful radiation, chemicals and pesticides; Sportswear: design, testing and materials – fibers , yarns, fabrics for temperature control and moisture management; Medical textiles; Classification, types and products, Health and Hygiene Textiles- protection against microbes, Wound management- dressings, suture and bandages, Implants and drug delivery systems ; Smart and Intelligent Textiles : Passive and Active functionality, stimuli sensitive textiles, Electronic Textiles : wearable computers, flexible electronics.

TXL721 Theory of Yarn Structure
3 Credits (3-0-0)
General description of yarn structure, Fibre packing arrangement in yarns, Fibre directional arrangement in yarns, Geometry of pores in yarns, Relationship among yarn count, twist, and diameter, Helical model of fibers in yarns, Yarn retraction, Limits of twisting, Radial migration of fibers in yarns, Model of ideal fibre migration, Model of equidistant migration, Tensile mechanics of yarns, Yarn tensile behavior in light of helical model, Relationship between tensile behaviors of fiber and yarn, Yarn strength as a function of gauge length, Bending mechanics of yarns, Mass unevenness of yarns, Martindale’s model of mass irregularity, Model of hierarchical structure of fibre aggregates, Hairiness of staple fibre yarns, Single- and double-exponential models of yarn hairiness, Structure and mechanics of plied yarns.

TXL722 Mechanics of Spinning Processes
3 Credits (3-0-0)
Pre-requisites: TXL221/TXL222 and EC75
Principles of bale management. Forces acting on fibres during opening and cleaning, analysis of fibre compactness and blending in blowroom. Carding process, cylinder load and transfer efficiency, design of high production card, fibre shedding and card wire geometry, Fibre configuration in card and drawn sliver. Fibre movement in drafting field, drafting force, roller slip, roller eccentricity and vibration, autolevelling. Fibre fractionation in comber, combing performance. Analysis of forces on yarn and traveller, spinning tension in ring and rotor spinning, spinning geometry, twist flow in ring and rotor spinning, end breaks. Mechanism of drafting and yarn formation in high speed spinning systems.

TXL724 Textured Yarn Technology
3 Credits (3-0-0)
Pre-requisites: TXL221/TXL222 and EC75
Principles of texturing and modern classification; False twist texturing process- mechanisms and machinery, optimization of texturing parameters, barre’, structure-property correlation of textured yarns; Draw-texturing- the need and fundamental approaches; Friction texturing- the need and development, mechanics of friction texturing, latest development in twisting devices, optimization of quality parameters. Noise control in texturing.

TXL725 Mechanics of Spinning Machines
3 Credits (3-0-0)
Pre-requisites: TXL221/TXL222 and EC75

TXP725 Mechanics of Textile Machines Laboratory
1 Credit (0-0-2)
Students will do experimental analysis of various machine elements on textile machines.

TXL731 Theory of Fabric Structure
3 Credits (3-0-0)

TXL732 Advanced Fabric Manufacturing Systems
3 Credits (3-0-0)
Fabric manufacturing systems, Yarn quality and weavability, Yarn Preparation for High speed weaving, Preparation of high performance fibres/tows for weaving, Sizing of filament yarn, Shuttle less weaving systems: Advancements in each system with respect to productivity, yarn characteristics and fabric quality, energy requirement, design flexibility, applications and limitations, Specialty weaving: 3D weaving, Multilayer weaving, Spacer weaving, Profiled weaving, Polar and Spiral fabric, Circular Weaving, Honeycomb weaving, Denim manufacturing, Multiaxial weaving, Multiphase weaving, Terry weaving, Leno Weaving, Filament Weaving, Properties and applications of fabrics produced in these systems. Wet and warp knitted structures for technical applications, Braiding; biaxial and triaxial braids, 3D braiding, Structure, properties and applications of braided fabrics, Development in nonwoven technologies, Stitch bonding methods, Nonwoven composite fabrics, Electrospinning, 3D nonwovens.

TXL734 Nonwoven Process and Products
3 Credits (3-0-0)
Pre-requisites: TXL221/TXL222/TXL223/TXL231/TXL232 and EC75
Fabrication, properties and applications of nonwoven fabrics, Determination of structure and mechanical properties of as spun, POY, nylon drawn yarns. Effect of temperature and tension on heat setting. Determination of structure of textured yarn under microscope.

**TXL740 Science & App. of Nanotechnology in Textiles**
3 Credits (3-0-0)

Pre-requisites: EC75

Introduction to Nanoscience and Nanotechnology; Size and surface dependence of their physical and chemical properties such as mechanical, thermodynamical, electronic, catalysis etc.; Synthesis of Nanomaterials used in Textiles such as carbon nanotube, fullerene, metal and metal oxide nanoparticles i.e. nano silver, nano silica, nano titania, nano zinc oxide, nano magnesium oxide etc.; Surface functionalization and Dispersion of nanomaterials; Nanotoxicity, Characterization techniques i.e. XRD, AFM, SEM/TEM, DLS etc.; Nanomaterial applications in textiles and polymers; Nanocomposites: definition types, synthesis routes; nanocomposite fibres and coatings e.g. gas barrier, antimicrobial, conducting etc.; Nanofibres: preparation, properties and applications i.e. filtration, tissue engineering etc.; Nanofinishing: self-cleaning, antimicrobial, UV protective etc.; Nanocoating on textile substrates; Plasma Polymisation, Layer-by-layer Self Assembly, Sol-Gel coating etc.

**TXL741 Env. Manag. in Textile and Allied Industries**
3 Credits (3-0-0)

Pre-requisites: TXL212/TXL241/TXL242 and EC 75


**TXL 747 Colour Science**
3 Credits (3-0-0)

Pre-requisites: EC 75

Colour and chemical constitution, physics and chemistry of colour, measurement of colour Colorimetry and CIE system, Qualities of Colorants, Colour-order systems, Colour Sensors, Physiology of Colour Vision, Visual and instrumental evaluation of whiteness, shade sorting, colour uncertainty.

**TXL748 Advances in Finishing of Textiles**
3 Credits (3-0-0)

Pre-requisites: EC 75/TXL747/TXL753


**TXP 748 Textile Preparation and Finishing Lab**
1 Credit (0-0-2)

Pre-requisites: TXL747/TXL753

Preparatory and finishing related project based experiments, Chemistry and principle of each treatment and analysis of results.

**TXL 749 Theory and Practice of Dyeing**
3 Credits (3-0-0)

Pre-requisites: EC 75

Advances in dyes, Specialty dyes: photochromic, thermostochromic, electrochromic, mechnanochromic; Fluorescent and near IR dyes; Dyes for camouflage; Banned dyes; Safe and eco-friendly dyes, natural dyes; Mechanisms of dyeing; Thermodynamics of dyeing; Kinetics of dyeing; Dye-fibre interactions; Role of fibre structure in dyeing; Advances in dyeing processes: low liquor, salt free, low energy intensive dyeing; Dyeing of blends; Mass colouration of man-made fibres; Dyeing of specialty fabrics: stretch fabrics, light weight, textured, garment dyeing, micro-denier fabrics, fibre dyeing; Effect of finishes on shade and fastness; Dyeing faults and case studies.

**TXP 749 Textile Colouration Lab**
1 Credit (0-0-2)

Pre-requisites: B Tech. Textile/ BE Textile/ MSc Textile

Project based experiments in dyeing and colouration, dyeing of fabric, visual and instrumental assessment of shade variation. Subjective vs objective evaluation, Shade sorting, whiteness index. Azo dye synthesis and characterization.

**TXL750 Science of Clothing Comfort**
3 Credits (3-0-0)

Pre-requisites: TXL211/TXL221/TXL222/TXL231/TXL232 and EC75


**TXL751 Apparel Engineering and Quality Control**
3 Credits (2-0-2)

Pre-requisites: TXL211/TXL221/TXL222/TXL231/TXL232 and EC75

of low stress mechanical properties for making up process, Fabric mechanical properties and sewing operation interaction, Concept of Tailorability, Formability and Lindberg theory, Quality control in apparel manufacturing, Determination of sewability, Effect of sewing on fabric mechanical and aesthetic properties, Fabric defects and their impact on garment quality, Quality inspection and defects in apparels, Evaluation of sewing threads, Evaluation of clothing accessories, Material Functionality in clothing, Engineering of functional clothing.

**TXL 755 Textile Wet Processing Machines: Automation and Control**
3 Credits (3-0-0)
Pre-requisites: EC 75
Basic concepts of fluid flow, heat and mass transfer with specific emphasis on textile processes, Feedback control principles and systems, Sensors and transducers used in chemical processing machines; Machinery for processing of textiles in fibre, yarn and fabric form, batch and continuous machines. Machines for pre-treatment, dyeing, printing and finishing, developments in machinery for improving the effectiveness of treatment and reduction in chemical, energy and water consumption, mechanical finishing machines, garment processing.

**TXL 756 Textile Auxiliaries**
3 Credits (3-0-0)
Pre-requisites: EC 75

**TXL 766 Design and Manufacturing of Textile Structural Composites**
3 Credits (3-0-0)
Pre-requisites: TXL211/TXL221/TXL222/TXL231/TXL232 and EC75

**TXL 771 Electronics and Controls for Textile Industry**
4 Credits (3-0-2)
Overview of electronics and controls in modern textiles equipments and machines. Overview of basic analog electronics: Elements (R, L, C, V, I), circuit laws and theorems. Overview of basic digital electronics: Gates and ICs. Sensors and transducers (displacement, position,

**TXXL772 Computational Methods for Textiles**  
3 Credits (2-0-2)  

**TXXL773 Medical Textiles**  
3 Credits (3-0-0)  
Pre-requisites: TXL211/TXL221/TXL222/TXL231/TXL232 and EC75  
Natural and synthetic polymers and Textile-based techniques used for medical applications, Fibrous extracellular matrix of human body and their characteristic features, Cell-Polymer interaction, Non-implantable materials (Wound-dressing, related hydrogel and composite products, Bandages, Gauges), Implantable biomedical devices (Vascular grafts, Sutures, Heart valves), Extra-corporeal materials (Scaffolds for Tissue engineering, Rapid prototyping, Cartilage, Liver, Blood Vessel, Kidney, Uterine bladder, Tendons, Ligaments, Cornea), Healthcare and hygiene products (Surgical Gowns, masks, wipes, Antibacterial Textiles, Super absorbent polymers, Dialysis, Soluble factor release), Safety, Legal and ethical issues involved in the medical textile materials.

**TXXL774 Process Control in Yarn & Fabric Manufacturing**  
3 Credits (3-0-0)  
Pre-requisites: TXL211/TXL221/TXL222/TXL231/TXL232 and EC75  

**TXXL775 Technical Textiles**  
3 Credits (3-0-0)  
Pre-requisites: TXL211/TXL221/TXL222/TXL231/TXL232 and EC75  

**TXXL777 Product Design and Development**  
3 Credits (3-0-0)  
Pre-requisites: TXL211/TXL221/TXL222/TXL231/TXL232 and EC75  

**TXXL781 Project Appraisal and Finance**  
3 Credits (3-0-0)  
Pre-requisites: TXL211/TXL221/TXL/TXL231/TXL232 and EC75  

**TXXL782 Prod. & Operations Management in Textile Industry**  
3 Credits (3-0-0)  
Pre-requisites: TXL211/TXL221/TXL222/TXL231/TXL232 and EC75  

**TXXL783 Design of Experiments and Statistical Techniques**  
3 Credits (3-0-0)  
Pre-requisites: TXL211/TXL221/TXL222/TXL231/TXL232 and EC75  

**TXXL784 Supply Chain Management in Textile Industry**  
3 Credits (3-0-0)  
Definition, objectives, stages and metrics of textile supply chain; Life cycle of textile products, demand and fashion forecasting,
forecasting techniques, bull-whip effect, aggregate forecasting in apparel industry; Designing of textile supply chain network, make vs buy and location decisions of textile SCM, reverse logistics in textile SCM; Risk mitigation in global textile supply chain, coordination among fabric, apparel and accessories manufacturers, role of dominant power; Transportation and distribution strategies; Supplier selection in textile SCM, quantitative models; Lean, agile and leagile textile supply chains and their enablers, designing resilient textile supply chain; Push-pull supply chain, decoupling point in textile SCM; Green and low carbon textile supply chain; Case studies related to textile and apparel supply chains.

**TXS805 Independent Study (Textile Engineering)**
3 Credits (0-3-0)
Student should undertake a research oriented activity including software development, machine design & development, product & process development, instrumentation and in-depth study of a subject which is outside the regular courses offered in the program. This study should be carried out under the guidance of a faculty member. The subject area chosen by the student should be sufficiently different from the area of major project being pursued by the student.

The student should submit a detailed plan of work to the program coordinator before approval of registration for the course. The student registered for this course should give one mid-term presentation followed by a final presentation before a committee constituted by the program coordinator.

**TXS806 Independent Study (TTF)**
3 Credits (0-3-0)
Student should undertake a research oriented activity including software development, machine design and development, product & process development, instrumentation and in-depth study of a subject which is outside the regular courses offered in the program. This study should be carried out under the guidance of a faculty member. The subject area chosen by the student should be sufficiently different from the area of major project being pursued by the student.

The student should submit a detailed plan of work to the program coordinator before approval of registration for the course. The student registered for this course should give one mid-term presentation followed by a final presentation before a committee constituted by the program coordinator.

**TXL807 Seminar (Textile Engineering)**
2 Credits (0-2-0)
A comprehensive literature review on a research topic of current interest or futuristic, pertaining to a textile process or product or technology. Student should perform a comprehensive literature review on a research topic of current interest or futuristic, pertaining to a textile process or product or technology. The student should give an outline of the review and get approval from the program coordinator for registration of this course. The student registered for this course should give one mid-term presentation followed by a final presentation before a committee constituted by the program coordinator.

**TXD809 Mini Project (Textile Engineering)**
4 Credits (0-0-8)
This is an open ended course where the students are expected to design and develop a product or equipment or instrument relevant to the field of textile technology. In this process, the students are expected to demonstrate their ability to think on their own in design and development of hardware item. They are also expected to put down their thinking process in a report form with relevant literature background, methodology of design and development process and should have conducted some experiments with the developed hardware system. Finally, they need to present their work for the award of grade.
CRL601 Basics of Statistical Signal Analysis
3 Credits (2-0-2)
Fundamentals of signals and systems, LTI systems, convolution, Fourier transforms, Z-transform, sampling and Nyquist criteria, set & probability theory, random variables, probability density distribution functions, moments, characteristic and moment generating functions, transformation of a random variable, random process, stationarity, ergodicity. Lab experiments using MATLAB will be given to understand the practical aspects of these concepts.

CRL611 Basics of RF and Microwaves
3 Credits (2-0-2)
Basic electromagnetics, plane waves and scattering, waveguide modes, Fourier series and transform, autocorrelation and power spectral density, holes and electrons in semiconductors, p-n junction.

CRL621 Fundamentals of Semiconductor Devices
3 Credits (3-0-0)
Si Crystal structure, crystal planes and directions, band formation in semiconductors, direct and indirect gap semiconductors, E-k diagram, concept of "hole" as charge particle, effective mass, carrier mobility, life time of carriers, recombination, doping of semiconductors, drift and diffusion currents in semiconductors, metal-semiconductor junctions, ohmic and non-ohmic contacts, Schottky diode, abrupt p-n junction, energy- band diagram, junction under zero-bias, forward bias and reverse bias; current calculations, break-down in p-n junction, diffused p-n junction; bipolar transistor: theory and operation; theory of MOS FET, ideal MOSFET, threshold voltage, sub-threshold conduction in MOSFET, C-V characteristics of MOS capacitor, short-channel effects.

CRL702 Architectures and Algorithms for DSP Systems
4 Credits (2-0-4)
Lectures:
Introduction – DSP Tasks and Applications, Real-time Signal Processing, Representation of DSP algorithms; Number Representations and Arithmetic Operations - Fixed point and floating point representations and arithmetic operations; Q notation; Digital Signal Processor Architectures – CPU, Peripherals; Specific DSP processor architecture; DSP Instruction Set and Assembly Language Programming – Instruction types; Parallel programming; Pipelining; Efficient programming; DSP Algorithms and their Efficient Implementation - a) Linear filtering; b) FFT and spectrum analysis; c) Scalar and vector quantization, source coding, linear prediction coding; d) Function generation; Software Design for Low Power Consumption.

The DSP architecture and assembly language programming will be studied in lectures and laboratory with reference to a specific DSP processor.

Laboratory:

CRL704 Sensor Array Signal Processing
3 Credits (3-0-0)
Representation of space - time signals: Coordinate systems; propagating waves; wave number-frequency space; arrays and apertures; space-time random processes and their characterization; Signal modeling and optimal filters: AR, MA, ARMA models; Autocorrelation and power spectral density; linear MMSE estimator; optimum filters; Power spectrum estimation: Non-parametric and parametric methods; Arrays and spatial filters: Frequency-wavenumber response and beam patterns; ULA; Performance measures; Synthesis of linear arrays and apertures: Spectral weighting; array polarizations; pattern sampling in wavenumber space, minimum beamwidth for specified sidelobe levels, broadband arrays; Optimum beamforming: MVD beamformers; MMSE beamformers; Eigenvector beamformers; Adaptive beamforming: Least mean squares algorithms; Recursive least squares; Generalized sidelobe canceler; Array geometries in higher dimensions: Rectangular arrays; Circular arrays; Spherical arrays; Cylindrical arrays.

CRL706 Selected Topics in Radars and Sonars
3 Credits (3-0-0)
The Radar and Sonar Equations: Basic System Parameters; Radar and Sonar Applications; Signal Design for range and Doppler resolution: Ambiguity functions, waveforms for CTFM/FMCW, MTI Radar, Pulse Doppler Radar; Detection theory for target extraction from clutter/ reverberation and noise (clutter/reverberation modeling); Synthetic Aperture Radar/Sonar; Target Tracking: active/passive, Monopulse Radar; Modern Techniques: thru-the-wall imaging, multi-static systems.

CRL707 Human & Machine Speech Communication
3 Credits (3-0-0)
Overview of human and machine speech communication: Applications; Speech signal measurement and representation. Speech science topics: Speech production and phonetics: Speech production mechanism; Articulatory and acoustic phonetics; Speech production model; International Phonetic Alphabet; Phonetic transcription; Hearing and perception. Speech signal analysis: Time domain analysis; Spectrum domain analysis; Spectrogram; Cepstrum domain analysis; Pitch estimation; Voicing analysis; Linear prediction analysis. Engineering applications: Speech coding; Speech quality assessment: Subjective and objective evaluation of quality; Automatic speech recognition: HMM; Language models; Keyword spotting; Text-to-speech synthesis: Concatenative and HMM speech synthesis; Prosody modification. The course will include audio demonstrations and require students to do practical exercises with recorded speech signals. An isolated word speech recognizer using open source resources shall be designed.

CRL708 Sonar System Engineering
3 Credits (3-0-0)
Introduction to Sonar applications, Units, Sonar Equations and their limitations, Propagation of sound, Transmission loss, Ambient Noise, Spatial Correlation, Directivity Index, Array Gain, Beam-patterns, Projector Source level, Reverberation, Scattering by targets, echo formation, Radiated Noise and Self Noise, Transmission and Reception modes, Dynamic Range Compression and Normalisation, Receiver Beamforming techniques, Sidelobe nulling, Detection Performance issues, Performance prediction, Sonar System Design examples.

CRL709 Underwater Electronic Systems
3 Credits, (3-0-0)

CRL711 CAD of RF and Microwave Circuits
4 Credits (3-0-2)
Review of basic microwave theory: Transmission lines-concepts of characteristics impedance, reflection coefficient, standing and

Familiarization of photolithography process, mask making using intelllicad and measurement using Automatic Network Analyzer in the laboratory classes. Design, optimization, fabrication and testing of Microstrip components and determining equivalent circuits.

**CRL712 RF and Microwave Active Circuits**
3 Credits (3-0-0)
Microwave Amplifier theory and design. Theory and design of microwave phase shifters, switches and attenuator. Analysis of microwave mixers.

**CRL715 Radiating Systems for RF Communication**
3 Credits (3-0-0)
Revision of Maxwell's equations, radiation, Poynting vector; antenna parameters like gain, radiation pattern, VSWR wire antennas – dipole monopole; antenna arrays; aperture antennas and equivalence theorems; printed antennas, scattering.

**CRL722 RF and Microwave Solid State Devices**
3 Credits (3-0-0)
Review of basics of semiconductor devices. Schottky diode, qualitative description, junction properties, I-V characteristics in forward and reverse biased diodes, high frequency application of Schottky diode, Schott barrier gate FET. GaAs MESFET I-V characteristics, High Electron Mobility Transistor (HEMT), Hetro-structures, SOI technologies and MOSFETS, Fabrication technologies for GaAs MESFET, MBE, Ion Implantation. Pattern transfer at sub-micron level.

**CRL724 RF and Microwave Measurements**
3 Credits (3-0-0)
Theory of operation of network analyzer, and spectrum analyser. VNA calibration, synthesized signal generation, noise measurement, measurement of antenna properties.

**CRL725 Technology of RF and Microwave Solid State Devices**
3 Credits (3-0-0)

**CRL726 MEMS Design and Technology**
3 Credits (3-0-0)
Introduction, origin and driving force for MEMS; extension of IC technologies for MEMS fabrication, major technologies for MEMS: bulk and surface micromachining, LIGA process anisotropic etching of silicon, piezoresistive -piezoelectric effect, piezoresistive silicon based pressure sensor, capacitive pressure sensor, RF switch design, fabrication and characterization, actuation in MEMS, MEMS accelerometer design, fabrication, vibration sensor, energy harvesting devices, piezoelectric materials for MEMS, MEMS based RF and microwave circuits.

**CRL727 Introduction to Quantum Electron Devices**
3 Credits (3-0-0)
The foundation of quantum electronics; Nanoscale resistors: quantum resistance, quantum conductance; Scattering at quantum levels: quantum contacts, quantum interference, Andrev scattering, spin-dependent scattering; Coulomb blockade, Resonant tunneling, Quantum capacitance, Single electron and tom transistors: coulomb blockade memory and logic devices, single electron inverters; Electron transport through single molecule: molecular transistors, memories and switches; Spinning of electron: spin valve and transistors, Sub-band quantum devices: quantum wells, wires an dots, sub band infrared and terahertz detectors; Quantum bit: quantum computers, different types of qubit, initialization, quantum manipulation, readout, charge qubit, phase and flux qubit, spin qubit.

**CRL729 Sensors and Transducers**
3 Credits (3-0-0)
Introduction to sensors and transducers, basic parameters and principles and applications of various sensors and transducers in characterization of materials, devices, circuits and systems; Acoustic and Ultrasonic sensors and transducers; Magnetic and Electrical sensors and transducers; Thermal sensors and transducers; Radiation including Optical sensors and transducers; Smart Sensors for characterization of RF materials, devices, circuits and systems; Mechanical and Thermal Engineering issues for RF Modules/Instruments; Typical applications and use of transducers in systems/instruments.

**CRL731 Selected Topics in RFDT-I**
3 Credits (3-0-0)
Advanced course on selected topics of relevance to the RFDT M.Tech. Program.

**CRL732 Selected Topics in RFDT-II**
3 Credits (3-0-0)
Advanced course on selected topics of relevance to the RFDT M.Tech. Program.

**CRL733 Selected Topics in RFDT-III**
3 Credits (3-0-0)
Advanced course on selected topics of relevance to the RFDT M.Tech. Program.

**CRL734 Selected Topics in RFDT-IV**
3 Credits (3-0-0)
Advanced course on selected topics of relevance to the RFDT M.Tech. Program.

**CRP718 RF and Microwave Measurement Lab**
4 Credits (1-0-6)
Laboratory experiments based on network analyzer, spectrum analyzer, antenna pattern measurement, thermography, data acquisition and digitization.

**CRP723 Fabrication Techniques for RF and Microwave Devices**
3 Credits (1-0-4)
CRS735 Independent Study
3 Credits (0-3-0)
Advanced course on selected topics of relevance to the RFDT M.Tech. Program.

CRV741 Acoustic Classification using Passive Sonar
1 Credit (1-0-0)
The challenges faced by a sonar designer, involved in developing underwater classification systems will be introduced and possible solutions will be discussed. The radiated noise characteristics from marine vessels and the unique characteristics of the acoustic signature with respect to the class of the marine platform will be presented. Recent research work has shown that classical homomorphic signal processing techniques and other channel inversion techniques can be used to significantly reduce the unwanted underwater channel distortions that otherwise affect the classifier performance drastically. The course shall provide insight into some of the methods that can improve sonar classification performance.

CRV742 Special Module in Radio Frequency Design and Technology-I
1 Credit (1-0-0)
Advanced module on selected topics of relevance to the RFDT M.Tech. program.

CRV743 Special Module in Radio Frequency Design and Technology-II
1 Credit (1-0-0)
Advanced module on selected topics of relevance to the RFDT M.Tech. program.

CRD802 Minor Project
3 Credits (0-0-6)
The project work shall be specific to each student.

CRD811 Major Project-I
6 Credits (0-0-12)
The project work shall be specific to each student.

CRD812 Major Project-II
12 Credits (0-0-24)
The project work shall be specific to each student.

CRD814 Major Project-III
6 Credits (0-0-12)
The project work shall be specific to each student.
ASL310 Fundamentals of Atmosphere and Ocean
4 Credits (3-0-2)
Composition of atmosphere and ocean, Thermodynamic state: distribution of temperature, density, pressure, water vapour, salinity, etc., Equations of state, Fundamental forces in the atmosphere and ocean; Pressure gradient, gravitational, Coriolis and frictional forces, Atmospheric chemistry: gas phase chemical reactions, tropospheric and stratospheric chemistry, Laws of motion in the rotating earth, geostrophic and hydrostatic balances, Thermodynamic laws and energy cycle: Radiation, conduction, convection and advection; adiabatic and diabatic cooling and warming, thermodynamic diagrams, General circulation in the atmosphere, Monsoons, Global ocean currents, unique characteristics of Indian ocean circulation, Wave propagation: Gravity waves, Oceanic Tides, Surges and Tsunamis, Atmosphere-Ocean interaction: some examples of air-sea interaction.

ASL320 Climate Change: Impacts, Adaptation and Mitigation
4 Credits (3-0-2)
Elements of physical climatology, climate variability; anthropogenic causes of climate change; concepts of radioactive forcing climate feedbacks and climate sensitivity; Observed climate record and paleo reconstruction, modeling aspects of the climate system; Carbon emission pathways, scenario development, climate simulations of the future; Socio-economic impacts, quantifying uncertainties, tipping points and irreversible changes; Observed and projected changes in weather, monsoons, teleconnections, extreme weather events, sea level in India; Climate hot spots, sector wise vulnerability and adaptation; Reducing greenhouse gas emissions, clean energy technologies, geoengineering options.

ASD330 Mini Project
6 Credits (0-0-12)

ASL410 Numerical Simulation of Atmospheric and Oceanic Phenomena
4 Credits (3-0-2)
Density stratification in atmosphere and ocean, static stability, equations of motion of a rotating fluid, scale analysis, hydrostatic approximation, vorticity and divergence, a coordinate system for planetary scale motion, Saint-Venant (shallow-water) equations; meteorologically important waves, Rossby and vertically propagating waves; basic concepts of barotropic and baroclinic instability.

Numerical methods: (a) Finite difference methods - advection equation, stability analysis, oscillation equations, (b) Galerkin Methods – transform method, application of spectral and finite element methods to barotropic vorticity equation. Time integration schemes for the advection equation.

Introduction to consequences of sound waves, surface gravity waves, internal gravity waves in weather prediction models. Boundary layers: Prandtl layer, Ekman layer, Monin-Obukhov similarity theory and surface layer, closure assumption, eddy diffusion and K-theory, one-dimensional models of boundary layer. Objective analysis and initialization: data preparation, need for initialization of numerical models; Introductory dynamic and normal mode initialization, variational and 4-dimensional data assimilation.

ASL730 Introduction to Weather, Climate and Air Pollution (Not allowed for : Any program other than AST and ASZ)
1 Credit (1-0-0)
Overview of the discipline, history and landmarks, career options, weather vs climate, online resources; composition of the atmosphere, Greenhouse Effect, Ozone Hole, vertical structure of the atmosphere and oceans; energy in the atmosphere, mechanisms of radiative transfer; water in the atmosphere, origin and types of clouds and precipitation; atmospheric and oceanic motion, forces, major wind patterns and ocean currents, monsoons, local circulations, scales of motion; climate and climate change, IPCC; air pollution, pollutants, acid rain, plumes, effects of wind and stability, episodes; observation tools including AWS, radar, satellite; weather and climate models, NWP, Isobaric coordinate system; Gradient wind approximation; thermal wind; vertical motion; barotropic and baroclinic atmospheres; Circulation and vorticity; vorticity equation; potential vorticity conservation. Boussinesq approximation; Reynolds averaging; mixing length hypothesis; Ekman layer; Acoustic, gravity, Poincare, Rossby and Kelvin waves. Atmospheric general circulation.

ASL732 Mathematical and Computational Methods for Atmospheric and Oceanic Sciences (Not allowed for : Any program other than AST and ASZ)
3 Credits (2-0-2)
Elements of FORTRAN programming; Initial and boundary value problems; second order ordinary differential equations, variation of parameters, orthogonal functions; Partial differential equations and their classification, method of separation of variables; Euler and Runge-Kutta methods for ODE; Spatial and temporal finite differencing schemes of various orders, comparison with exact solutions, accuracy and numerical stability, limitation of finite difference methods; Numerical solution of linear advection equation, advection-diffusion equation, and shallow water equation.

ASL733 Physics of the Atmosphere
3 Credits (3-0-0)
Structure of the atmosphere; Hydrostatic equilibrium, Geopotential, Hypsometric equation and scale height, Altimetry; Adiabatic processes, Lagrange equation, Static stability, dynamic stability; Atmospheric Boundary Layer Structure and evolution, turbulence etc.

Atmospheric Thermodynamics: Thermodynamic laws; Thermodynamics of water vapour and moist air: Moisture parameters, Saturated adiabatic and Pseudoadiabatic processes, Conditional and convective instability, Free and forced convection; Thermodynamic diagrams; Phase change and Clausius-Clapeyron equation; Clouds: Formation and classification, Precipitation; Atmospheric visibility: Dew, Frost and fog, smog etc.

The fundamental physics of radiation: solar and terrestrial radiation, radiation laws; absorption, emission and scattering in the atmosphere, Schwarzschild's equation; Radiation in the earth-atmosphere system: Geographical and seasonal distribution, Radiative heating and cooling of the atmosphere, Surface energy budget, The mean annual heat balance.

ASL734 Dynamics of the Atmosphere
3 Credits (3-0-0)
Fundamental forces; basic laws of conservation; hydrodynamic equations in rotating frame of reference; dimensionless analysis; geostrophic and hydrostatic approximations; Atmospheric stability; Isobaric coordinate system; Gradient wind approximation; thermal wind; vertical motion; barotropic and baroclinic atmospheres; Circulation and vorticity; vorticity equation; potential vorticity conservation. Boussinesq approximation; Reynolds averaging; mixing length hypothesis; Ekman layer; Acoustic, gravity, Poincare, Rossby and Kelvin waves. Atmospheric general circulation.

Centre for Atmospheric Sciences
ASL735 Atmospheric Chemistry and Air Pollution
3 Credits (3-0-0)
Atmospheric Composition and air pollutants, Geochemical cycles: Evolution of the atmosphere and geochemical cycling of elements; Atmospheric photochemistry; Chemistry of the troposphere: Basic photochemical cycle, atmospheric chemistry dealing with various pollutant species and photochemical smog; OXidising power of the troposphere and the Hydroxyl radical, global budgets of precursor species; Stratospheric Chemistry and Ozone: Overview, Chapman mechanism, reservoir species and catalytic cycles, Ozone hole and polar stratospheric clouds, Arctic Ozone loss, Ozone depletion potential; Aqueous phase atmospheric chemistry and acid rain; Atmospheric Aerosols: sources and characteristics, radiative effects and perturbation to climate; Atmospheric air pollutants: sources, impacts and standards; Air Pollution Meteorology: sources of air pollutants, classification and air quality standards, stability conditions, wind velocity profile, turbulence, mixing depth, characteristics of stack plumes; Dispersion of pollutants in the atmosphere: A Gaussian dispersion model, dispersion parameters and effective stack height.

ASL736 Science of Climate Change
3 Credits (3-0-0)
Description of the climate system (General circulation, hydrological cycle, carbon cycle). Natural greenhouse effect and the effect of trace gases and aerosols. Forcings (natural & anthropogenic), Fast and Slow Feedbacks; Equilibrium Climate Sensitivity, Transient Climate Response. Climates of the past (ice ages, proxy records, abrupt climate change, instrumental record of climate). Climate variability and time-scales; MJO, ENSO, PDO, Milankovic cycles. Modeling climate: Simple EBMs, Coupled Climate Models. Natural and Anthropogenic climate change. Future climate projections.

ASL737 Physical and Dynamical Oceanography
3 Credits (3-0-0)
Properties of sea water; temperature and salinity distributions; stratification and stability of oceanic water column; equation of state of sea water; oceanic mixed layer processes; governing equations for oceanic motions; inertial and geostrophic currents; wind-driven circulation; thermohaline circulation; Barotropic and baroclinic transports; western boundary intensification: gyres and meso-scale eddies; gyre systems, major currents in world oceans; Indian ocean circulation; physics and dynamics of ocean wind waves, internal waves and tides; coastal ocean processes; upwelling and downwelling in coastal and equatorial oceans; Rossby and Kelvin waves; biological productivity of oceans; heat and salt budget of oceans; observational methods in oceans; storm surges, ENSO andIOD phenomenon.

ASL738 Numerical Modeling of the Atmosphere and Ocean (Not allowed for : Any program other than AST and ASZ)
3 Credits (2-0-2)
Introduction to weather and climate models, Numerical Modeling Approaches. Other Modeling Approaches: Examples of atmospheric and oceanic simulations, Model Hierarchy (Simple, Intermediate, Complex); Governing equations in Cartesian, Isobaric and sigma coordinate systems; Numerical discretization (finite difference, finite volume, spectral) and integration, stability, CFL criterion, unconditionally stable numerical scheme; model components, dynamical core, physical parameterization, tracers, coupling of components; global and regional models used in weather forecasting and climate simulations.

ASL750 Boundary Layer Meteorology
3 Credits (3-0-0)
Introduction to the boundary layer, definition and qualitative description of temporal evolution and vertical structure; Fourier series and their properties. Reynolds averaging, interpreting variance/covariance as turbulent kinetic energy and fluxes, tensors and Einstein summation notation; Prognostic equations for mean variables in a turbulent flow, simplifications; Prognostic equations for turbulent fluxes and variances; TKE equation, static and dynamic instability, Reynolds number, Richardson number, Obukhov length, stability parameter relationships, closure problem in turbulent flow, first-order local closure; surface boundary conditions, surface momentum, energy and moisture budgets, fluxes at surface and entrainment zone, drag and Bowen ratio methods; surface layer Similarity Theory, Buckingham Pi method, applications to wind profiles; Stable and convective mixed layer phenomena including nocturnal jets, thermals, dust devils; boundary layer clouds, fair-weather cumulus, fog; geographically generated local circulations like slope and valley winds, sea/lake breeze, geographically modified flow, fetch, internal boundary layer.

ASL751 Dispersion of Air Pollutants
3 Credits (3-0-0)
Air Pollution, Various types, sources and effects of pollutants in the atmospheric environment; Particulate matter and atmospheric visibility; Atmospheric dispersion theories and types of dispersion models; Lapse rates and various types of stability classification, Wind-profile, Wind rose, Mixing Depth, General characteristics of the stack plumes; Dispersion of pollutants in the atmosphere and solution of advection diffusion equation with Gaussian distribution for point, line and area sources, plume rise, dispersion parameters and various methods of their evaluation; Atmospheric Removal processes and residence time; Effect of buildings and topography on dispersion; Similarity theory and profiles in the surface layer; Air Quality and Emission standards, their measurements and statistics; Introduction of air quality models for regulatory applications.

ASL752 Mesoscale Meteorology
3 Credits (3-0-0)
Overview of mesoscale phenomena relevant to India including tornadoes, thunderstorms, cloud bursts, fog, extreme rain events, lightning, etc; Circulation systems related to orography, mountain drag, mountain waves, valley winds, valley air pollution; Adiabatic mesoscale perturbations in a straightforward atmospheric flow; Theory of linear gravity waves, orographic gravity-wave drag; Parameterization of mesoscale phenomena in general circulation models; Mesoscale models and their application in India.

ASL753 Atmospheric Aerosols
3 Credits (3-0-0)
Introduction to atmospheric aerosols; Characterization of Aerosols; Physical and Optical properties of aerosols, size distribution, refractive indices of aerosols, absorption and scattering of radiation by aerosols; single scattering albedo, aerosol optical depth, aerosol phase function, hygroscopic growth; mixing state, vertical distribution in the atmosphere; Aerosol Chemical Composition; mixing state of aerosols; New particle formation; volatile chemical compounds and gas-to-particle conversion processes; Observations and Measurements of aerosols; Climatology of Tropospheric Aerosols; Stratospheric aerosols; Dynamics of single aerosol particle and aerosol population; Transport and transformation of aerosols; Removal of aerosols; Thermodynamics of aerosols; Role in Nucleation; Role in Cloud Physics; Interaction of aerosols with radiation; Direct, indirect, and semi-direct effects of aerosols and their influence on Climate; Aerosol effects on human health and air quality; Aerosols in chemistry transport models; Aerosols in climate models; Latest trends in aerosol research and future directions.

ASL754 Cloud Physics
3 Credits (3-0-0)
Cloud types; cloud formation; cloud dynamics; entrainment, detrainment and downdraft initiation in cumuli, large scale convergence, mesoscale convective system; Kohler theory; CCN and IN; homogeneous and heterogeneous nucleation; fundamental equations governing cloud processes; warm cloud microphysics: diffusion growth, droplet population, collision-coalescence, radiative cooling; ice cloud microphysics: nucleation, ice multiplication, growth of ice particles by accretion and ice particle melting; hydrometeor; impact of microphysical processes on dynamics; cloud chemistry; aerosol-cloud interaction: direct, indirect and semi-direct effects; clouds in numerical models: parameterization of cloud microphysics; cloud-climate interaction.
ASL755 Remote Sensing of the Atmosphere and Ocean
3 Credits (3-0-0)
Basics of satellite remote sensing: satellite orbits, sensor characteristics, view angle, passive and active remote sensing; atmospheric radiative transfer application in retrievals of geophysical parameters; aerosol remote sensing using ground-based (passive radiometer and lidar) and satellite platforms, retrieval algorithm, vertical distribution, application of aerosol products in climate studies; cloud remote sensing, cloud detection using multi-spectral technique, issues in cloud-masking, CO2 slice technique; trace gas retrievals; ocean colour remote sensing, SST retrieval, wind scatterometry, altimetry; microwave remote sensing; soil moisture retrieval, passive (brightness temperature) and active (radar) microwave remote sensing for precipitation, sounding, remote sensing of cryosphere; satellite meteorology for extreme weather events (e.g. cyclone, thunderstorms etc.); land-use/land-cover change; hydrological application using gravity anomaly from satellites.

ASL756 Synoptic Meteorology
3 Credits (3-0-0)
Different scales of atmospheric motion; Different types of air masses and tropical systems; Western disturbances and monsoonal cyclonic systems, Meteorological charts and diagrams, map projections, plotting of synoptic maps; Analysis of sea level pressure patterns, pressure tendency, surface temperature and dew point, stream lines and wind patterns, temperature patterns and isotach; Analysis of the vertical structure of the atmosphere.

ASL757 Tropical Weather and Climate
3 Credits (3-0-0)
Overview; Structure of the tropical atmosphere; Role of the Tropics in the Global Mass, Momentum, and Energy Balance; Tropical Circulation & Mean Precipitation Distribution; ITCC (Inter-tropical Convergence Zone); Tropical Waves and Tropical Variability (Intra-seasonal: MJO (Madden-Julian Oscillation), CCEWs (Convectively Coupled Equatorial Waves), Inter-annual: ENSO (El Niño Southern Oscillation), QBO (Quasi-biennial oscillation), Decadal: PDO (Pacific Decadal Oscillation), AMO (Atlantic Multi-decadal Oscillation), NAO (North Atlantic Oscillation)); Monsoons (Mean and variability); Tropical Cyclones; Modeling of the Tropical Climate & Weather.

ASL758 General Circulation of the Atmosphere
3 Credits (3-0-0)

ASL759 Land-Atmosphere Interactions
3 Credits (3-0-0)
Introduction: components of the Earth System, energy, hydrologic and biogeochemical cycles; Weather and climate processes including atmospheric boundary layer, convection, clouds and precipitation, surface energy and moisture fluxes, climate, climate variability; Canopy-air interactions: canopy processes, observations, big leaf models, canopy models; Terrestrial hydrology: watershed hydrology, river routing models; Soil: soil physics, soil moisture, soil biogeochemistry, soil models; Carbon cycle: photosynthesis, vegetation dynamics, global biogeography, carbon cycle models; Terrestrial forcings: landscape heterogeneity, landscape induced and modified flow, feedbacks, land models, coupled Earth System models; Land-use/land-cover change: Deforestation, agriculture, urbanization, forest fires, effects on weather and climate.

ASL760 Renewable Energy Meteorology
3 Credits (3-0-0)
Introduction to the atmosphere: weather and climate processes; Solar radiation and surface energy balance: Solar constant, solar geometry, atmospheric radiative transfer, clouds and aerosols, surface energy budget, urban energy use, sensors and observations; Meteorological considerations for solar power: solar resource assessment, solar forecasting for different timescales, uncertainty estimation, types of solar systems; Wind in the atmospheric boundary layer: boundary layer structure and evolution, surface layer, stability, log and power laws, flow over complex terrain, low-level jets, offshore winds, sensors and observations; Meteorological considerations for wind power: wind resource assessment, wind forecasting for different timescales using statistical and numerical methods, uncertainty estimation, types of turbines, turbine wakes, wake interactions in wind farms, turbine and wake models, LES and mesoscale models of wind farms; Solar-wind coupling: resource variability, power demand, optimization.

ASL761 Earth System Modeling
3 Credits (3-0-0)
Basics of Earth System Science (Earth system components, Physical phenomena in the Earth system, Globally averaged energy budget, Energy transports by atmosphere and ocean, concepts of radiative forcing, feedbacks and climate change), Physical Processes in the Earth System and governing principles (Equation of state, Continuity equation, Conservation of momentum, Temperature equation, Moisture equation and salinity equation, Moist processes, Wave processes in the atmosphere and ocean), Representation of Physical processes in Earth System Models (Treatment of sub-grid scale processes such as dry convection, moist convection, land surface, snow, ice and vegetation; Radiation, greenhouse gases, aerosols and other climate forcings), Biogeochemical and Biophysical Processes, coupling between physics packages, Dynamics in Earth System Models (Dynamical core, Grid scale processes, Numerical representation of the grid scale processes, Grids, Resolution, Accuracy, Efficiency, and Scalability), Earth system model simulations (Climate simulations and climate drift, Verification and Validation of simulations with observations, Emission Scenarios & forcings, Global-average response to greenhouse warming scenarios, Transient climate change versus equilibrium response experiments, Trends & natural variability, scale dependency of simulations, Multi-model simulations & ensemble averages, Simulation examples from Coupled Model Inter-comparison Project).

ASL762 Air-Sea Interaction
3 Credits (3-0-0)
State of matter near the air-sea interface, marine boundary layer, transfer properties between atmosphere and ocean, solar and terrestrial radiation, sea surface radiation budget, surface wind waves, air-sea interaction processes using examples of ENSO, hurricane, Indian monsoon, turbulent transfer near the interface, bubbles and spray, transport of trace gases across the interface; latent, sensible, and momentum fluxes in the surface boundary layer over the sea, bulk parameterizations, large-scale forcing by sea surface buoyancy fluxes, spatio-temporal variability of ocean surface fluxes with reference to Indian ocean.

ASL763 Coastal Ocean and Estuarine Processes
3 Credits (3-0-0)
Wave generating and restoring forces, shallow water waves, coastal trapped long waves, influence of sea-bed friction, Wave spectra, Refraction and shoaling of waves, Seiches, waves-current interaction, wave transformation in shallow waters, Tsunamis, Breaking waves, Phenomenon of wave reflection, refraction, and diffraction, Surf zone hydrodynamics, shoreline setup, Swash and runup heights, wave generated alongside currents, Rip currents, Storm surges, theory of tides, Tides in rivers and coastal lagoons, General characteristics of estuaries, Classification of estuaries, stratification, estuarine
circulation and mixing, shear instability at an interface, entrainment and sedimentation in estuaries, dispersion processes: advective and turbulent diffusion, river-estuary-near-shore systems, Sediment characteristics, sediment transport mechanisms: bedform dynamics, suspended particles in wave flows and vortices, Morpho-dynamics: beach profiles, tide range influence on beach morphology, lee side erosion, beach realignment due to climate change, interaction of an estuary with the near-shore bay.

**ASS800 Independent Study**
3 Credits (0-3-0)
To be given by the interested faculty.

**ASP820 Advanced Data Analysis for Weather and Climate (Not allowed for: Any program other than AST and ASZ)**
3 Credits (1-0-4)
Weather Forecast Evaluation: Jet stream analysis, standard diagnostics and skill scores, extreme events analysis. Using correlation to explore the relationships between large-scale atmospheric conditions, and local weather. Analyzing trends in climate data, and determining if they are statistically significant (regression, Mann-Kendall test etc). Regression based approaches, simple linear & multiple. Using indexes, Compositing patterns, Isolating patterns using EOF/PC analysis; Analysis of Time Series, Autocorrelation and Spectra.

**ASL821 Advanced Dynamic Meteorology**
3 Credits (3-0-0)
Pre-requisites: ASL734

**ASL822 Climate Variability**
3 Credits (3-0-0)
Major modes or patterns of climate variability on intraseasonal to interannual and decadal time scales. Well-known modes including Madden-Julian Oscillation, El Nino-Southern Oscillation, Pacific Decadal Oscillation, Atlantic Multidecadal Oscillation, Indian Ocean Dipole, Monsoon, North Atlantic Oscillation, and Annular Modes (Arctic and Antarctic Oscillation) and their impacts on extreme weather and climate. The course will review climate mode/pattern dynamics, their teleconnection mechanisms and impacts on weather/climate such as droughts etc. Temporal behavior—including how these modes have changed in the past, and how anthropogenic climate change may affect future mode behavior. Discussion of predictability of climate modes/patterns on seasonal to interannual time scales. Detection and attribution of climate change.

**ASL823 Geophysical Fluid Dynamics**
3 Credits (3-0-0)
(i) Fundamental concepts in geophysical fluid dynamics: equations of motion on a rotating planet, vorticity and circulation, conservation of potential vorticity, thermal wind, Taylor-Proudman theorem; Ertel-Rossby invariants; Ertel's potential vorticity conservation theorem; consequences of geostrophic and hydrostatic approximation. (ii) Shallow-water theory: derivation of shallow-water equations; derivation of vorticity equation; linearized form of shallow-water equations; plane waves in a layer of constant depth; dispersion diagrams of Kelvin and Poincaré waves. (iii) Rossby wave theory: mechanism of Rossby wave generation; inertial boundary currents; derivation of potential vorticity on beta-plane; quasigeostrophic scaling; Rossby waves in a zonal current; method of multiple scales for linear potential vorticity equation; reflection and radiation of Rossby waves; generation of Rossby waves by an initial disturbance; Quasigeostrophic normal modes in a closed basin; resonant interaction; energy and enstrophy conservation; upscale energy transfer. (iv) Friction effects in geophysical flows: turbulent Reynolds stresses; Ekman layers in a homogeneous, incompressible rotating fluid; Ekman layer on a sloping surface; quasigeostrophic potential vorticity with friction and topography. (v) Instability theory: linear stability; normal modes; growth rates; baroclinic instability; Eady model and Charney model; instability in a two-layer model.

**ASL824 Parameterization of Physical Processes**
3 Credits (3-0-0)
Pre-requisites: Any one of ASL733, ASL734

**ASP825 Mesoscale Modeling (Not allowed for: Any program other than AST and ASZ)**
3 Credits (0-0-6)
Introduction to the Weather Research and Forecasting (WRF) model and parallel computing; Install WRF, NCL and associated libraries; Conduct test simulations for 2-d idealized cases such as flow over a hill, sea-breeze, etc., configure and conduct test simulations for a full 3-d real case, conduct numerical experiments by changing initial & boundary conditions and namelist parameters/flags; Understand WRF code structure and registry by adding new variables into different modules; Introduction to parameterizations in WRF, explore the science and the codes of a land surface scheme and a cumulus scheme, make simple modifications to the schemes, conduct numerical experiments with modified schemes.

**ASL826 Ocean Modeling (Not allowed for: Any program other than AST and ASZ)**
3 Credits (2-0-2)
Introduction to ocean dynamics, governing equations of oceanic motions, numerical methods in ocean modelling, hydrostatic and non-hydrostatic phenomenon, barotropic and baroclinic processes, lateral and open boundary conditions, parameterization of sub-grid scale processes, large scale ocean circulation, modelling of shelf circulation, tides and storm surge modelling, regional and coastal ocean models, shallow water models, multi-level basin scale and global ocean models, ocean wave modelling, introduction to data assimilation techniques.

**ASL827 Advanced Dynamic Oceanography**
3 Credits (3-0-0)
Pre-requisites: Either ASL734 or ASL737
Conservation laws for moving fluids, Ekman and Sverdrup theories, coastal upwelling and fronts, Western boundary intensification, barotropic currents, baroclinic transport over topography, thermohaline circulation, Meso scale eddies and variability. Indian ocean circulation, wave theory, ocean wave spectra, wave energy equation, breaking waves, reflection and dissipation, theory of tides, tidal currents, tidal processes in embayment and estuaries, wind and buoyancy driven currents, near-shore circulation, alongshore currents, wave-current interaction, sediment transport, coastal ocean response to extreme wind forcing, storm surges, Planetary and equatorial waves, coastally trapped Kelvin waves.
ASL851 Special Topics in Climate
3 Credits (3-0-0)
To be given by the interested faculty.

ASL852 Special Topics in Oceans
3 Credits (3-0-0)
To be given by the interested faculty.

ASL853 Special Topics in Atmosphere
3 Credits (3-0-0)
To be given by the interested faculty.

ASL854 Special Topics in Air Pollution Studies
3 Credits (3-0-0)
To be given by the interested faculty.

ASP855 Special Topics in Atmosphere and Ocean (Not allowed for : Any program other than AST and ASZ)
3 Credits (1-0-4)
To be given by the interested faculty.

ASL856 Special Topics in Atmospheric and Oceanic Observations (Not allowed for : Any program other than AST and ASZ)
3 Credits (2-0-2)
To be given by the interested faculty.

ASV862 Special Module in Climate
1 Credit (1-0-0)
To be given by the interested faculty.

ASV863 Special Module in Oceans
1 Credit (1-0-0)
To be given by the interested faculty.

ASV864 Special Module in Atmosphere
1 Credit (1-0-0)
To be given by the interested faculty.

ASV865 Special Module in Air Pollution Studies
1 Credit (1-0-0)
To be given by the interested faculty.

ASV866 Special Module in Atmosphere and Ocean
1 Credit (1-0-0)
To be given by the interested faculty.

ASP867 Special Module in Weather Forecasting (Not allowed for : Any program other than AST and ASZ)
1 Credit (0-0-2)
To be given by the interested faculty.

ASP868 Special Module in Atmospheric and Oceanic Observations (Not allowed for : Any program other than AST and ASZ)
1 Credit (0-0-2)
To be given by the interested faculty.

ASC869 Atmospheric and Oceanic Science Colloquium (Not allowed for : Any program other than AST and ASZ)
1 Credit (0-1-0)
To be given by the interested faculty.

ASD881 Project-I (Not allowed for : Any program other than AST and ASZ)
6 Credits (0-0-12)
To be given by the interested faculty.

ASD882 Project-II (Not allowed for : Any program other than AST and ASZ)
12 Credits (0-0-24)
Pre-requisites: ASD881
Centre for Biomedical Engineering

BML330 Safety Principles for Engineers
3 Credit (3-0-0)
Pre-requisites: EC 60

BML700 Introduction to Basic Medical Sciences for Engineers
3 Credit (3-0-0)
Anatomical and physiological study of different human systems. Cell and tissue organization and metabolism Cardiovascular System; hemodynamics, blood, conduction system in the heart. Soft and hard tissues and joints endocrine and nervous system and their role in homeostasis; Respiratory physiology; kidneys and the urinary system.

BMV700 Biomechanical Design of Medical Devices
1 Credit (1-0-0)

BMV701 Basic Electronics
1 Credits (1-0-0)

BMV702 Basic Mathematics for Biologists
1 Credits (1-0-0)
Introduction to calculus, function, sets, Derivatives, integrals, exponentials and logarithm, complex numbers, sequence, series. Linear Algebra: Matrix, vector, basic operations on matrix, system of equations, linear and non linear equations. Differenceal Equations. Exposure to other topics like complex analysis, Fourier series.

BMV703 Basic biology & Physiology
1 Credits (1-0-0)

BMV704 Mechanics of Biomaterials
1 Credits (1-0-0)

BML710 Industrial Biomaterial Technology
3 Credits (3-0-0)
Good Manufacturing practice regulations, biomedical materials, quality assurance and quality control, Labeling, Device failure, synthetic and biopolymers, Biodegradable materials, Host reactions to biomaterials, Sterilization of Medical devices, Advances in Sterilization Technology of clean room, Polymeric materials for drug delivery systems, active and passive targeting, intelligent materials.

BML720 Medical Imaging
3 Credits (3-0-0)

BML735 Biomedical Signal and Image Processing
3 Credits (2-0-2)
Introduction to Biomedical Signal and Image data obtained using various techniques (ECG, FTIR, NMR spectroscopy, MRI, CT, nuclear imaging, ultrasound and optical imaging). Noise and error propagation in Biomedical Signal and Image data. Basic statistics for biomedical signal and image data analysis. Biomedical signal processing in time domain. Fourier and Laplace transform. Biomedical signal processing in frequency domain. Biomedical image processing, including segmentation, registration and pattern recognition. Mathematical models used in biomedical signal and image data analysis.

BML736 Application of Mathematics in Biomedical Engg.
2 Credit (2-0-0)
Mathematical functions commonly used in biomeadeval engineering; biomedical data, data analysis (Basic Biostatistics), data fitting; refreshing Engineering Mathematics; Applications of Mathematics in various areas of Biomedical Engineering (Biochemistry, Biomedical Signal and Imaging, Biosensors, Biomechanics, etc.), Mathematical modeling and simulations.

BML740 Biomedical Instrumentation
3 Credits (3-0-0)

BML741 Medical Device Design
4 Credits (2-0-4)
Introduction to medical device design course and its significance in the current scenario; basic human physiology, communicable and non-communicable diessese; different approaches to medical device design; considerations in medical device design; case studies of medical device design; identification of need, immersion, disease burden, disease state fundamentals, and the need for validation; development of concepts, ideation & brainstorming, evaluation of concepts, risk/ benefit analysis; usability analysis & methods of prototyping; user feedback, stakeholder analysis & characterization; IP and regulatory requirements; conclusions.
BMD742 Minor Biodesign Project
4 Credits (0-0-8)
The course will cover activities pertaining to design-build-test-modify iterations in order to build functional prototypes of medical devices.

BML743 Special Topics In Biodesign
3 Credits (3-0-0)
The course contents will be flexible covering state of the art design, research and innovation issues pertaining to biodesign.

BMP743 Basic Biomedical Laboratory
2 Credits (0-0-4)
Students shall be introduced with practical training on basic electronic design and interfacing, and be given laboratory exercises on bioinstrumentation. Students will also be exposed to the role of medical imaging and signal processing in biomedical engineering. A few experiments training in materials synthesis, characterization and modification of various biomaterials will be given. Students will also get trained on sterile techniques of cell culture, cytotoxicity assays and cell staining techniques.

BML750 Point of Care Medical Diagnostic Devices
3 Credits (3-0-0)
Brief introductions to analytical chemistry and biochemistry; sensors and biosensors (immobilization, transducers, electronic components, op-amps and general circuits; data processing and presentation - LabVIEW based virtual instrumentation, etc.); Medical diagnostic techniques (biochemical, pathological, hematological analysis, DNA, RNA based analysis, etc.); Necessity for rapid and in-situ medical analysis; Point of care technology (POCT); Miniaturation of medical diagnostic devices – Microfabrication (materials, processes, techniques for detection); Microfluidics (concept, procedure, applications and challenges); Integrated microfluidic devices: Lab-on-a-chip, system-on-a-chip, micro-total analysis system (µTAS); Present research scenario and future prospects; Case studies on POCT devices; Laboratory visit and demonstration of microfabrication processes and Lab-on-a-chip devices.

BML760 Biomedical Ethics, Safety and Regulatory Affairs
2 Credits (2-0-0)
Introduction to medical ethics and bioethics, environmental ethics. Use of animals in pre-clinical trials and ethical approval. Ethics issues in biomedical sciences (inhalable, injectable, implantable systems). Principles of biosafety. Biosafety cabinets, Laboratory biosafety levels. vertebrates and invertebrates safety levels, Biosafety of infectious agents: bacteria, fungus, parasite, prions, viruses, Biosafety of infectious agents: bacteria, fungus, parasite, prions, viruses. Laboratory security and emergency response, guidelines to work with infectious agents and toxins. Regulatory frameworks: FDA, BIS, ISO certification, CDSCO; health & family welfare laws and regulations on design, development, testing and production of biomedical products, including biologics, drugs, biotechnology-derived therapeutics, vaccines and medical devices, Clinical trials and current good manufacturing Practices. Basic introduction to IPR. Post-market issues and requirements.

BML770 Fundamentals of Biomechanics
3 Credits (3-0-0)
Overview and significance or biomechanics to lead a better life, challenges and opportunities, inventions/research. Orthopaedic components - bones, tendons, ligaments and cartilages -primary functions, material constituents (osteoelasts, osteotoblasts, collagen, collagen fibrils), mechanical strength, building vs recuperation rate, force analysis. Cardiovascular components-arteries, veins, primary functions & flowrate, material constituents, mechanical strength, inflammation, life span vs. recuperation rate, force analysis. Biomaterials - Metals/alloys, polymers, ceramics, shape-memory alloys, composites and functionally graded materials. Basic Principles - Force-Motion, Force-Time, Inertia, Range of Motion, Segmental Interaction, Balance, Cordination continuum, Projection & Spin. Force analysis of joints at various kinetic states - Spine (running, climbing, stairs, running downhill etc), Knee (squattting, jumping, climbing stairs, kickingsoccer), shoulder (adduction, abduction, bowling, smashing - racquet sports), Elbow (tennis, golf) and Hip (during fall, running). Demonstrations - Characterization, fractures & ruptures, non-invasive analysis (MRI, CT scan).

BML771 Orthopaedic Device Design
2 Credits (2-0-0)
Pre-requisites: AML732/AML835/AML851/MEL739
Introduction: a. Bones, tissues and muscles, b. Properties; Static and dynamic loads; Kinematics and Kinetics; Bone healing and remodelling; Strength, Wear and Corrosion; Design of Orthopaedic prostheses; Methods to avoid reoccurance of fractures; Bone modelling; Guest lectures; Demonstrations.

BML772 Biofabrication
3 Credits (2-0-2)
Pre-requisites: 50 Credits
Introduction; bioprinting tissues, bones and cartilages; self-assembly, directed assembly, enzymatic assembly; laser-assisted bio-printing; fabrication of scaffolds (hydrogel method and fibre based); artificial bacteria (active/pasive drug delivery, microswimmer); component fabrication (stereolithography, laser machining etc); mass production (stamping, micro-injection molding etc). Experiments: CAD (solidworks) and data import (from MRI/CT) - hands-on; Fused deposition molding (3D printing) - hands on; Fused deposition molding (3D printing) - hands on; Tissue & Organ printing (3D organ printer) - demonstration only; Scaffold generation - Hydrogel (Wet Chemistry and Fibres (electrospinning) - hands on; Laser machining - hands on; Mask generation (E-beam lithography and focussed ion beam) - demonstration only; Characterization (Imaging, Profilometry, optical scanner) - hands on; Stamping - hands on; Micro-injection molding - demonstration only.

BML790 Modern Medicine: An Engineering Perspective
3 Credit (2-1-0)
The course will cover an overview of patho-physiology of some of the common non-communicable human diseases. Details of Cerebral Ischemia/Stroke, Diabetes and cardiac abnormalities will be discussed. With respect to each diseases the corresponding diagnostic techniques, tools, and physical principles of these instruments will be discussed. Students will be encouraged with lateral thinking and brain storming future engineering research potentials in improvement of current diagnostic and treatment modalities.

BML800 Research Techniques in Biomedical Engineering
3 Credits (3-0-0)
Simulation and analysis of physiological systems by up to date computer techniques and development of physical models; Biomechanical analysis and network representation; State of art bioinstrumentation techniques; monitoring physiological parameters electrical, mechanical and chemical parameters of human body, Microminiaturization of electronics including MEMS; BIOMEMS technology; Biomedical signal processing and imaging modalities; Research planning and interpretation of biomedical data; Telemedicine; Robotics in Medicine.

BMD801 Major Project-1
9 Credits (0-0-18)
The curriculum shall comprise of practical training on chosen research topic, optimization of experimental conditions, so as to take up independent research in major project.

BMD802 Major Project-2
12 Credits (0-0-24)
Students are expected to carry out research in biomedical engineering disciplines and preferably be able to publish or communicate their work at the end of project. A total of 18 credits including 12 from this curriculum shall enable them to submit M.Tech. Dissertation, which shall also be regarded as a publication.
Biomedical Engineering

**BML810 Tissue Engineering**  
3 Credits (3-0-0)  
The course will cover importance and scope of tissue engineering, Introduction to biomaterials and scaffolds, Criteria of modifying biomaterials as tissue engineering scaffolds, Properties and types of scaffolds, Different methods employed in the synthesis of scaffolds, animal cell biology, stem cells, organization of cells into tissues, tissue microenvironment, tissue injury and wound healing. Basic immunology, response of body to foreign materials. Animal cell culture on scaffolds, consequences, optimization strategies and important considerations for Skin, Liver, Bone, Cartilage, Nerve and Vascular tissue engineering.

**BML815 Selected Topics in Biomedical Engineering**  
2 Credits (2-0-0)  
Select current and emerging topics in biomedical engineering will be covered; details will be decided by the instructor.

**BML820 Biomaterials**  
3 Credits (3-0-0)  
Introduction to the use of implants. Structure and properties of materials used as implants : polymers, ceramics, metal and composites; biological response to implants, wound healing process, cellular response to foreign materials, criteria for selecting implants both for soft tissue and hard tissue, polymers used as vascular prosthesis, contact lens and reconstructive surgery materials.

**BML830 Biosensor Technology**  
4 Credits (3-0-2)  

**BMV840 Emerging Biomedical Technology & Health Care**  
1 Credit (1-0-0)  
Importance of health related data collection and analysis, Epidemiological survey; brief them about various communicable & non-communicable diseases, path-physiological processes, environmental health and Life style diseases. Define the process of evolution of emerging technologies to solve the current health problems through an integrated approach of synergizing the discipline of medicine, engineering and management systems. Importance/ methodology of conducting clinical trials-human & animals.

**BML850 Cancer: Diagnosis and Therapy**  
3 Credit (3-0-0)  
Cancer and its classes; Hallmarks of cancer: Evasion of Apoptosis, Limitless replicative potential, Sustained Angiogenesis, Inflammation; Causes of Cancer: Carcinogens, oncogenes, mutations, viruses, disregulation of cell cycle and the checkpoints; Tumor architecture, Importance of Hypoxia and angiogenesis in cancer; Tumor metabolism, Metastatic potential of cancer; Cancer Stem Cells and Biomarkers of Cancer; Diagnosis of cancer: Biopsy, Imaging, Endoscopy, Blood work; Therapy: Chemotherapy (small molecule, nanoparticle based), radiation, hyperthermia, immunotherapy, photodynamic, transplants and transfusions, targeted therapy, RNAi, non-invasive technologies; Resistance in Cancer; Scientific advances for understanding the origin, diagnosis and treatment of Cancer; Future prospects for cancer cure and diagnosis.

**BML860 Nanomedicine**  
3 Credit (3-0-0)  
Introduction to some basic nanoscience: quantum confinement and its effect; surface plasmon etc. Nanomaterial synthesis including bottoms-up and top-down approaches. The significance of nano size, multiplexing and multilayering. Properties of nanoparticles and its dependence on shape, size, charge and aspect ratio. Interface of nanoparticles with biological systems (cells, viruses, bacteria, in vivo etc.) Techniques used for nanoparticle characterization before and after biological interface. Functional nanomaterials for biological and medical applications: Design criteria and synthetic protocols; Nanomaterials in tissue engineering, drug delivery, biosensors, hyperthermia, photodynamic therapy, etc. Modulating the specific biological response by nanostructures. Nanotoxicology.

**BMV870 Vascular Bioengineering**  
1 Credit (1-0-0)  
Embryology and formation of vascular networking in fetus and adult human body, autonomic nervous system influences, peculiarities of micro and macro vasculatures, the physiological fluid dynamic principles involved, the molecular level changes occurring in normal and abnormal conditions like atherosclerosis, cancers, utero-placental system and various imaging modalities.
Centre for Energy Studies

ESL300 Self-Organizing Dynamical Systems
3 Credits (3-0-0)
Pre-requisites: EC60 (for UG students)
Dynamical systems dissipative and area preserving, Patterns in Hamiltonian dynamics invariants and symmetry, KAM theorem/coherent structures, complexity and pattern formation, Belousov - Zhabutinsky reaction, Landau-Ginzburg / mean-field models, scaling fractals, Cellular automata, Wavelet transforms, Phase transitions and order parameter, Criticality the border of order and chaos, Entropy and direction of time, Nientropic systems, Self-organized criticality, lattice models, Examples: Electrical circuits, Management systems, Astrophysical systems, Plasma and magnetic surface systems, Biological systems, Non-linear systems.

ESL330 Energy, Ecology & Environment
4 Credits (3-1-0)
Overlaps with: Some overlap with ESL710
Pre-requisites: EC60 (for UG students)
Concepts of ecosystems and environment, Characteristics and types of ecosystems, Autecology and synecology, Energy flow in ecosystems, Feedback loops, Trophic webs, Eco-technology and Eco-development, Energy-environment interaction, Impact of energy sources (coal, oil, natural gas, solar, wind, biomass, hydro, geothermal, tidal, wave, ocean thermal and nuclear) on environment, local regional and global implications, Approaches to mitigate environmental emissions from energy sector, Global initiatives Kyoto Protocol, Clean development mechanism, Case studies.

ESL340 Non-Conventional Source of Energy
4 Credits (3-0-2)
Overlaps with: Some overlap with ESL740
Pre-requisites: EC60 (for UG students)

ESL350 Energy Conservation and Management
3 Credits (3-0-0)
Overlaps with: ESL720
Pre-requisites: EC60 (for UG students)

ESL360 Direct Energy Conversion Methods
4 Credits (3-1-0)
Overlaps with: Some overlap with ESL730
Energy classification, Sources and utilization, Principle of energy conversion, Indirect/direct energy conversion, Basic principles of design and operations of (i) Thermoelectric (ii) Thermionic converters (iii) Photovoltaic energy systems (iv) Fuel cells (v) Plasma diodes (vi) Magneto hydrodynamic Power generators and (vii) Advanced energy conversion systems.

ESL710 Energy, Ecology and Environment
3 Credits (3-0-0)
Interrelationship between energy and environment, Sun as a source of energy, nature of its radiation, Biological processes, photosynthesis, Autecology and Synecology, Population, Community Ecosystem (wetland, terrestrial, marine) Food chains, Ecosystem theories. Sources of energy, Classification of energy sources, Environmental issues related to harnessing to fossil fuels (coal, oil, natural gas), geothermal, tidal, nuclear energy, solar, wind, hydropower, biomass, Energy flow and nutrient cycling in ecosystems, Environmental degradation, primary and secondary pollutants. Thermal/ radioactive pollution, air and water pollution, Micro climatic effects of pollution, Pollution from stationary and mobile sources, Biological effects of radiation, heat and radioactivity disposal, Acid rain, Global warming and greenhouse gases, Ozone layer depletion.

ESL711 Fuel Technology
3 Credits (3-0-0)
Solid, liquid and gaseous fuels, Coal as a source of energy and chemicals in India, Coal preparation, Carbonization, Gasification and liquefaction of coal and lignite, Principle of combustion, Petroleum and its derived products, Testing of liquid fuels, Petroleum refining processes, Inter-conversion of fuels, Natural gases and its derivatives, sources, potential, Gas hydrates, Combustion appliances for solid, liquid and gaseous fuels, Introduction to nuclear fuel, RDF, Bio-fuels, etc.

ESL714 Power Plant Engineering
3 Credits (3-0-0)
Types of thermal power stations, Steam power stations based on fossil fuels, Economy and thermal scheme of the steam power stations, Thermal power plant equipment boilers, super heaters, super critical steam generator, economizers, feed water heater, condensers, combustion chamber and gas loop, turbines, cooling towers, etc. Gas turbine power stations, Combined cycle power plants, Internal combustion engine plant for peak load, standby and start up, Elements of hydropower and wind turbine, Elements of nuclear power plants, Nuclear reactors and fuels. Recent advances in power plants (IGCC, super critical power plants, etc.). Case studies, Introduction to solar power generation, Sterling engine, Decentralized power technologies.

ESL718 Power Generation, Transmission and Distribution
3 Credits (3-0-0)
AC Transmission: Overhead and cables, Transmission line equations, Regulation and transmission line losses, Reactive power compensation, Flexible AC transmission.
HVDC transmission: HVDC converters, advantages and economic considerations, converter control characteristics, analysis of HVDC link performance, Multi-terminal DC system, HVDC and FACTS.
Distribution: Distribution systems, conductor size, Kelvin’s law, performance calculations and analysis, Distribution inside and and commercial buildings entrance terminology, Substation and feeder circuit design considerations, distribution automation, Futuristic power generation.

ESL720 Energy Conservation
3 Credits (3-0-0)
Introduction, Thermodynamics of energy conservation, Energy and exergy concepts, Irreversibility and second law analysis and efficiency of thermal systems such as mixing, throttling, drying and solar thermal
systems. Thermal power plant cycles. Refrigeration and air conditioning
cycles, thermal insulation in energy conservation, energy conservation
through controls, electric energy conservation in building heating and
lighting, energy efficient motors, Tariffs and power factor improvement
in electrical systems. Energy conservation in domestic appliances,
transport, energy auditing, energy savings in boilers and furnaces,
energy conservation Act. Energy conservation in small scale domestic
appliances and agriculture.

**ESL722 Integrated Energy Systems**
3 Credits (3-0-0)
Pattern of fuel consumption: agricultural, domestic, industrial and
community needs. Projection of energy demands, Substitution of
conventional sources by alternative sources and more efficient modern
technologies, Potential, availability as well as capacity of solar, wind,
biogas, natural gas, forest produce, tidal, geothermal, mini-hydro and
other modern applications. Hybrid and integrated energy systems,
Total land use and waste heat utilization, Energy modeling to
optimize different systems.

**ESL726 Waste Heat Recovery**
3 Credits (3-0-0)
**Pre-requisites: EC 75 (for UG Students in Minor Area)**
Introduction to Waste heat recovery, Classifications, Principles,
Utilizations, Strategy of using waste heat recovery. Basic Heat
Exchanger Design Concepts, Heat Exchanger equipment classifications,
Steam generation equipment, Power plant heat recovery systems.
Commercial waste heat recovery systems with detailed study of
Re recuperators, Radiation/Convective Hybrid Recuperator, Ceramic
Regenerator, Introduction to efficient building design.

**ESL730 Direct Energy Conversion**
3 Credits (3-0-0)
Basic science of energy conversion. Indirect verses direct conversion,
Physics of semiconductor junctions for photovoltaic and photo-
electrochemical conversion of solar energy. Fabrication and evaluation
of various solar cells in photovoltaic power generation systems,
Technology and physics of thermo-electric generations, Thermal-
electric materials and optimization studies. Basic concepts and design
considerations of MHD generators. Cycle analysis of MHD systems,
Thermonic power conversion and plasma diodes, Thermodynamics
and performance of fuel cells and their applications.

**ESL731 Biomass - A Renewable Resource**
3 Credits (3-0-0)
**Pre-requisites: EC 75 (for UG Students in Minor Area)**
Biogas-animal dung and agroresidues and other cellulose wastes,
ethanol from wheat or corn, sugar cane, sweet sorghum, beet roots,
grapes, starchets, pyrolysis of biomass. Direct combustion of biomass,
Improved stoves routes, Second Generation Biofuels: Biodiesel from
oil seeds, Gasification of agroresidues, sawdust etc. Micro-power
generation through biomass gasifiers, waste incineration fluidized
bed combustion of biomass. Third Generation Biofuels: Algae based
Biodiesel, Ethanol, Hydrogen, alcohols from agroresidues, chemical
composition of lignocellulosic biomass, fuels and chemicals from each
component biomass (Hemicellulose, Cellulose, and Lignin), Chemical,
Thermochemical and Biochemical processes, Availability of biomass,
biorefineries.

**ESL732 Bioconversion and Processing of Waste**
3 Credits (3-0-0)
Biomas and solid wastes, Broad classification, Production of
biomas, photosynthesis, Separation of components of solid wastes and
processing techniques, Agro and forestry residues utilisation
through conversion routes: biological, chemical and thermo chemical,
Bioconversion into biogas, mechanism, Composting technique,
Bioconversion of substrates into alcohols, Bioconversion into hydrogen,
Thermo chemical conversion of biomass, conversion to solid, liquid
and gaseous fuels, pyrolysis, gasification, combustion, Chemical
conversion processes, hydrosis and hydrogenation, Solvent extraction
of hydrocarbons. Fuel combustion into electricity, case studies.

**ESL734 Nuclear Energy**
3 Credits (3-0-0)
**Introduction:** Scope of nuclear energy (fission and fusion energy),
typical reactions

**Basics Concepts:** Binding Energy of a nuclear reaction, mass energy
equivalence and conservation laws, nuclear stability and radioactive
decay, radioactivity calculations.

Interaction of Neutrons with Matter: Compound nucleus formation,
elastic and inelastic scattering, cross sections, energy loss in scattering
collisions, polyenergetic neutrons, critical energy of fission, fission
cross sections, fission products, fission neutrons, energy released in
fission, fission interaction with matter and energy deposition, fission
fragments.

The Fission Reactor: The fission chain reaction, reactor fuels,
conversion and breeding, the nuclear power resources, nuclear power
plant & its components, power reactors and current status.

**Reactor Theory:** Neutron flux, Fick’s law, continuity equation, diffusion
equation, boundary conditions, solutions of the DE, group diffusion
method, Neutron moderation (two group calculation), one group
reactor equation and the slab reactor Health Hazards: radiation
protection & shielding.

**Nuclear Fusion:** Fusion reactions, reaction cross-sections, reaction
rates, fusion power density, radiation losses, ideal fusion ignition,
Ideal plasma confinement & Lawson criterion.

**Plasma Concepts:** Saha equation, Coulomb scattering, radiation from
plasma, transport phenomena.

**Plasma Confinement Schemes:** Magnetic and inertial confinement,
current status.

**ESL737 Plasma Based Materials Processing**
3 Credits (3-0-0)
**Introduction:** Plasma based processing of materials

**Plasma Concepts:** Plasma fluid equations, single particle motions,
unmagnetized plasma dynamics, diffusion and resistivity, the DC
sheath and probe diagnostics.

**Basics of Plasma Chemistry:** Chemical reactions and equilibrium,
chemical kinetics, particle and energy balance in discharges.

**Low Pressure Plasma Discharges:** DC discharges, RF discharges -
Capacitively and inductively coupled, microwave, ECR and helicon
discharges.

**Low Pressure Materials Processing Applications:** Etching for VLSI,
film deposition, surface modification and other applications (plasma
nitriding, plasma ion implantation, biomedical and tribological
applications).

**High Pressure Plasmas:** High pressure non-equilibrium plasmas,
thermal plasmas – the plasma arc, the plasma as a heat source, the
plasma as chemical catalyst.

**Applications of High Pressure Plasmas:** Air pollution control, plasma
pyrolysis and waste removal, plasma based metallurgy – ore
enrichment, applications in ceramics, plasma assisted recycling.

**ESL740 Non-conventional Sources of Energy**
3 Credits (3-0-0)
Types of non-conventional sources, Solar energy principles and
applications, efficiency of solar thermal and PV systems, Biomass:
generation, characterization, Biogas: aerobic and anaerobic bio-
conversion processes, microbial reactions purification, properties of
biogas, Storage and enrichment, Tidal and wind energy potential
and conversion efficiency, Mini/micro hydro power: classification of
hydropower schemes, classification of water turbine, Turbine theory,
Essential components of hydropower system, system efficiency,
Fusion: Basic concepts, fusion reaction physics, Thermonuclear fusion reaction criteria, Confinement schemes, Inertial and magnetic confinement fusion, Current status, Geothermal: Geothermal regions, geothermal sources, dry rock and hot aquifer analysis, Geothermal energy conversion technologies, OTEC, Wave Energy.

ESL742 Economics and Financing of Renewable Energy Systems
3 Credits (3-0-0)
Pre-requisites: EC 75 (for UG students in Minor Area)

ESL746 Hydrogen Energy
3 Credits (3-0-0)
Introduction of Hydrogen Energy Systems
Hydrogen pathways introduction – current uses, General introduction to infrastructure requirement for hydrogen production, storage, dispensing and utilization, and Hydrogen production power plants.
Hydrogen Production Processes
Hydrogen Storage
Physical and chemical properties – General storage methods, compressed storage – Composite cylinders – Glass micro sphere storage - Zeolites, Metal hydride storage, chemical hydride storage and cryogenic storage.
Hydrogen Utilization
Overview of Hydrogen utilization: I.C. Engines, gas turbines, hydrogen burners, power plant, refineries, domestic and marine applications, Hydrogen fuel quality, performance, COV, emission and combustion characteristics of Spark Ignition engines for hydrogen, back firing, knocking, volumetric efficiency, hydrogen manifold and direct injection, fumigation, NOx controlling techniques, dual fuel engine, durability studies, field trials, emissions and climate change.
Hydrogen Safety
Safety barrier diagram, risk analysis, safety in handling and refueling station, safety in vehicular and stationary applications, fire detecting system, safety management, and simulation of crash tests.

ESL748 Economics of Energy Conservation
3 Credits (3-0-0)
Pre-requisites: EC 75 (for UG Students in Minor Area)
Overview of measures and approaches towards improved energy efficiency and energy conservation in various sectors of the economy; Need for studying economics of energy conservation; Identification and quantification of costs and benefits associated with energy conservation projects; Time value of money, discount rate and basic formulae of engineering economics; Measures of financial/economic performance for appraisal/evaluation of energy conservation projects; Approaches for considering uncertainty in appraisal/evaluation; Existing and potential incentives for promoting energy conservation measures, regulations and policy measures; Carbon mitigation benefits; Development of techno-economic models; Software for economic assessment of energy conservation projects; Financing of energy conservation projects; Case studies.

ESL750 Economics and Planning of Energy Systems
3 Credits (3-0-0)

ESL755 Solar Photovoltaic Devices and Systems
3 Credits (3-0-0)
Photovoltaic materials bulk and thin film forms. The role of microstructure (single crystal, multi crystalline, polycrystalline, amorphous and nano-crystalline) in electrical and optical properties of the materials. Different cell design and the technology route for making solar cells. Different methods of characterization of materials and devices. Applications of Photovoltaic for power generation from few watts to Megawatts.

ESL760 Heat Transfer
3 Credits (3-0-0)
General heat conduction equation with heat generation, Analysis of extended surfaces, transient (and periodic) heat conduction, Two dimensional heat conduction problems and solutions, Theory of convective heat transfer, Boundary layer theory, Heat transfer in duct flows laminar and turbulent, Boiling, condensation and heat exchangers, Laws of thermal radiation, Radiation heat transfer between black and grey bodies, Numerical solutions of radiation network analysis, Thermal circuit analysis and correlations for various heat transfer coefficients, Overall heat transfer.

ESL768 Wind Energy and Hydro Power Systems
3 Credits (3-0-0)
Introduction, General theories of wind machines, Basic laws and concepts of aerodynamics, Micro-siting, Description and performance of the horizontal-axis wind machines, Blade design, Description and performance of the vertical-axis wind machines, The generation of electricity by wind machines, case studies, Overview of micro mini and small hydro, Site selection and civil works, Penstocks and turbines, Speed and voltage regulation, Investment issues, load management and tariff collection, Distribution and marketing issues, case studies, Wind and hydro based stand-alone/hybrid power systems, Control of hybrid power systems, Wind diesel hybrid systems.

ESL770 Solar Energy Utilization
3 Credits (3-0-0)
ESL776 Industrial Energy and Environmental Analysis
3 Credits (3-0-0)
Pre-requisites: EC 75 (for UG Students in Minor Area)

ESL784 Cogeneration and Energy Efficiency
3 Credits (3-0-0)
Pre-requisites: EC 75 (for UG Students in Minor Area)
The cogeneration concept, Main design parameters for cogeneration, Cogeneration alternatives, Bottoming and Topping cycles, Steam turbine plants, Gas turbine plants, Diesel and gas engine plants, Thermodynamic evaluation, Combined cycle applications, Sterling engine, Industry/Utility cogeneration, Trigeneration, Techno economic and environmental aspects, Cogeneration in sugar, textile, paper and steel industry, Case studies.

ESL785 Energy Analysis
3 Credits (3-0-0)
Pre-requisites: EC 75 (for UG Students in Minor Area)

ESL786 Exergy Analysis
3 Credits (3-0-0)
Pre-requisites: EC 75 (for UG Students in Minor Area)
Thermodynamic basis of available energy, exergy and entropy, Exergy balance equations for closed and open flow systems under steady state and unsteady state conditions, Exergetic efficiency definition for various devices, components including heat exchangers, mixing chamber and drying process. Exergy analysis of thermal energy systems including thermal power plants, refrigeration and heat pump/air-conditioning plants, Exergy analysis of solar energy systems, solar cooker/dryer/collector/concentrator/solar still/solar pond/thermal storage systems and solar thermal power generation, solar photo voltaic system, Economics based on exergy analysis of thermal energy systems.

ESL796 Operation and Control of Electrical Energy Systems
3 Credits (3-0-0)
Control of Power & Frequency : Turbine-Governor Control Loops, Single Area and Multi-Area Systems Control, Effect of high penetration of Wind & Other Renewable/Distributed Generation on P-F Control.

JSD799 Minor Project (JES)
3 Credits (3-0-0)

JSD801 Major Project Part – 1 (JES)
6 Credits (0-0-12)

JSD802 Major Project Part – 2 (JES)
12 Credits (0-0-24)

JSS801 Independent Study (JES)
3 Credits (0-3-0)

ESL810 MHD Power Generation
3 Credits (3-0-0)
Principle of MHD power generation, Properties of working fluids, MHD equation and types of MHD duct, Losses in MHD generators, Diagnostics of parameters, MHD cycles, MHD components (air heater, combustion chamber, heat exchanger, diffuser, insulating materials and electrode walls, magnetic field etc.), Economics and applications of MHD, Liquid metal MHD generators.

ESL840 Solar Architecture
3 Credits (3-0-0)

ESL850 Solar Refrigeration and Air Conditioning
3 Credits (3-0-0)

ESL860 Electrical Power Systems Analysis
3 Credits (3-0-0)
ESL870 Fusion Energy
3 Credits (3-0-0)
Fission and fusion, Need for plasma, Lawson criterion, Confinement problem, Laser driven fusion, Magnetic confinement, Plasma concept, Single particle motions in complex magnetic field geometries, Equilibrium and stability, Cross field transport, Important heating schemes, Tokamak and magnetic mirror, Reactor concepts, Current status.

ESL871 Advanced Fusion Energy
3 Credits (3-0-0)
Tokamak confinement Physics, Particle motions in a tokamak, Toroidal equilibrium, Toroidal stability, High-beta Tokamak, Experimental observations, Fusion Technology, Commercial Tokamak Fusion-power plant, Tandem-mirror fusion power plant, Other Fusion reactors concepts, Inertial confinement fusion reactors, Reactor cavity, Hybrid fusion/fission systems, Process heat and synthetic fuel production.

ESL875 Alternative Fuels for Transportation
3 Credits (3-0-0)
Pre-requisites: EC 100 (for UG Students in Minor Area)
An introduction to hydrocarbon fuels-their availability and effect on environment, Gasoline and diesel self-ignition characteristics of the fuel, octane number, cetane number, Alternative fuels – liquid and gaseous fuels, physico-chemical characteristics, Alternative liquid fuels, Alcohol fuels – ethanol and methanol, fuel composition, Fuel induction techniques, Fumigation, Emission of oxygenates, Applications to engines and automotive conversions, Biodiesel formulation techniques, Trans esterification, Application in diesel engines, DME (Dimethyl ether), properties fuel injection consideration general introduction to LPG and LNG, Compressed natural gas components, mixtures and kits, Fuel supply system and emission studies and control, Hydrogen combustion characteristics, Flashback control techniques, Safety aspects and system development, NOx emission control, Biogas, Producer gas and their characteristics system development for engine application.

ESL880 Solar Thermal Power Generation
3 Credits (3-0-0)
Relevance of solar thermal power generation; Design and performance characteristics of different solar concentrator types suitable for thermal power generation; Tracking of solar concentrators; performance characterization of solar concentrators, Storage option for solar thermal power plants; Modes of power generation in solar thermal power plants; Sizing solar thermal power plants; Operation and maintenance issues; Emerging trends in solar thermal power generation; Economics of solar thermal power generation; Case studies.

ESP713 Energy Laboratories
3 Credits (0-0-6)
Pre-requisites: EC 75 (for UG Students in Minor Area)
Industrial Tribology, Machine Dynamics and Maintenance Engineering Centre

**ITL702 Diagnostic Maintenance and Condition Monitoring**
4 Credits (3-0-2)

Maintenance strategies and introduction to Condition Based Maintenance (CBM), Application and economic benefits, Signature analysis - online and off-line techniques, Various Condition Monitoring (CM) techniques - Vibration monitoring and analysis, Shock Pulse Method, Noise monitoring, Envelope detection technique, Cepstrum analysis, Oil analysis including wear debris and contaminant monitoring, Performance monitoring, Acoustic emission and other techniques, Non-destructive testing techniques, Temperature monitoring including Thermography, Application and choice of the method, Practical applications of diagnostic maintenance, Condition monitoring of mechanical and electrical machines, Case studies.

**ITL703 Fundamentals of Tribology**
4 Credits (3-0-2)


Contact of engineering surfaces- Hertzian and non-hertzian contact. Contact pressure and deformation in non-conformal contacts. Genesis of friction, friction in contacting rough surfaces, sliding and rolling friction, Various laws and theory of friction. Stick-slip friction behaviour, frictional heating and temperature rise. Friction measurement techniques. Wear and wear types. Mechanisms of wear - Adhesive, abrasive, corrosive, erosion, fatigue, fretting, etc., Wear of metals and non-metals. Wear models - asperity contact, constant and variable wear rate, geometrical influence in wear models, wear damage. Wear in various mechanical components,

wear controlling techniques. Introduction to lubrication. Lubrication regimes. Introduction to micro and nano-tribology.

**ITL705 Materials for Tribological Applications**
3 Credits (3-0-0)

Introduction to tribological processes and tribological relevant properties of materials. An overview of engineering materials having potential for tribological application.

Characterization and evaluation of Ferrous materials for tribological requirements/applications, Selection of ferrous materials for rolling element bearings, gears, crank shafts, piston rings, cylinder liners, etc. Non-ferrous materials and their applications such as sliding bearings, piston rings, cylinder liners, etc., materials for dry friction materials.

Composite materials (PM, CMC and MMC) for tribological applications.

Surface treatment techniques with applications such as carburizing, nitriding, induction hardening, hard facing, laser surface treatments, etc.

Surface coating techniques such as electrochemical depositions, anodizing, thermal spraying, Chemical Vapour Deposition (CVD), Physical Vapour Deposition (PVD), etc. and their applications.

Lubricants- Introduction, requirements, types, Evaluation and testing of lubricants.

**ITL709 Maintenance Planning and Control**
3 Credits (3-0-0)

Objectives of planned maintenance, Maintenance philosophies, Preventive and Predictive maintenance, Emerging trends in maintenance-Preactive Maintenance, Reliability Centred Maintenance (RCM), Total Productive Maintenance (TPM), etc. Implementation of Maintenance strategy, Maintenance organization, Basis of planned maintenance system, Maintenance planning and scheduling, Maintenance control system and documentation. Spares and inventory planning, Manpower planning, maintenance auditing. Human factors in maintenance and training, maintenance costing, Maintenance performance. Repair decisions- Repair, replacement and overhaul,

Computer applications in maintenance, Expert systems applications, maintenance effectiveness, Case studies.

**ITL710 Design of Tribological Elements**
3 Credits (3-0-0)

Introduction-Tribological consideration in design, Conceptual design, Classification of tribological components, Mechanisms of tribological failures in machines, Zero wear concept, Computational techniques in design.

Design of Dry Frictional Elements-Dry friction concepts, Brakes and Clutches, Friction belts and Dry rubbing bearing.


Rolling elements bearings, Performance analysis of bearings, gears, seals, piston rings, machine tool slide ways, cams and follower and wire rope.

**ITL711 Reliability, Availability and Maintainability (RAM) Engineering**
3 Credits (3-0-0)


**ITL714 Failure Analysis and Repair**
4 Credits (3-0-2)

Introduction, need for failure analysis, Classification of failures, Fundamental causes of failures, influence of type of loading (e.g- static, fatigue, shock, etc.) on nature of failures, Role of stress; processing and fabrication defects, Effect of residual stresses induced during fabrication processes, Influence of temperature and environment on failure, Crack and subsurface crack like defects and their significance in failure.

Micro mechanisms of failures; Ductile and brittle fracture, Fatigue initiation and propagation, Fatigue failures, Wear related failures, High temperature failures, low temperature failures, etc., Studies and analysis of failed surfaces.

Identification of failures, Techniques of failure analysis, Microscopic methods, Fracture mechanics techniques, Prediction of failures, Residual life assessment and life extension, Typical case studies in failure analysis, Logical fault finding and its application, Inspection and safety measures, Repair techniques and economic considerations, Failure analysis for design improvement and proactive maintenance, Design for reparability, Case Studies.

**ITL717 Corrosion and its Control**
3 Credits (3-0-0)

Importance of corrosion control in industrial practices, Thermodynamics of corrosion, Broad forms of corrosion – uniform, uneven, pitting, cracking, etc. influencing factors on corrosion. Surface film, Polarisation and effect, Theory of passivity, kinetics of corrosion, Various types of corrosion along with case studies – Galvanic, Thermogalvanic, High temperature corrosion, Intergranular, Pitting, Selective attack (leaching), fretting corrosion – erosion, cavitation, Stress corrosion cracking, hydrogen embrittlement, etc., Various techniques for corrosion evaluation and monitoring, Corrosion Control-Design improvement, Selection of material, fabrication process for corrosion control, Role of residual stress, Changes in operating conditions, Use of inhibitors, Anodic and Cathodic protection, Corrosion resistant coatings, Case studies.
ITL730 Lubricants  
3 Credits (2-0-2)  
Overview of friction (F), wear (W) and lubrication, Primary role of lubricants in mitigation of F & W & heat transfer medium, Composition and properties of lubricant; Types of lubricants such as mineral oil based, synthetic lubricants, solid lubricants, and greases; Characteristics properties of lubes & greases; their evaluation methods, Classification systems such as API, SAE, AGMA, NLGI, ISO; Additives such as Viscosity-index improver (VII); Anti-oxidant (AO); Anti-friction (AF) Antwear (AW) Extreme-pressure (EP); Corrosion inhibitors (CI), detergents, dispersants; Selection criteria for lubricants for various tribological situations and applications; Used lubes-environment & health hazards and disposibility and recycling, evaluation of oil degradation by various techniques.

ITL740 Risk Analysis and Safety  
3 Credits (2-1-0)  
Introduction, Typical hazards, Accident indices, Fire and explosion hazards, Dow’s fire and explosion index, Hazards identification procedures for plants and machinery; Preliminary hazard analysis (PHA), Fault Hazard Analysis (FHA), Safety analysis (SHE), Hazard operability (HAZOP), What if, Check lists, Failure mode and effects analysis (FMEA), Failure mode, effects and criticality analysis (FMECA), HAZAN: Hazard analysis; FTA (Fault tree analysis), ETA (Event tree analysis), and CCA (Cause consequence analysis), Transportation of hazardous materials, Safety audit, Health and safety aspects of lubricants, Human factors in safety, Risk evaluation and acceptance criteria, Disaster management, Safety codes and Case studies.

ITL752 Bulk Materials Handling  
3 Credits (2-0-2)  
Nature of bulk materials, Flow of gas-solids in pipelines, Mechanical Handling equipments like screw conveyors, belt conveyors and bucket elevators, Pneumatic conveying systems- Components, Design and Selection, Troubleshooting and Maintenance of pneumatic conveying systems, Performance evaluation of alternative systems, Bend erosion-influencing factors, materials selection and potential solutions, Case studies, and Design exercises.

ITL760 Noise Monitoring and Control  
3 Credits (2-0-2)  
Introduction to noise, Properties of noise, Loudness and weighting networks, Noise measurement parameters and standards, Impulse noise, Frequency analysis - octave, one third octave and FFT analysis, Instrumentation for noise measurement and analysis, Sound power, Sound intensity measurement technique with applications, Noise source location, Noise diagnostics, Noise monitoring of machines with examples, Estimation of machinery noise, Cepstrum analysis, Noise control methods, Maintenance and noise reduction, Road vehicle and aircraft noise sources and control, Case studies.

ITL810 Bearing Lubrication  
3 Credits (3-0-0)  

JID800 Minor Project  
3 Credits (0-3-0)  
The students will select a research topic for the minor project. It is expected that such topics would involve understanding of basic processes and applications.

JIS800 Independent Study  
3 Credits (0-3-0)  
This is meant only for such students who are selected for DAAD fellowship.

JID801 Major Project-Part-I  
6 Credits (0-0-12)  
The students will select a research topic for the major project. It is expected that such topics would involve understanding of basic processes and extensive experimentation.

JID802 Major Project-Part-II  
12 Credits (0-0-24)  
The research topic selected in Part-I shall continue in Part-II also.
Instrument Design and Development Centre

**DSL601 Electronic Components and Circuits (for students other than Electrical/Electronics/Electronics and Communication)**

3 Credits (3-0-0)

Review of Electronic Components: Passive Components, Active Components including components used in Industrial Environment.


Analog-Digital circuits: A/D and D/A converters, classification and characteristic parameters of DACs and ADCs. Testing criteria. Multiplying DACs.

Digital Electronics: Logic gates, Combinational logic design, Sequential logic design, Counters;

Memory Devices, SRAM, DRAM, ROM, EPROM, Flash Memories and Programmable Gate Arrays.

Microprocessors: 8 bit and 16 bit microprocessor, basic structure and programming.

Application of microprocessors in instruments. Introduction to microcontrollers and embedded systems.

**DSL603 Material and Mechanical Design (for students from Electrical/Electronics/Electronics and communication)**

3 Credits (3-0-0)


**DSP703 Instrument Technology Laboratory 1**

3 Credits (0-0-6)

The laboratory essentially supports the courses taught in the first semester courses. It consists of experiments on:-

Study of packaging and characterization of transducers used for measurement of different physical variables like displacement, temperature, pressure, strain, flow etc.; Study of practical signal conditioning techniques and electronic measurement methods; Study of Electronic subsystems used in instruments Experiments on Cardinal points measurements using Nodal slide method, Measurement of wedge angle of optical flat and right angle of a prism by Autocollimation, Measurement the long radius of curvature of concave mirror using Foucault Knife edge test and Ronchi test, Newton and Fizeau Interferometer for Testing of optical surface, Quantitative testing of optical elements using polarisation based Twyman-Green interferometer, Measurement of small radius of curvature of lens using “Optical Spherometer”, Moire interferometry for displacement measurement.

**DSP704 Instrument Technology Laboratory 2**

3 Credits (0-0-6)

The laboratory supports the subjects taught in the second semester courses. The laboratory consists experiments on:

Study of various techniques used for analog and digital conditioning of signals from various transducers/ detectors; Study on modulation/ demodulation techniques, noise generation and measurement, Study of testing and calibration methods of instruments.

The structure of experiments has been designed to impart design level familiarity with various subsystems of instrumentation set up. The subsystems may consist of a detector-transducer, signal conditioner, a level power amplifier, display, actuator/final control element. The study will generally focus attention on one of the subsystems. In electronics conditioning.

Specific Case Study Experiments as below:

- Experiments in Control involving speed, position, temperature controls using MATLAB
- Experiments in Heat Conduction/ Convection. And Heat Sink Characterisation
- Data conversion, ADC & DAC, synchronous detectors, multipliers, dividers, instrumentation amplifiers
- Microprocessor/Microcontroller based system design with emphasis on real world interfacing
- Experiments on precision measurement methods and metrology.

**DSP705 Advanced Instrument Technology Lab**

3 Credits (0-0-6)

Experiments on design, simulation and verification of instrumentation sub-systems addressing the following objectives:

The performance of practical transducer systems and their processing circuits dealing with other devices and circuitual noise validation of algorithms for information extraction from sensor signatures dynamic range, threshold and sensitivity characterization and response time evaluation in practical environments

Experiments based on Digital Signal Processing hardware and software to: Study of DSP architecture; Interfacing with peripheral components; Implementation of DSP algorithm; Experiments based on Talbot effect, Digital Speckle Pattern Interferometry and Shack Hartmann Sensor.

**DSL710 Framework of Design**

2 Credits (2-0-0)

Definition of design as an industrial and social activity. Understanding of 'design' as a noun and as a verb. Design as a case of ill structured, ill defined, ill constrained problem solving. Comparative study of production processes in art, engineering and design. Design as cycle of analysis, synthesis, and validation of ideas. Design as the meeting point of the user needs, technology affordance and business goals. History of art and design. Influence of society and culture on design. Study of successful and failed products. Study of evolution of designed products. Consideration of advertising, marketing, consumer satisfaction, prevalent expertise, economic viability, production ecosystem, future prediction, legal and statutory concerns, IPR issues in design success.

**DSL711 Sensors and Transducers**

3 Credits (3-0-0)

Transducer Fundamentals: Transducer terminology Design and performance characteristics. --- criteria for transducer selection, Case Studies – Transducers principles of representative cases with emphasis on special “Electronic Conditioning requirements” of different type of sensors-- Resistive transducer; Inductive transducers; capacitive transducers; piezoelectric transducer; semiconductor and other sensing structures. Displacement transducers; tachometers and velocity transducers; accelerometers and gyros; strain gauges; force and torque transducers; flow meters and level sensors; pressure transducers; sound and ultrasonic transducer. Phototubes and photodiodes; photovoltaic and photoductive cells, photomission, photo electromagnetic, detectors pressure actuated photodiode detectors, design and operation of optical detectors, detector characteristics.

Brief Introduction -- Smart Intelligent Sensors, MEMS, Nano.

Transducer Performance: Static and dynamic performance parameters

Standards: Electrical tests, measurement unit, measurement standards of of voltage, current, frequency, impedance etc.

Errors and noise: types of errors, Effect of noise and errors on resolution and threshold. Dynamic range.
Testing: Calibration, dynamic tests, environmental test, life test.


DSP711 Computer Aided Product Detailing
3 Credits (1-0-4)

DSL712 Electronic Techniques for Signal Conditioning and Interfacing
3 Credits (3-0-0)

Review of Network theory, transmission lines and Circuit parameters (Z Y Hybrid, etc) and introduction to HF Design and S parameters Analog signal conditioning, Ultra- precision conditioning, Gain; attenuation; input and output impedances; single ended and differential signals; CMRR; system-module interfacing consideration; measurement and characterization of electronic system modules.

Analog and digital System Co-housing: EMI effects and EMC measures; circuit card placement; shielding and grounding techniques; ground loop management; isolation and interference filtering. EMI hardening and EMC interfacing.

Analog and digital data transmission; modulation & demodulation; Data transmission; channel noise and noise immunity factors. Data busses; GPIB and other standards in parallel data transmission. Opto-electronic interfacing techniques.

Analog and digital representation of data; comparisons and relative merits; multiplexing and demultiplexing of analog and digital data, ADC/DAC. Microcontroller and DSP applications.

Application of CPU's in signal and data handling; response linearization and drift compensation; data logger, computer aided measurement and control.

DSP712 Exhibitions and Environmental Design
3 Credits (2-0-2)


DSL714 Instrument Design and Simulations
3 Credits (2-0-2)


Dynamic properties of instrument systems: Review of instrument control systems, on-off, proportional and PID controllers. Stability considerations, gain and phase margin.


DSS720 Independent Study
3 Credits (0-3-0)

DSP721 Design and Innovation Methods
3 Credits (1-0-4)


DSL722 Precision Measurement Systems
3 Credits (3-0-0)

Fundamentals of precision measurements: accuracy, precision, resolution, repeatability, reproducibility, consistency, drift analysis, dynamic range, Measurements and error estimation, systematic and random errors, Instrument transfer function, least square method and its applications, filtering, polynomial fitting, data analysis and statistical inference, correlation. Surface roughness, waviness and shape measurements. Study of some measurement systems such as mechanical and optical profilers, circularity, cylindricity and conicity measurement systems, Co-ordinate measuring machine, profile projector, long trace slope measuring profilometer, Shack-Hartmann sensor for slope measurement, Different Interferometers for optical metrology, absolute testing techniques, Moire techniques for measurements in industrial applications.

DSP722 Applied Ergonomics
2 Credits (1-0-2)

Definition, origin, scope and goals of ergonomics as a field of study. Examples of applications of ergonomics in design. Types of data from human at physical, physiological, cognitive and affective levels. Data gathering and analysis techniques. Use of descriptive and inferential statistics in ergonomic data. Applications of mean, median, mode and percentile in anthropology. Use of anthropometry in workstation design. Human physiological potentials and limitations in terms of load carrying capacity. Concept of comfort, fatigue and stress. Design for the cognitive user. Concept of mental workload. Cognitive perspective in control panel design and graphical user interface design.

DSL731 Optical Components and Basic Instruments
3 Credits (3-0-0)

Generation of light: Thermal, non-thermal and semiconductor light sources. Measurement of light and instrumentation. Properties and propagation of light; The Ray Optics, Wave Optics, and Electromagnetic Optics; Basics of interference, diffraction and polarization of light. Optical Components: Reflecting components, plane, Spherical, paraboloidal, total internal reflection. Refracting components; Converging, diverging and combination of lenses, Design analysis and image formation by lenses, Wavefront aberrations; Monochromatic (Seidel), and chromatic aberrations. Eyepieces: Huygens, Ramsden, and special eyepieces; Prisms, Polarizing prisms: Glan Taylor Polarizer, Glan- Thomson prism polarizer, Rochon Prism Polarizer, Senarmont prism polarizer, Wollaston Prism, Phase plates (λ/2, λ/4), Soleil -- Babinet compensator; Diffraction components; diffraction by single/multiple openings, types of gratings and fabrication techniques, diffractive optical elements. Polarizing components; Polarization by reflection, and double refraction, birefringence crystals, and polarization based optical devices, Rotatory Polarization, Polarization rotators; Optical instruments: Microscopes, Telescopes, cystoscope; Refracting, reflecting, interferometric telescopes. Interferometers; two-beam, multiple-beam, and Shearing interferometers; Detectors: Photodetectors, CCD and CMOS detectors, IR-detectors.

DSP731 Communication and presentation skills
3 Credits (1-0-4)

Concept of sketching for designers, sketching through geometrical shapes, Sketching in isometric grids, sculpting conceptual objects while sketching through cuboids. The use of shade and shadows,
Rendering, physical product modeling through frugal materials and by the use of MDF, HIPS, Vacuum forming, modeling in FRP, product photography, video recording for presentations.

**DSL732 Adv Mat Processes & Die Design**
3 Credits (2-0-0)
Understanding properties and selection of natural and manmade materials including metals, plastics, ceramics, composites and natural materials.
Understanding various manufacturing and prototyping methods including digital manufacturing/ prototyping.
Hands on product realization exercises involving selection of materials and manufacturing processes.
Die and mould manufacturing methods including surface treatment and finishing processes.
Prototyping projects involving CNC, 3-D Printing, Vacuum forming, etc.

**DSL733 Optical Materials and Optical Techniques in Instrumentation**
3 Credits (2-0-0)
Photo-Lithography and its optical system, Illumination and projection systems, Astronomical and remote sensing systems, Detectors: Thermal detectors, photon detectors and Imaging detectors.

**DSL734 Laser Based Instrumentation**
3 Credits (3-0-0)

**DSL737 Display Devices and Technology**
3 Credits (3-0-0)
Non-emissive displays: basics of liquid-crystal materials, their properties and characterization. Liquid-crystal display devices and technologies. Transmissive, reflective, active and passive matrix, thin-film transistor (TFT), transreflective, and back lighting technologies for LCDs. Electronic-ink, electronic paper, and flexible and transparent display technologies and their applications. Laser based projection displays.

Display electronics and digital light processing technologies. Three-dimensional (3-D) imaging and display technologies: Micro-displays, STEREOSCOPIC 3D displays. HOLOGRAPHIC 3-D displays. Laser based 3D-TV.

**DSL740 Instrument Organization and Ergonomics**
3 Credits (2-0-0)
Functions of instrument systems, classification of tasks as man-machine systems, need analysis, product specifications, solutions search, product planning, systems break-up. Strengths and weaknesses of the machines.
Understanding the potentials and weaknesses of the human beings, application of force, load lifting, load carrying, stride patterns. Functions of controls and displays, handles, levers, knobs, switches, dials, LCD screens. Hand-held devices, workstations, large control systems.
Case studies, Exercises & Projects.

**DSP741 Product Interface & Design**
2 Credits (1-0-2)

**DSL751 Form and Aesthetics**
3 Credits (2-0-2)
Elements of design, Nature inspired design, Gestalt, Product semantics, Color theory and color trends, Varied approaches for form, Product styling, case studies and design discourse on form, exercises on from development of a product (existing or conceptual).

**DSR761 Social Immersion :**
1 Credit (0-0-2)

**DSR762 Vehicle Design**
3 Credits (2-0-2)

**DSR772 Transportation Design**
3 Credits (2-0-2)
DSL782 Design for Usability
3 Credits (2-0-2)

DSD792 Design Project-I
3 Credits (0-0-6)
Aim of the project to help the student independently solve a design problem against an pre-identified design brief.

DSD801 Major Project Part-I
6 Credits (0-0-12)

DSR801 Summer Internship:
2 Credits (0-0-4)
Identifying of the project area, setting the objectives, milieu and deliverables of the Internship, report writing/Presentation.

DSD802 Major Project Part-I
12 Credits (0-0-24)

DSL810 Special Topics in Design-I
3 Credits (3-0-0)
Special topics in design.

DSL811 Selected Topics in Instrumentation-I
3 Credits (3-0-0)
Advanced course on Selected Topics in Instrumentation to the M.Tech. Instrument Technology Programme.

DSC812 Term Paper and Seminar
3 Credits (0-3-0)

DSR812 Media Studies
3 Credits (2-0-2)
To enable designers to use different media optimally. Principles and processes of photography, videography, print and animation. Study of design constraints and affordances in differ media. Exercises in photography, videography, print, animation Cinematography etc. Design of corporate identity programs.

DSL814 Selected Topics in Instrumentation-II
3 Credits (3-0-0)
Advanced course on Selected Topics in Instrumentation to the M.Tech. Instrument Technology Programme.

DSL815 Special Topics in Instrumentation
1 Credit (1-0-0)

DSL820 Special Topics in Design-II
3 Credits (3-0-0)
Special topics in design.

DSV820 Special Modules in Design
1 Credit (1-0-0)

DSR822 Design for Sustainability
3 Credits (2-0-2)
Concept of sustainability, Tipple bottom line, world vision for sustainability, Emerging trends in the area of sustainability, Metrics for measurement of sustainability, Product lifecycle management and sustainability, Ecodesign.

DSR832 Design for User Experience
3 Credits (3-0-0)

DSL841 Design Management and Professional Practice
3 Credits (3-0-0)
Considerations in professional design startups including setting up a design office, getting finances, finding clients, running the office, business correspondence, brief and briefing, feasibility reports, letters of contract. Estimates of design fee as lump sum, hourly basis, consulting, commissioning and royalties. Study of govt. regulations, consumer protection acts, ISI standards, design registrations, patents and copyrights. Professional ethics in design practice. Creativity theory. Integrated product development. Assessing risks and opportunities. Cost cutting in design.

DSR852 Strategic Design Management
3 Credits (2-0-2)
Branding and brand development, Repositioning in market, disruptive innovation for market capitalization, Retail design, design of services, designing for new businesses.

DSR862 Design in Indian Context
3 Credits (3-0-0)
Introduction to culture form product design perspective. Models and definitions of culture. Product design culture of India. Culture as an aid in consumer product choice. Cross cultural biases in product decisions. Cross cultural design teams. Considerations in designing for a user from another culture. Exercises in product as a cultural thought. Culture in evolutionary perspective and design of new material cultures through products and lifestyles design.

DSD891 Design Project-II
6 Credits (0-0-12)
The student will be able to practice the design process to solve a professionally challenging design problem. The student should exhibit the sensitivity to the multidimensionality of the problems in the design domain. They should be able to prove their design outcome as viable and practice solution for the given problem. The students are expected to exhibit their work to the professional community.

DSD892 Industry/ Research Design Project
9 Credits (0-0-18)
To develop the ability to look at design problems from a research perspective. The student is expected to contribute to the professional design field thorough new design knowledge generation. The project is aimed to polish the designer’s research skills. The designer is expected to deliver cutting edge research and be able to articulate it professionally.
PTV700 Special Lectures in Polymers  
1 Credit (1-0-0)  
There will only be special lectures followed by a final assignment or quiz.

PTL701 Polymer Chemistry  
3 Credits (3-0-0)  
Introduction to polymers, nomenclature, addition, condensation, chain growth and step growth polymerization, kinetics of polymerization, material classes, polymerization techniques: bulk, suspension and emulsion polymerization; cationic, anionic and free radical polymerization; copolymerization, reactivity ratios; atom transfer radical polymerization.

PTL702 Polymer Processing  
3 Credits (3-0-0)  
Course covers the classification of polymer processing operations, extrusion, molding based processes, compounding and mixing, thermoforming and other processing methods.

PTL703 Polymer Physics  
3 Credits (3-0-0)  
The course content will include polymer molecules, their conformations, crystalline and two phase structures and their effects on various thermo-physical properties such as melting, glass transition and crystallization kinetics.

PTL704 Polymer Technology  
3 Credits (3-0-0)  
Polymers of commercial importance; additives for plastics; stabilizers, fillers, plasticizers and extenders, lubricants and flow promoters, flame retardants, blowing agents, colourants, cross-linking agents and biodegradation additives; manufacture, properties and applications of major thermoplastic and thermosetting polymers: polyethylene, polypropylene, poly(vinylene chloride), polystyrene and other styrenics, phenol-formaldehyde, urea-melamine formaldehyde and unsaturated polyester resins.

PTL705 Polymer Characterization  
3 Credits (3-0-0)  
Molecular weight and molecular dimensions by end-group analysis, osmometry, light scattering, viscometry, gel permeation chromatography, MALDI-TOF, Infra-red, NMR, UV-visible and Raman spectroscopic techniques. Thermal properties by differential scanning calorimetry, differential thermal analysis, thermogravimetry; Microscopy: optical and electron microscopy, X-ray scattering from polymers, small angle light scattering; crystallinity by density measurements.

PTL707 Polymer Engineering and Rheology  
3 Credits (3-0-0)  
Course covers Newtonian and non-Newtonian flow, simple shear flow and its significance, normal stresses, simple elongational flow and its significance, viscoelasticity, Rheometers, molecular, theoretical and related models.

PTP709 Polymer Science Laboratory  
2 Credits (0-0-4)  
Experiments: identification of polymers; purification of monomers; suspension polymerization of styrene; emulsion polymerization of vinyl acetate and butyl acrylate; bulk and solution polymerization of methyl methacrylate; preparation and testing of epoxy resins; unsaturated polyester resin technology; preparation of nylon 6 and nylon 10 by interfacial polymerization; copolymerization and determination of reactivity ratios; epoxide equivalent; molecular weight determination by viscometry and end-group analysis; atom transfer radical polymerization of styrene; thermal characterization by DSC and TGA; GPC; FTIR and NMR.

PTP710 Polymer Engineering Lab  
1 Credit (0-0-2)  
The course comprises of eight regular experiments on various processing equipments and two experientys dealing with rheology of polymer melts.

PTL711 Engineering Plastics and Speciality Polymers  
3 Credits (3-0-0)  
Introduction to engineering polymers, applications, processing, thermoplastic engineering plastics, polycarbonates, polyimides, polyphenylene oxide, liquid crystalline polymers, poly(ether ketone), thermosets, specialty polymers, hydrogels, conducting polymers, fluropolymers.

PTL712 Polymer Blends and Composites  
3 Credits (3-0-0)  
The course will cover definition and classification of blends and composites, miscibility, phase behaviour, nature of interface, nature of polymer matrices, reinforcements, basic theoretical models to predict mechanical properties and the role of fibre length, distribution, dispersion etc. on the performance properties of polymer based blends and composites.

PTL713 Polymer Testing and Properties  
3 Credits (3-0-0)  
Properties of polymers and their measurements by standard test methods; tensile, flexural and impact properties; hardness, abrasion resistance and long term fracture properties; softening point, heat distortion temperature, thermal expansion coefficient and thermal conductivity; electrical insulation and conductivity; sorption, diffusion and permeation of gases/liquids through polymer membranes; standards used are BIS, BS, ASTM, ISO and DIM; correlation of test with actual performance; statistical quality control in various tests.

PTL714 Biodegradable Polymeric Materials  
3 Credits (3-0-0)  
Concept of biodegradation; mechanism of biodegradation; kinetics of biodegradation; methods to evaluate biodegradation; bioplastics, biodegradable polymers and their synthesis; biodegradable polymer blends and composites; technology and processing of biodegradable polymers; applications of biodegradable polymers.

PTL716 Rubber Technology  
3 Credits (3-0-0)  
Rubber and elastomers, compounding and vulcanization, mastication, fillers-reinforcing and non-black (loading type). Other compounding ingredients; peptizers, vulcanizing agents, accelerators, accelerator activator, softeners, anti aging additives, miscellaneous additives, colourant, flame retarders, blowing agents, deodorants, abrasive retarders etc. Processing and vulcanization tests, vulcanization theory and technology, natural and synthetic rubbers, styrene butadiene rubbers, polybutadiene and polysisoprene rubbers, ethylene-propylene rubber, butyl and halobutyl rubber, nitrile and silicone rubber, thermoplastic elastomers, acrylate and fluoro elastomers.

PTL718 Polymer Reaction Engineering  
3 Credits (3-0-0)  
Course covers reaction kinetics in condensation and all types of addition polymerisation reactions, prediction of molecular weight for polymerisation in different types of reactors, batch and continuous processes, the effect of mixing on kinetics and MWD, reactor design.

PTL720 Polymer Product and Mould Design  
3 Credits (2-0-2)  
Course covers the types of moulds and dies, product and mould design, details of construction and manufacturing methods of tools, dies and moulds.
**PTL722 Polymer Degradation and Stabilization**  
*3 Credits (3-0-0)*  
Introduction to degradation, thermal and oxidative degradation; radiative, mechanical and chemical degradation; biological degradation; degradation pathways for common polymers; methods to monitor degradation; mechanical degradation, waste management.

**PTL724 Polymeric Coatings**  
*3 Credits (3-0-0)*  
Introduction and mechanism of adhesion of polymeric coatings on various substrates. Solvent based polymeric coatings. Water based polymeric coatings. UV and EB curable coatings. 100% convertible coatings. Selection criteria of coatings for various substrates. Health, safety hazard and environmental aspects of coatings during manufacturing and applications.

**PTL726 Polymeric Nanomaterials and Nanocomposites**  
*3 Credits (3-0-0)*  
The course content include the basic concepts and elements related to the understanding of nano structured polymer materials and nanocomposites.

**JPD799 Minor Project**  
*3 Credits (0-0-6)*  
A project in any area of polymers as decided by the supervisor.

**JPS800 Independent Study**  
*3 Credits (0-3-0)*  
The course contents are as defined for the program elective courses offered by the Centre.

**JPD801 Major Project Part-I**  
*6 Credits (0-0-12)*  
A project in any area of polymer science and technology.

**JPD802 Major Project Part-II**  
*12 Credits (0-0-24)*  
A project in any area of polymer science and technology.
Centre for Rural Development and Technology

RDL700 Biomass Production
3 Credits (3-0-0)

RDL701 Rural Industrialisation: Policies, Programmes and Cases
3 Credits (3-0-0)
Background: Rural Industrialisation, India's rural poverty and possible solutions, Rural Industrialisation during planned era. Farm & Non-Farm Sector Synergy: Lessons from Asian experience, Rural Industrialisation in China: Township & village enterprises. Rural transformation through decentralized technologies, Sustainable Livelihoods: Participatory Management Approach, Appropriate strategy for Rural Industrialization, Policies for Rural Industrialisation Entrepreneurship, Development for Rural Youth, Women and appropriate Technology in Rural Industrialization, Industrialization of rural areas around urban centres, Industrialization in tribal area, Role of Govt. & Financial Institutions in Rural Industrialization, Role and Impact of District Industries Centres in Rural Industrialization, Gramodyaya Scheme and rural industrialization, Development of Handloom Industry, Growth of production & employment in KVs in India, Rural Industrialisation through Artisanal industry, Rural Industrialisation: Case Studies, Industrialisation of a drought-prone district: Grass root level planning, PURA Model of Rural Development, Some successful case Studies.

RDL705 Rural Resources and Livelihoods
3 Credits (2-0-2)
Field projects related to Natural resource based livelihoods.

RDL722 Rural Energy Systems
3 Credits (2-0-2)

RDL724 Technologies for Water and Waste Management
3 Credits (2-0-2)

RDL726 Herbal, Medicinal and Aromatic Products
3 Credits (2-0-2)
Herbal, Medicinal and Aromatic plants of India: Overview and Uses Ayurveda, Siddha, Homeopathy, Unani & Tribal systems of Medicine, Role of Traditional Medicine in Primary Health Care, Identification of Medicinal and Aromatic plants, Classification of Medicinal plants, Pharmacology and Phytochemistry, Medical Bio-prospecting and Chemo prospecting, Biomarkers, Active principle and Phytomedicine, Cultivation, Harvesting and Storage of Medicinal and Aromatic plants: Organic farming of Medicinal and Aromatic Plants, Good Agriculture Practice, Post Harvest Processing of Medicinal and aromatic Plants, Cleaning and Washing, Drying, Grinding, processes of Medicinal and Aromatic plants – Extraction, Purification of Active Principle/Phytomedicine – Distillation, Herbal food formulation, Herbal cosmetics and cosmochemicals, Nutraceuticals, Mosquito control Products, Aromatherapy, Herbal Veterinary medicine, Natural Dyes and Colours, Quality Control and Analysis.
Practical and Project related to Herbal, Medicinal and Aromatic products.

RDL730 Technology Alternatives for Rural Development
3 Credits (3-0-0)
Concept of technologies appropriate for Rural India. Social, economic and environmental considerations. Appropriate technology for energy, agriculture, housing, textiles, water-supply and sanitation, health care, transport and small-scale industries. An integrated approach to the use of steams – technologies. Uses of Technology transfer

RDL740 Technology for Utilization of Wastelands and Weeds
3 Credits (3-0-0)
Land as a parameter in rural development. Wastelands and importance of using them. Biomass growth on various types of lands. Introduction to plant taxonomy, under-utilized terrestrial plants and aquatic weeds,
flora of tropics, arid lands and hilly areas. Constituents of biomass, biochemical and chemical conversion processes.

Applications of biomass as unconventional plant-based source for food, cattle feed, chemicals, fibres, construction materials and energy. An integrated technological approach to biomass and wasteland utilization. Possible ecological effects.

**RDD750 Minor Project: Intensive Study on Topics of Specific Interest**

*3 Credits (0-0-6)*

Project work related to any topics of interest within the specified time frame.

**RDP750 Biomass Laboratory**

*3 Credits (0-0-6)*

Soil and Water analysis for Biomass Production: Soil Sampling from a plot/field and soil analysis for its texture, pH, EC, C.N.P and K. Water analysis: TDS, Alkalinity, Total Hardness, EC and pH.

Soil Microflora and Root Association: Isolation and cultivating of nitrogen fixers (Rhizobium, Azotobacter, Azospirillum and blue green algae), ecto and endomycorrhizal fungi. Measurement of total microbial biomass in soil and respiration rate of microbes. Bacterial and fungal root infection.


Bioinoculants for rapid composting.


**RDL760 Food Quality and Safety**

*3 Credits (0-0-6)*

Concept of Holistic Health, Holistic Food, Food Quality & Safety. Food quality parameters and standards, Natural and chemical preservatives & colors, toxins, pesticides, pathogens etc. Nutrients (macro and micro), shelf life, seasonal food and diversity 'satvik' characteristics.

Food processing industries - Current Status and Policy guidelines, Multi residue analysis and mycotoxin contamination in food, Processing techniques for enhancing bioavailability of micronutrients, Minimizing pesticide residue and mycotoxins in food products, Organic food: quality control and export potential, APEDA and IFOAM Certification.

BIS, MRL's under India conditions etc. Policy and regulatory safe guards, Food fortification and Nutraceuticals, Traditional as well as modern system, Botanical pesticides for stored grain protection, Major storage pests and their life cycle, traditional system and their limitations, Traditional systems and their limitations (storage structures, pest control measures etc.) Innovations, Village cluster Grain storage model for Rural Entrepreneurship, Enhancing shelf life of G-K products, grain flour, raw milk, fruits and vegetables, bamboo shoot mushroom etc., Equipments & machinery for food processing and preservation small scale food outlets (vendors), SHG, WTP and quality control (case study).

**RDL801 Successful Grassroot Organisations**

*3 Credits (2-0-2)*


**RDL803 Informatics and Rural Development**

*2 Credits (2-0-2)*


**RDL807 Women, Technology and Development**

*2 Credits (2-0-2)*

Role of women in development, Gender bias and indicators, Strategies for women empowerment, Technology and Women uplift, Women and energy, Women and water management, Women and health care, Women and holistic health, Women and Vector control, Women in farm sector, Women in non-farm sector, Women in the service sector, Women and Information technology.

Field projects related to Women, Technology and Development.
VEL700 Human Values and Technology
3 Credits (2-1-0)

VEL710 Traditional Knowledge Systems and Values
3 Credits (3-0-0)
The values inherent in The Traditional Knowledge Systems (TKS) viz., respect for all life and non-life, respect for diversity; awareness of social and ecological impact of activities; self-sufficiency; sustainability, socially appropriate, use of local natural and knowledge resources viz., decentralized, aesthetically pleasing, wealth distributive etc. It would be emphasized that these values are inherently present in the framework of traditional knowledge systems and are not add-ons. Traditional Technologies which are developed as part of the TKS framework are invented and tested in the field, where all environmental and social interaction, in particular its effect on other life-forms known and unknown are allowed to play their part. This non-fragmented approach makes such knowledge holistic and avoids the errors and pitfalls when technologies are applied on the basis of incomplete or inadequate theories.

VEV731 Special Module on Inner Development-I
1 Credit (0.5-0-1)
This module will primarily consist of courses which address one or more aspects of inner development such as comprehensive mindfulness, in-depth intellectual understanding of oneself and one's aspirations, selfless service etc. These courses are expected to provide a practical experience to the students in how small positive changes can be brought about in one's inner self through a systematic practice of looking within.

VEV732 Special Module on Inner Development-II
1 Credit (0.5-0-1)
(Same as VEV731).

VEV733 Special Module on Leadership-I
1 Credit (0.5-0-1)
This module will address the strong linkages between the personal values of an individual and the desirable qualities of a leader. Going beyond the theories, it will emphasize on the practical aspect of looking within as well as connecting to the outside world and hence developing the qualities of a leader.

VEV734 Special Module on Leadership-II
1 Credit (0.5-0-1)
(Same as VEV733).

VEV735 Special Module on Sustainability-I
1 Credit (0.5-0-1)
This module will consist of courses which address one or more aspects of sustainability vis-a-vis the societal value system. The three core components of sustainability, viz, sustainable use of resources, environmental protection and equity in the society need to be understood in-depth with respect to the values of excessive materialism and individualism, competitiveness and unlimited economic growth on one hand and the values of compassion, fraternity and cooperation on the other. The practical sessions will be used to carry out group exercises of planning and analysis of real life case studies.

VEV736 Special Module on Sustainability-II
1 Credit (0.5-0-1)
(Same as VEV735).

VEV737 Special Module on Civilization-I
1 Credit (0.5-0-1)
This module will address one or more aspects of development of civilizations and promotion of societal peace which have strong linkages with the value system of the society. This could include value systems reflected in constitutions of different countries, the way a society deals with human rights and the like.

VEV738 Special Module on Civilization-II
1 Credit (0.5-0-1)
(Same as VEV737).

VEV739 Special Module on Professional Ethics-I
1 Credit (0.5-0-1)
This module will bring out the need for professional ethics as recognised by several professional bodies in the world through discussion of practical case studies and the underlying tenets of the code of conduct of professional bodies. The course will initiate discussion on reasons behind deviation from these tenets and the relevance of these tenets of professional ethics in the contemporary world.

VEV740 Special Module on Professional Ethics-II
1 Credit (0.5-0-1)
(Same as VEV740).

VED750 Minor Project
3 Credits (0-0-6)
To carry out detailed studies (under the guidance of a faculty member) on issues like Science, Technology and Human Values, Engineering Ethics, Sustainable Development, Scientific basis of human values etc.
SIL765 Networks & System Security  
4 Credits (3-0-2)  
The goal of this course is to introduce challenges in securing computer systems and networks. We will discuss various types of vulnerabilities in existing software interfaces, such as buffer overflows, unsafe libc functions, filesystem design issues, etc. We will also discuss modern-day defenses against attacks exploiting these vulnerabilities. In network security, we will discuss security problems in network protocols and routing, such as sniffing, denial of service, viruses, worms, etc. and defenses against them. The course will involve reading research papers on relevant topics, programming assignments, and projects.

SIL769 Internet Traffic -Measurement, Modeling & Analysis  
4 Credits (3-0-2)  

SIL801 Special Topics in Multimedia System  
3 Credits (3-0-0)  
Content of this course, depending upon the teacher, will be focused on some aspect(s) of multimedia systems like content based retrieval, multimedia communication, compression techniques, speech and audio technology, etc.

SIL802 Special Topics in Web Based Computing  
3 Credits (3-0-0)  
Content of this course, depending upon the teacher, will be focused on some aspect(s) of web based computing like semantic web, web based distributed computing, search methods, etc.

SIV813 Applications of Computer in Medicines  
1 Credit (1-0-0)  
This course will consist of 14 lecture-hours that focus on information and communication technologies (ICT) that are being developed and used in medical education and clinical practice today. Various technologies ranging from computer aided instruction (CAI), simulations, and networked applications at one end to electronic medical records (EMR), telemedicine, and robotic surgery at the other end will be described. The process of research, development, and evaluation in the designing and making of these applications and tools will be detailed. Writing assignments, creative thinking, and interactive discussions will form an integral part of this course.

SIV861 Information and Comm Technologies for Development  
1 Credit (1-0-0)  
Notion of appropriate technology; case studies of ICTD projects such as KioskNet, WiLDNet (Wireless Long Distance Networks), AIR (Advanced Interactive Radio), Spoken Web, GRINS (Gramin Radio Inter Networking System), Digital Green; design principles to be kept in mind; evaluation methodologies.

SIV864 Special Module on Media Processing & Communication  
1 Credit (1-0-0)  
Communication today has rich multimedia contents. Under the varying bandwidth attention is required for appropriate processing of the media contents satisfying desired quality of service. This course will focus on bringing the two broad areas of multimedia processing and communication together. In media processing fundamental concepts of media processing and compression will be introduced with exposure to current techniques and standards. In communication protocols and algorithms for both wired and wireless networks will be discussed in relation to multimedia communication.

SIV871 Special Module in Computational Neuroscience  
1 Credit (1-0-0)  
Special module that focuses on research problems of importance in this area of Neuroscience from a computational perspective. Specific coverage will vary with each offering, and may include project work and design/case studies. Topics for each offering of the course will be separately listed.

SIV889 Special Module in Human Computer Interface  
1 Credit (1-0-0)  
Special module that focuses on research problems of importance in this area from a computational and design perspective. Specific coverage will vary with each offering, and may include project work and design/case studies. Topics for each offering of the course will be separately listed.

SID880 Minor Project in Information Technology  
3 Credits (0-0-6)  

SID890 Major Project (SIY)  
40 Credits (0-0-80)  

SIV895 Special Module on Intelligent Information Processing  
1 Credit (1-0-0)  
This course will focus on presenting conclave of methods which are being practiced for intelligent computing – learning techniques, classification methods, embedding intelligence, neural networks, soft computing and evolutionally methods. Emphasis will also be given on the variety of multidisciplinary applications of such techniques.

BSR895 MS Research Project  
36 Credits (0-0-72)
SBL100 Introductory Biology for Engineers
4 Credits (3-0-2)
Darwinian evolution & molecular perspective; Introduction to phylogeny - Classification systems in biology and relationships; Cellular assemblies -- From single cell to multi-cellular organisms: Geometry, Structure and Energetics; Comparing natural vs. humanmade machines; Infection, disease and evolution – synergy and antagonism; Immunology – An example of permutations and combinations in biology; Cancer biology – Control and regulation; Stem cells – Degeneracy in biological systems; Engineering designs inspired by biology – Micro- to Macro- scales.
Pre-requisites: SBL100 and EC80
Laboratory: Biosafety; Buffers in biology - Measuring microlitres, Preparation of standard biological buffers, buffering capacity and pKa of buffers, response of cells and plant tissues in different buffering conditions; Observing cell surface and intracellular contents using light and fluorescence microscopy, measuring cellular motion using real-time video microscopy; Measuring and visualizing intracellular molecular components - Proteins and Genomic DNA

SBL201 High-Dimensional Biology
3 Credits (3-0-0)
Pre-requisites: SBL100
Introduction to Genomics, proteomics, Metabolomics & Cellomics; Size vis-à-vis packaging and replication challenges, Biomolecular architecture and assemblies leading to function, Immortal cells and aging, Minimalist Genomes & Designer Genomes; Molecular Engines; Proteins as nanobiomachines; network circuits for genome organization and proteinprotein interactions, date hubs, party hubs, structure-function axioms, Biochemical cycles and feedback loops, Omics Applications, forensics, drug targets.

SBL703 Advanced Cell Biology
3 Credits (3-0-0)
Pre-requisites: EC 90
Overview and history of systems biology; Basic elements of molecular biology – DNA and protein, the genetic code, transfer RNA and protein sequences and control of gene expression; Signal transduction – signaling pathways and cascades, information processing and transmission, pathway dynamics; Trees and sequences – graphs, connectivity, trees, flows in networks; Elements of process control – feedback, feed forward and cascade control, dynamics of closed loops, analogies with control of gene expression; Examples of transcription networks, determination of simple motifs that are repeated in genetics; guidelines for analyzing genetics circuits, layouts and representations, circuit dynamics; modeling, simulation and prediction of cellular events, micro-macro relations; Experimental methods in systems biology, creation of directed information, existing databases; platforms and applications; Case studies from literature – circadian clock, metabolic networks, gene circuit design; New frontiers.

SBL704 Human Virology
3 Credits (3-0-0)
Pre-requisites: EC 90
Introduction, overview and history of medical Virology; Virus structure, classification and replication – symmetries, replication, maturation and release; Principles of viral pathogenesis- entry, cell tropism. Cellular pathogenesis, clearance and persistence; Respiratory viruses – Influenza, paramyxoviruses, adenoviruses, SARS, RSV; Viral gastroenteritis – causative agents, epidemiology; Hepatitis viruses – food borne and blood borne; Herpes viruses – infections in immunocompetent and immunocompromised individuals, latency; Enteroviruses – Polio, ECHO, coxsackie viruses; Congenital viral infections – effects on foetus, prevention; Retroviruses – HIV, AIDS; Arboviruses and Viral zoonoses – arthropod vectors, vertebrate hosts, transmission cycles, rabies and viral haemorrhagic fevers; Tumour viruses – oncogenic mechanisms of viruses; Strategies for control of viral infection – active and passive immunophrophylaxis, antiviral agents; Safety precautions – lab acquired infections, hazard groups and containment levels; Case studies from literature, evolving and emerging areas of interest.

SBL705 Biology of Proteins
3 Credits (3-0-0)
Pre-requisites: EC 90
Overview of protein preparation, modification, maturation; protein-protein interactions in cells, Heat shock proteins and their structure and functions in cells, protein mimicry, assisted protein maturation processes in cells, Protein trafficking and dislocation, protein secretion from cell, kinetics and thermodynamics of protein folding and unfolding reactions, biomarker discovery, ribosome profiling.

SBL706 Biologics
3 Credits (3-0-0)
Pre-requisites: EC 90 and BEL 110 or CYL 110 or CYL 120 or Equivalent
Definition and classification of biologics, Biologics, Biopharmaceuticals Vs. conventional drugs, Biosimilars, Role of rDNA technologies, transgenics (animal and plant), obligonucleotides, peptide, PNA mediated therapeutics, drug delivery systems (lipids, cell penetrating peptides), vaccine, monoclonal antibodies produced by and in the living organisms, nanobiopharmaceutics, overview of the technologies
employed for identification, characterization and production of biologics, Bioprospecting for novel drug discovery and development, Gene prospecting, plant bioprospecting, marine bioprospecting. Phytomedicines, plant secondary metabolites, herbal drugs, edible vaccines, Bioresource based alternative medicine systems - AYUSH, Southeast Asian medicine system, PIC, MAT and ABS, assessing the role of biomimetics, system biology, synthetic biology in biologic production, GMPs, legislations, Safety Regulations associated with biologics in biopharmaceuticals.

**SBL707 Bacterial Pathogenesis**

3 Credits (3-0-0)

Pre-requisites: EC 90 and BEL 110 or CYL 110 or CYL 120 or Equivalent

Common features of bacterial pathogens, structural features, capsules and cell walls, Pathogenicity islands, types of toxins produced, effect of toxins on host cells, secretion systems, production and function of adhesions, attachment to host cells, mechanisms of cellular invasion, extracellular and intracellular invasion, intracellular survival and multiplication, virulence factors, mechanisms of antibiotic resistance, interaction with the host immune system - innate and adaptive, evasion strategies, Immunocompromised individuals and opportunistic pathogens, specific examples such as Listeria, Mycobacterium, Shigella, Yersinia etc., strategies for prevention and cure, drug designing and scope for future studies, emerging infectious bacterial pathogens.

**SBL708 Epigenetics in Human Health and Disease**

3 Credits (3-0-0)

Pre-requisites: EC 90 and BEL 110 or CYL 110 or CYL 120 or Equivalent

Introduction – overview of epigenetics in human health and disease; Epigenetic mechanisms – basic mechanisms: DNA methylation and genome imprinting –role of DNA methylation; Epigenetics in cancer Biology – global and region specific changes and effects on transcription; DNA methylation and repeat instability diseases; Epigenetic reprogramming and role of DNA methylation in mammalian development –role in embryogenesis; Epigenetics in pluripotency and differentiation of embryonic stems cells; MicroRNA in carcinogenesis – mechanisms and potential therapeutic options; Epigenetic regulation of viruses by the host –role in pathogenesis; methods in epigenetics- methylation patterns and histone modifications; Case studies from literature, evolving and emerging areas of interest.

**SBL709 Marine Bioprospecting**

3 Credits (3-0-0)

Pre-requisites: EC 90 and BEL 110 or CYL 110 or CYL 120 or Equivalent

Significance, Overview of Marine Bioresources, Marine Biomedical Research and Development; Drug discovery continuum in Marine Biotechnology, Omics, Biosensors, Biomaterials, Bionanotechnology, Bioactive compounds, Nutraceuticals, Pharmaceuticals, Cosmeceuticals, Novel Technologies in Marine Research, Sustainable development, Case studies, Emerging issues and challenges; IPRs, Marine Biodiversity and Traditional Knowledge (medicine).

**SBL710 Chemical Biology**

3 Credits (3-0-0)

Pre-requisites: EC 90 and BEL 110 or CYL 110 or CYL 120 or Equivalent

Chemical modifications of proteins, protein and nucleic acid immobilization; The Organic Chemistry of Biological Pathways; cross linking in biomolecules; Physical Chemistry of proteins; fluorescent labeling of proteins and nucleic acids, sequencing of proteins and amino acids, radio labeling of proteins and nucleic acids, chemistry of glycosylation, phosphorylation, sulphonylation, methylation, of proteins and nucleic acids, non-ribosomal peptide synthesis, nano particles mediated monitoring of protein conformational transition, folding and unfolding processes; surface properties of proteins and subsequent implications in cellular processes, solubility of proteins, physical basis for biomolecular structure formation, environmental effects on structure-function of biomolecules, chemistry of enzymatic digestion of nucleotides and proteins, role of metal ions in the cellular function, metallo-enzymes and their biosynthesis, Hydrogen/Deuterium exchange reaction and its application in monitoring biological processes, basic concept of chemical synthesis of life.

**SBL711 Cell Signalling**

3 Credits (3-0-0)

Pre-requisites: SBL100 and SBL201 (or equivalent) and EC90

Signaling as a basis of cellular communications, conversion of information into cellular response, first messenger, intracellular and extracellular receptors, second messenger, signaling proteins, signal amplification, cascade formation, adapters, domains, scaffold, recruitment of signaling proteins, pseudosubstrates, convergence, divergence, cross talk, molecular switches, critical nodes, multisite protein phosphorylation, G-protein coupled signal transduction, nuclear receptors, growth factors and tyrosine kinases, mitogen activated protein kinases, insulin signal transduction, phosphatases, emerging technologies like antisense, omics, RNAi; high content screening, target hunting, combination of mutations, systems approach to understand signaling complexity.

**SBL712 Dynamics of Infection Biology**

3 Credits (3-0-0)

Pre-requisites: SBL100 and either SBL201 or SBL311 and EC90

Features of bacterial/viral/other pathogens, molecular evolution and dissemination, factors influencing dissemination, host entry, receptors and pathways, host genetics, persistence and latency, co-infection dynamics, host-pathogen interactions, innate and adaptive immunity, Th1-Th2 balance, intracellular survival and dissemination, molecular mimicry, apoptosis and necrosis, intervention strategies and application of bioinformatics in infection biology.

**SBL713 Introduction to Structural Biology**

3 Credits (3-0-0)

Pre-requisites: SBL100 and either SBL204 or SBL311 and EC90

Introduction to protein structure; secondary, tertiary and quaternary structures; expression and purification of recombinant proteins for structure determination; basics of X-ray crystallography, space groups, diffraction basics, phasing techniques, validation and Ramachandran plot; cryoelectron microscopy, freezing and imaging techniques, model building; small angle X-ray scattering (SAXS), application to protein samples; NMR, chemical shifts, common NMR experiments, assignment, validation; advantages and disadvantages of each technique, types of applications.

**SBL714 Plant Biotechnology and Human Health**

3 Credits (3-0-0)

Pre-requisites: EC90

Overview of medicinal plants and their geographical distribution, economics of medicinal plants, KNapSACK family database, metabolic diversity, genomic and transcriptomic profiling, phenomics, antivenoms, plant toxins, bioactive peptides, genetic engineering and molecular biology technologies such as DNA barcoding, DNA chip technology, cDNA, AFLP, microarray, sRNA, antisense, bioanalytics, plant models systems, Nutrigenomics, smart and functional foods, Plants based human diseases communicable and noncommunicable diseases, synthetic biology approaches.

**SBL750 Quantitative Biology**

3 Credits (3-0-0)

Pre-requisites: SBL100 and SBL201 (or equivalent) and EC90

Overview of quantitative biology; Biomolecules - a study of how information is code in molecules - DNA, RNA and proteins, information representation; Molecular sequences - the alignment problem, PAM and BLOSUM matrices, applications - global, local and overlap alignment; Gene prediction - computational gene finding, ab-initio methods, comparative methods; Molecular evolution - molecular
clock, explicit models and evolutionary rate estimation; Population genetics - polymorphism, genetic diversity and Neutral theory; Testing evolutionary hypothesis; Genetic circuits - motifs search, satio-temporal logic, methods of analyses; Protein structure prediction, protein-protein interaction networks, drug target identification, Biological network dynamics; Biological pattern formation; Self organization in biology.

**SBV750 Bioinspiration and Biomimetics**  
1 Credit (1-0-0)  
*Pre-requisites: EC 90*  
Introduction to Bioinspiration and biomimetics, Bioinspiration pools marine and terrestrial plants and animals, Biomimetic/Bioenabled biomaterials, biomimisation, Biomimetic adhesives and attachment devices in nature, prosthetics function design and bioinspired robotics, biomimetic pattern formation, colour and camouflage, photocells, role in agriculture and human health, future prospects in the industry.

**SBL751 Chemical and Molecular Foundations of Cell**  
3 Credits (3-0-0)  
*Pre-requisites: SBL100 and SBL201 (or equivalent) and EC90*  
Protein conformation, dynamics and function, Enzyme activity, Biomolecular interactions in cell, biomolecular assemblies in the cell, Generation and storage of metabolic energy, Biosynthesis of macromolecular precursors like, amino acids, lipids, hormones, nucleotides, Characterisation and identification of cells, Genes, genomics and chromosomes, Genetic material, DNA replication, Repair, Translation, Mutation, mutations and mutants, Plasmid and transposable element, Recombinant DNA and genetic engineering, Protein targeting into membranes and organelles, Vesicular traffic, secretion, and endocytosis, Cellular organization of movement, microtubules, Eukaryotic cell cycle, functions and mode of action of nucleus, Nerve cells, Immune response, Evolution of cells, prebiotic synthesis, RNA catalysis, evolution of gene structure, Epigenetics, Non-coding RNA, Hologenome.

**SBC795 Graduate Student Research Seminar-I**  
0.5 Credit (0-0-1)  
*Pre-requisites: EC 90*  
The course is aimed at giving the student a forum to periodically present their research, to critique the research of colleagues and learn about the best research in their fields. Discussions will be held on scientific methodology and inculcated with a value system for pursuing a career in science. Activities will be carried out in workshop mode.

**SBC796 Graduate Student Research Seminar-II**  
0.5 Credits (0-0-1)  
*Pre-requisites: EC 90*  
Special topics in research will be assigned by Coordinator; results of the research of each student registered for the course will be discussed; Discussions on scientific material from recently published papers in areas related to their research; The "Laboratory" activities will include delivery of seminars on their research and participation in the seminars and critique.

**SBS800 Independent Study**  
3 Credits (0-3-0)  
*Pre-requisites: EC 120*  
The course is aimed at providing the student an opportunity to pursue a special research topic. A research topic assigned and mutually agreed upon by the faculty and student. Registration will require the submission of a proposal through the research committee on the topic clearly delineating the objectives to be achieved.

**SBL801 Signal Transduction and Drug Target Identification**  
3 Credits (3-0-0)  
*Pre-requisites: EC120*  
Eukaryotic cellular communications, importance of signal transduction, principles of signaling, recurring themes of signal transduction, reception, transduction, response, signal amplification, coordination of signaling, cascade formation, structure to function, anchors, adaptors, scaffold, recruitment of signaling proteins, topology and functional domains, dual specificity, modules, convergence, divergence, cross talk, receptors, G-protein coupled signal transduction, growth factors and tyrosine kinases, mitogen activated protein kinases, insulin signal transduction, critical nodes, protein phosphorylation, drug target identification, mechanism of drug action against signal transduction, antagonists of cell surface receptors and nuclear and receptors, ion channel blockers, transport inhibitors, targeting protein kinases and phosphatases, inhibitors of kinases and phosphatases, pseudosubstrates, examples of clinical drugs against protein kinases/ phosphatases, new and emerging technologies to identify drug target like antisense, omics, RNAi, high content screening, target hopping, combination of mutations, systems approach, complexity in signaling, techniques in signal transduction.

**SBL802 Macromolecular Structure and Data Processing**  
3 Credits (3-0-0)  
*Pre-requisites: EC120*  
Treatment of macromolecules to generate suitable crystals, hanging drop and sitting drop techniques, seeding, cryoprotecting and freezing crystals, acquisition of diffraction data, synchrotron radiation, indexing and scaling data, space group identification, symmetry elements, Fourier transformation and structure factors, the phase problem, heavy atom methods, molecular replacement, anomalous X-ray scattering, calculation of electron density, model building and phase refinement, co-crystallography, small angle X-ray scattering, preparing samples for transmission electron microscopy, negative staining, cryo-techniques for freezing grids, manual vs. automated data collection, cryotomography, software packages for data collection and processing, generating a model, refinement and validation, time resolved cryoEM.

**SBP810 Advanced Bioscience Techniques**  
2 Credits (0-0-4)  
*Pre-requisites: EC90*  
Particle sizing, biological and biomolecular visualization tools, advanced and analytical spectrometry, cell and molecular separation techniques, DNA and protein interaction techniques, membrane interaction and signalling, bioreactors, tissue culture, transgene technology, electrophysiology methods.

**SBV881 Advances in Chemical Biology**  
1 Credit (1-0-0)  
*Pre-requisites: EC 120*  
Structural aspects of proteins and nucleic acids, Mechanism of action of biological molecules, Chemical approaches to solve biological problems, Designing chemical tools for addressing problems in biology, Biocongjugate chemistry, Recent developments in these areas.

**SBV882 Biological Membranes**  
1 Credit (1-0-0)  
*Pre-requisites: EC 120*  
Introduction to the hydrophobic effect, Phospholipid model systems, Cellular membrane asymmetry, Membrane dynamics, Membrane trafficking, Membrane fusion, Membrane proteins (Form and function), Small molecule permeability, Pores channels and transporters, Lipid systems for drug delivery.

**SBV883 Chaperone and Protein Conformational Disorders**  
1 Credit (1-0-0)  
*Pre-requisites: EC 120*  
Molecular mechanism of protein misfolding, fate of aggregated proteins in the cell, various protein misfolding disorders in humans, mechanism of action of molecular chaperones in various cells, chaperone assisted suppression of protein misfolding.
SBV884 Elements of Neuroscience
1 Credit (1-0-0)
Pre-requisites: EC 120
Introduction to cell biology of neurons; presynaptic and post synaptic mechanisms; signal transduction cascades; neural integration; Hodgkin-Huxley experiments; Na and K pumps; physiological significance of pump modulation; Na and K channels; type and function of different Ca activated K channels; structure function and inactivation; tools for studying Ca signalling; caging and releasing Ca in the neurons; role of nitric oxide; Long term potentiation.

SBV885 Protein Aggregations and Diseases
1 Credit (1-0-0)
Pre-requisites: EC 120
Introduction to protein aggregation (amorphous and amyloid), types of aggregates, difference between aggregation and precipitation; External and internal factors for protein aggregation, pH, temperature and protein concentration effects; hydrophobicity, discordant helices; Structural and conformational prerequisites of amyloidogenesis, predominance of beta-sheet, alpha-helices or random coils of native protein; generic nature of protein folding and misfolding, Cytotoxic intermediates in the fibrillation pathway, Oxidative stress and protein deposition disease, Protein aggregation, ion channel formation, and membrane damage, Recent trends in prevention of amyloidosis; drugs, antibodies, combination therapy.

SBV886 Signaling Pathway Analysis
1 Credit (1-0-0)
Pre-requisites: EC 120
Introduction to modelling of biological systems – history, types of models, macroscopic phenomena, modelling of cellular systems; hierarchy in information transmission and utilization, interaction between different levels of information leading complex behaviour; robustness of cellular systems and its significance; molecules that transmit signals, role of signaling in regulation of cellular functions, gene regulation; signal transduction – evolution and history; first messengers and receptors, GTP-binding proteins; Calcium Signaling – free, bound and trapped calcium, mechanisms regulating calcium concentration, calcium changes in single cells; protein phosphorylation as a switch, protein kinase A, protein kinase C, structure of signaling pathways, extracting motifs from pathways, relating motifs to observations; dynamics and periodicity in signaling pathways.

SBV887 Current Topics in Computational Biology
1 Credit (1-0-0)
Pre-requisites: EC 120
Bring about awareness of the challenges in Genomics, Proteomics, Metabolomics and Structural Biology.

SBV888 Current Trends in Computer Aided Drug Discovery
1 Credit (1-0-0)
Pre-requisites: EC 120
Teach students various methods for target identification, and applications QSAR and molecular modelling in drug discovery.

SBV889 Diagnostic Virology
1 Credit (1-0-0)
Pre-requisites: EC 120
Introduction to diagnostic virology – direct and indirect methods, specimens and window period; Microscopy – light microscopy, electron microscopy, and fluorescence microscopy in virus identifications; Methods of virus isolation – cell culture, embryonated egg inoculation and animal inoculation; Viral antigen detection – methods, assay characteristics, rapid antigen identification techniques; Detection of viral antibodies – methods, role of quantitative measurements, class-specific immunoglobulin detection; Viral nucleic acids – amplification, detection and quantitation methods; Molecular epidemiology of viral infections – high throughput methods; Identifying antiviral resistance – genotypic and phenotypic approaches; Quality control in diagnostic virology – internal and external quality control, international standards, and Shewhart control charts.

SBV890 Kinetoplastid Parasites and Novel Targets
1 Credit (1-0-0)
Pre-requisites: EC 120
Kinetoplastid diseases, transmission, clinical features, immune evasion, treatment, antimicrobial chemotherapy, drug resistance, cross – resistance, Leishmania, promastigotes and amastigotes, procyclic and metacyclic, macrophage, interaction with sand fly, cytokine response, transmission, syndromes associated with leishmaniasis, microtubules in kinetoplastida, dynamics and postranslational modifications, drug interactions, resistance against tubulin binding agents, arsenite resistance in Leishmania, transporters in kinetoplastid protozoa and drug targets, leishmanial glucose transporters, function of histone deacetylases in kinetoplastid protozoa, DNA – topoisomerases in Leishmania, a possible therapeutic target, exoproteome of leishmania, importance and its application in Leishmania.

SBV891 – Virus Host Interactions
1 Credit (1-0-0)
Pre-requisites: EC 120
Introduction to the virus life cycle; host cell surface molecules utilized as virus receptors, mechanism of cellular membrane penetration for enveloped and non-enveloped animal viruses, cellular entry of bacteriophages and plant viruses;icosahedral and helical capsids; disassembly and transport of genome to the replication site, process of replication, modification of cellular organelles and hijacking of host cell resources ; site and manner of progeny virus assembly ; lytic and lysogenic viruses; virus egress and involvement of the host secretory pathway; host defence mechanisms, virus strategies to evade host immune system, antiviral therapies and drug discovery.

SBD895 MS Research Project
36 Credits (0-0-72)
The research problem will be assigned by the supervisor. It is expected that the student will undertake the problem early in the program.
Interdisciplinary M.Tech. Programmes

M.Tech. Programme in Optoelectronics and Optical Communications

JOP791 Laboratory-I (Fiber Optics and Opt. Comm. Lab)
3 Credits (0-0-6)

JOP792 Laboratory-II (Fiber Optics and Opt. Comm. Lab)
3 Credits (0-0-6)

JOL793 Selected Topics-I
3 Credits (3-0-0)

JOL794 Selected Topics-II
3 Credits (3-0-0)

JOS795 Independent Study
3 Credits (0-3-0)

JOV796 Selected Topics in Photonics
1 Credit (1-0-0)

JOD801 Major Project Part-I
6 Credits (0-0-12)

JOD802 Major Project Part-II
12 Credits (0-0-24)
# Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>BAP</td>
<td>Board of Academic Programmes</td>
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<tr>
<td>B.Tech.</td>
<td>Bachelor of Technology</td>
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<td>CGPA</td>
<td>Cumulative Grade Point Average</td>
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<td>CRC</td>
<td>Centre Research Committee</td>
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<td>DGPA</td>
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<td>DRC</td>
<td>Department Research Committee</td>
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<td>EC</td>
<td>Earned Credits</td>
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<td>IRD</td>
<td>Industrial Research and Development</td>
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<td>M.B.A.</td>
<td>Master of Business Administration</td>
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<td>M.Des.</td>
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<td>M.S.(R)</td>
<td>Master of Science (Research)</td>
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<td>M.Tech.</td>
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<td>PGS&amp;R</td>
<td>Postgraduate Studies and Research</td>
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<td>Ph.D.</td>
<td>Doctor of Philosophy</td>
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<td>SGPA</td>
<td>Semester Grade Point Average</td>
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<td>SRC</td>
<td>Student Research Committee (for M.S.(R) and Ph.D. student)</td>
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<td>SRC</td>
<td>Student Research Committee (in respect to School)</td>
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Note:
1. Five-cycle lab / tutorial schedule would have lab / tutorial classes also on Wednesday between 1-5 p.m.
2. TG1 and TG2 are slots for courses that would like all groups to have tutorials together or in parallel at the same time.
INDIAN INSTITUTE OF TECHNOLOGY DELHI
THE HONOUR CODE

I ........................................................................................................................................ Entry No.......................... do hereby undertake that as a student at IIT Delhi:

1) I will not give or receive aid in examinations; that I will not give or receive unpermitted aid in class work, in preparation of reports, or in any other work that is to be used by the instructor as the basis of grading; and

2) I will do my share and take an active part in seeing to it that others as well as myself uphold the spirit and letter of the Honour Code.

I realise that some examples of misconduct which are regarded as being in violation of the Honour Code include:

☞ Copying from another's examination paper or allowing another to copy from one's own paper;

☞ Unpermitted collaboration;

☞ Plagiarism;

☞ Revising and resubmitting a marked quiz or examination paper for re-grading without the instructor's knowledge and consent;

☞ Giving or receiving unpermitted aid on take home examinations;

☞ Representing as one's own work, the work of another, including information available on the internet;

☞ Giving or receiving aid on an academic assignment under circumstances in which a reasonable person should have known that such aid was not permitted; and

☞ Committing a cyber-offence, such as, breaking passwords and accounts, sharing passwords, electronic copying, planting viruses, etc.

I accept that any act of mine that can be considered to be an Honour Code violation will invite disciplinary action.

Date..................................................... Student's Signature...................................................

Name........................................................ Entry No..........................................................
Indian Institute of Technology Delhi
Hauz Khas, New Delhi-110 016 (India)