COURSES OF STUDY

2013-2014

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
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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 and social sciences and engineering sciences apart from departmental requirements. Departmental courses (core and electives) constitute 50% 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 his parent discipline. At the postgraduate level, students are encouraged to look beyond their area of specialization to broaden their horizons through open electives.

The medium of instruction in the Institute is English.

The Institute follows the semester system. An academic year runs from July through June next year and is comprised of three semesters. Typically, the 1st semester starts in the last week of July and ends in the 2nd week of December; the 2nd semester starts in the last week of December/first week of January and ends in the 2nd week of May. The summer semester starts in the 3rd week of May and ends in the 2nd week of July. Detailed schedule is given in the Semester Schedule that is available before the start of the semester.

1.2 Departments and Centres

Each course is offered by an academic unit which could be a department, centre or school. The various Departments, Centres and Schools and their two-letter code are given below. Some courses are offered jointly by multiple academic units and are classified as interdisciplinary courses; their codes are also given in table 1.

Table 1. Academic departments, centres and schools.

<table>
<thead>
<tr>
<th>Name of Academic Unit (alphabetical order)</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied Mechanics, Department of</td>
<td>AM</td>
</tr>
<tr>
<td>Applied Research in Electronics, Centre for</td>
<td>CR</td>
</tr>
<tr>
<td>Atmospheric Sciences, Centre for</td>
<td>AS</td>
</tr>
<tr>
<td>Biochemical Engineering and Biotechnology, Department of (dual degree entry no. ‘BB’)</td>
<td>BE</td>
</tr>
<tr>
<td>Biological Sciences, School of</td>
<td>BL</td>
</tr>
<tr>
<td>Biomedical Engineering, Centre for</td>
<td>BM</td>
</tr>
<tr>
<td>Chemical Engineering, Department of</td>
<td>CH</td>
</tr>
<tr>
<td>Chemistry, Department of</td>
<td>CY</td>
</tr>
<tr>
<td>Civil Engineering, Department of</td>
<td>CE</td>
</tr>
<tr>
<td>Computer Science and Engineering, Department of</td>
<td>CS</td>
</tr>
<tr>
<td>Electrical Engineering, Department of</td>
<td>EE</td>
</tr>
<tr>
<td>Energy Studies, Centre for</td>
<td>ES</td>
</tr>
<tr>
<td>Humanities and Social Sciences, Department of</td>
<td>HU</td>
</tr>
<tr>
<td>Industrial Tribology, Machine Dynamics and Maintenance Engineering Centre</td>
<td>IT</td>
</tr>
<tr>
<td>Information Technology, Amar Nath and Shashi Khosla, School of</td>
<td>SI</td>
</tr>
<tr>
<td>Instrument Design and Development Centre</td>
<td>ID</td>
</tr>
<tr>
<td>Management Studies, Department of</td>
<td>SM</td>
</tr>
<tr>
<td>Mathematics, Department of</td>
<td>MA</td>
</tr>
<tr>
<td>Mechanical Engineering, Department of</td>
<td>ME</td>
</tr>
<tr>
<td>Physics, Department of (Engineering Physics courses start with ‘EP’)</td>
<td>PH</td>
</tr>
<tr>
<td>Polymer Science and Technology, Centre for</td>
<td>PS</td>
</tr>
<tr>
<td>Rural Development and Technology, Centre for</td>
<td>RD</td>
</tr>
<tr>
<td>Telecommunication Technology and Management, Bharti School of</td>
<td>BS</td>
</tr>
<tr>
<td>Textile Technology, Department of</td>
<td>TT</td>
</tr>
<tr>
<td>Value Education in Engineering, National Resource Center for</td>
<td>VE</td>
</tr>
</tbody>
</table>
Table 2. Interdisciplinary programmes

<table>
<thead>
<tr>
<th>Name of Interdisciplinary programme (alphabetical order)</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Computer Applications</td>
<td>JCA</td>
</tr>
<tr>
<td>Energy Studies</td>
<td>JES</td>
</tr>
<tr>
<td>Energy and Environment Management</td>
<td>JEN</td>
</tr>
<tr>
<td>Industrial Tribology and Maintenance Engineering</td>
<td>JIT</td>
</tr>
<tr>
<td>Instrument Technology</td>
<td>JID</td>
</tr>
<tr>
<td>Optoelectronics and Optical Communication</td>
<td>JOP</td>
</tr>
<tr>
<td>Polymer Science and Technology</td>
<td>JPT</td>
</tr>
<tr>
<td>Power Generation Technology</td>
<td>JPG</td>
</tr>
<tr>
<td>Telecommunication Technology and Management</td>
<td>JTM</td>
</tr>
<tr>
<td>VLSI Design Tools and Technology</td>
<td>JVL</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 followed by interviews in some cases. Details are given in Prospectus booklet. The various programmes and their specialization are listed below.

1.3.1 Postgraduate programmes

A. Postgraduate Diploma

<table>
<thead>
<tr>
<th>Department</th>
<th>Specialization</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied Mechanics</td>
<td>D.I.I.T (Naval Construction) (for candidates sponsored by the Indian Navy)</td>
<td>AMX</td>
</tr>
<tr>
<td>Civil Engineering</td>
<td>PG Diploma in Metro Rail Transport: Technology and Management (for candidates sponsored by DMRC)</td>
<td>CEX</td>
</tr>
</tbody>
</table>

The DIIT is also available in every corresponding Master of Technology programme listed in Item E below. It is awarded only to those students who have been able to complete only partially the corresponding M.Tech. degree requirements. For details see Section 5.6 in Courses of Study.

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

<table>
<thead>
<tr>
<th>Department</th>
<th>Specialization</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>

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

<table>
<thead>
<tr>
<th>Department</th>
<th>Specialization</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Management Studies</td>
<td>M.B.A. (with focus on Management Systems)</td>
<td>SMF</td>
</tr>
<tr>
<td></td>
<td>M.B.A. (with focus on Telecommunication Systems management)</td>
<td>SMT</td>
</tr>
<tr>
<td></td>
<td>M.B.A. (with focus on Technology Management) (part-time and evening programme)</td>
<td>SMN</td>
</tr>
</tbody>
</table>

D. Master of Design: (M.Des.)

<table>
<thead>
<tr>
<th>Specialization</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master of Design in Industrial Design</td>
<td>JDS</td>
</tr>
</tbody>
</table>
### Master of Technology: (M.Tech.)

<table>
<thead>
<tr>
<th>Department/Centre</th>
<th>Specialization</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Applied Mechanics</td>
<td>M.Tech. in Engineering Mechanics</td>
<td>AME</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Design Engineering</td>
<td>AMD</td>
</tr>
<tr>
<td>Chemical Engg.</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 Engg.</td>
<td>M.Tech. in Geotechnical and Geoenvironmental Engineering</td>
<td>CEG</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Rock Engineering and Underground Structure</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; Engg.</td>
<td>M.Tech. in Computer Science and Engineering</td>
<td>MCS</td>
</tr>
<tr>
<td>Electrical Engg.</td>
<td>M.Tech. in Communications Engineering</td>
<td>EEE</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Computer Technology</td>
<td>EET</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Control and Automation</td>
<td>EEA</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Integrated Electronics and Circuits</td>
<td>EEN</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Power Electronics, Electrical Machines and Drives</td>
<td>EEP</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Power Systems</td>
<td>EES</td>
</tr>
<tr>
<td>Mechanical Engg.</td>
<td>M.Tech. in Design of Mechanical Equipment</td>
<td>MED</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Industrial Engineering</td>
<td>MEE</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Production Engineering</td>
<td>MEP</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Thermal Engineering</td>
<td>MET</td>
</tr>
<tr>
<td>Physics</td>
<td>M.Tech. in Applied Optics</td>
<td>PHI</td>
</tr>
<tr>
<td>Textile Technology</td>
<td>M.Tech. in Fibre Science &amp; Technology</td>
<td>TTF</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Textile Engineering</td>
<td>TTE</td>
</tr>
<tr>
<td>Applied Research in Electronics</td>
<td>M.Tech. in Radio Frequency Design and Technology</td>
<td>CRF</td>
</tr>
<tr>
<td>Atmospheric Sciences</td>
<td>M.Tech. in Atmospheric-Oceanic Science and Technology</td>
<td>AST</td>
</tr>
<tr>
<td>Interdisciplinary Programme</td>
<td>M.Tech. in Computer Applications</td>
<td>JCA</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Energy Studies</td>
<td>JES</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Energy and Environmental Management</td>
<td>JEN</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Industrial Tribology and Maintenance Engineering</td>
<td>JIT</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Instrument Technology</td>
<td>JID</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Optoelectronics and Optical Communication</td>
<td>JOP</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Polymer Science and Technology</td>
<td>JPT</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in Telecommunication Technology Management</td>
<td>JTM</td>
</tr>
<tr>
<td></td>
<td>M.Tech. in VLSI Design Tools and Technology (*)</td>
<td>JVL</td>
</tr>
</tbody>
</table>

**NOTE:** (*) These are sponsored programmes.
F. Master of Science (Research): M.S.(R)

The Master of Science (Research) programme is offered by the respective department, centre or school.

<table>
<thead>
<tr>
<th>Department/School</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>
</tbody>
</table>

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

All departments, centres and schools listed in Section 1 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) For details see section 7.

1.4 Student’s entry number

The entry number of a student consists of eleven alpha-numerals.

```
2 0 0 8 A B C 6 7 8 9
```

- **Entry Year** (academic year of joining)
- **Programme code**
  - Fields 7 6 & 5: Academic Unit Code
    - Y for M.S. (Research)
    - Z for Ph.D.

In case of a programme change, the three alphabets (fields 5, 6 and 7) will be changed. However, his/her unique numeric code 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 students present status will be in use.

1.5 Honour Code

The *Honour Code* of IIT Delhi is given on the inside back cover of this booklet. Every student is expected to adhere to the *Honour Code*. 
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. At the beginning of the semester, a student registers 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 number is denoted by six alpha-numerals, three alphabets followed by three numerals:

E E L 7 0 5

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>Lecture courses</td>
</tr>
<tr>
<td></td>
<td>(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>P</td>
<td>Laboratory based courses</td>
</tr>
<tr>
<td></td>
<td>(where performance is evaluated primarily on the basis of practical or laboratory work with LTP structures like 0-0-3, 0-0-4, 1-0-3, 0-1-3, etc.)</td>
</tr>
<tr>
<td>D</td>
<td>Project based courses leading to dissertation (e.g., Major, Minor, Mini Projects)</td>
</tr>
<tr>
<td>N</td>
<td>Introduction to the Programme or to Humanities and Social Sciences, etc.</td>
</tr>
<tr>
<td>S</td>
<td>Independent Study</td>
</tr>
<tr>
<td>V</td>
<td>Special Topics Lecture Courses (1 or 2 credits)</td>
</tr>
</tbody>
</table>

(a) Codes for the nature of the course

The nature of the course corresponding to the third alphabet in the course code is given in table 3:

(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 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,

500 level courses : Courses for M.Sc. programmes.

These courses are not open to other PG students.

600 level courses : Preparatory/introductory courses for M.Tech. programmes.

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.
(c) Numbering scheme for courses of special nature
The numbering scheme for courses of special nature is given below. Here ‘xx’ is the Academic unit code, and ‘y’ is the digit from the programme code.

Table 4. Numbering scheme for courses of special nature

<table>
<thead>
<tr>
<th>Course description</th>
<th>Course number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to the Programme</td>
<td>xxN1y0</td>
</tr>
<tr>
<td>Independent Study</td>
<td>xxS3y0</td>
</tr>
<tr>
<td>Professional Practices</td>
<td>xxR3y0</td>
</tr>
<tr>
<td>Practical Training</td>
<td>xxT4y0</td>
</tr>
<tr>
<td>Colloquium</td>
<td>xxC4y0</td>
</tr>
<tr>
<td>Mini Project</td>
<td>xxD1y0</td>
</tr>
<tr>
<td>B.Tech. Major Project Part 1</td>
<td>xxD4y1</td>
</tr>
<tr>
<td>B.Tech. Major Project Part 2</td>
<td>xxD4y2</td>
</tr>
<tr>
<td>Minor Project (Dual Degree)</td>
<td>xxD7y0</td>
</tr>
<tr>
<td>M.Tech. Major Project Part 1</td>
<td>xxD8y1</td>
</tr>
<tr>
<td>M.Tech. Major Project Part 1 (alternative)</td>
<td>xxD8y3</td>
</tr>
<tr>
<td>M.Tech. Major Project Part 2</td>
<td>xxD8y2</td>
</tr>
<tr>
<td>M.Tech. Major Project Part 2 (alternative)</td>
<td>xxD8y4</td>
</tr>
</tbody>
</table>

Each course is associated with a certain number of credits; see below.

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. The 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.

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. Details are given in the section on rules and regulations for UG students (Section 4) and PG students (Section 5).

All programmes are defined by the total credit requirement and a pattern of credit distribution over courses of different categories. Total credit requirement for different programmes are given in section 4 for UG students and section 5 for PG students. Category-wise break-up for each programme are given in sections 6 and 7 for UG and PG programmes, respectively.

2.3 Course credits assignment

Each course, except a few special courses, has a certain number of credits assigned to it depending upon its lecture, tutorial and laboratory contact hours in a week. This weightage is also indicative of the academic expectation that includes in-class contact and self-study outside of class hours.

Lectures and Tutorials: One lecture or tutorial hour per week per semester is assigned one credit.
Practical/Laboratory: One laboratory hour per week per semester is assigned half credit.

A few courses are without credit and are referred to as non-credit (NC) courses.
Example: Course CEL 753 Structural Geology; 3 credits (2-0-2)
The credits indicated for this course are computed as follows:

\[
\begin{align*}
\text{2 hours/week lectures} & = 2 \text{ credits} \\
\text{0 hours/week tutorial} & = 0 \text{ credit} \\
\text{2 hours/week practical} & = 2 \times 0.5 = 1 \text{ credit}
\end{align*}
\]

Total = 2 + 0 + 1 = 3 credits

Also, (2-0-2) 3 credit course = (2 h Lectures + 0 h Tutorial + 2 h Practical) per week
= 4 contact hours per week

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

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. Further details are given in the Courses of Study.

2.4 Earning credits
At the end of every course, 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. A student’s performance is measured by the number of credits that he/she has earned and by the weighted grade point average. A student has the option of auditing some courses. Grades obtained in these audit courses are not counted for computation of grade point average. However, a pass grade is essential for earning credits from an audit course; this does not apply to postgraduate programmes. A minimum number of earned credits are required in order to qualify for a degree and continuation of registration at any stage. Currently students in the postgraduate programmes can audit courses but they do not count towards earned credits.

The credit system enables continuous evaluation of a student’s performance, and allows the students to progress at an optimum pace suited to individual ability and convenience, subject to fulfilling minimum requirement for continuation.

2.5 Course content description
Course content description consists of following components: (i) Course Number, (ii) Title of the Course; (iii) Credit and L-T-P; (iv) Pre-requisites; (v) Overlapping/Equivalent courses; and (vi) Description of the content. Content descriptions for all courses are given in Section 8. An example is given below:

**SIL769 Internet Traffic – Measurement, Modelling & Analysis**
4 credits (3-0-2)
*Pre-requisites: CSL374 / CSL672 or equivalent*

2.6 Course coordinator
Every course is usually coordinated by a member of the teaching staff of the Department/Centre/School which is offering the course in a given semester. For some courses, faculty from other departments/centres or even guest
faculty participates in the teaching and/or coordination of a course. This faculty member is designated as the Course Coordinator. He/she has the full responsibility for conducting the course, coordinating the work of the other members of the faculty as well as teaching assistants involved in that course, holding the tests and assignments, 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 and generally announced at the start of the semester. For all non-100 level ‘L’ category courses, not more then 80% of the course aggregate can be associated with minor and major examination components. Course coordinator will have additional evaluation components over and above two minors and majors.

2.7 Grading system

The grading reflects a student’s own proficiency in the course. While relative standing of the student is clearly indicated by his/her grades, the process of awarding grades is not based upon fitting performance of the class 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 instructor’s expectation.

2.7.1 Grade points

The grades and their equivalent numerical points are listed in table 5:

Table 5. 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>Continued</td>
</tr>
<tr>
<td>S</td>
<td>-</td>
<td>Satisfactory completion</td>
</tr>
<tr>
<td>Z</td>
<td>-</td>
<td>Course continuation</td>
</tr>
</tbody>
</table>

2.7.2 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 performance requirement.

C grade

The ‘C’ grade stands for average performance. This average performance refers to “average” as per instructor’s expectations in a holistic sense. This is the minimum grade required to pass in the Major Project Part 1 and Part 2 of Dual degree, Integrated M.Tech. and 2 year M.Tech. & M.S. Programmes.
D grade
The ‘D’ grade stands for marginal performance; i.e. it is the minimum passing grade in any course. 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 take a re-major test (an examination with weightage same as that of Major) for only ‘L’ Category Courses. If they perform satisfactorily, they become eligible for getting the grade converted to a ‘D’ Grade, otherwise they will continue to have ‘E’ Grade. However, 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 first year courses will be centrally notified by the Chairman, Time-Table Committee. A student can take a maximum of three such re-major tests in a given semester. If a student can not appear for the re-major test due to any reasons, he/she will not get any additional chance.

A student has to repeat all core courses in which he/she obtains ‘F’ Grades until a passing grade is obtained. For ‘E’ Grade in a core course, a student has to repeat the same core courses or take a re-major test to obtain a passing grade. For the other (elective) courses in which ‘E’ or ‘F’ grade have been obtained, the student may take the same course or any other course from the same category or take re-major in case of ‘E’ Grade. ‘E’ & ‘F’ Grades are not counted in the calculation of the CGPA; however, these are counted in the calculation of the SGPA.

I grade
An ‘I’ grade denotes incomplete performance in any L (lecture), P (practical), V (special module) category courses. It may be awarded in case of absence on medical grounds or other special circumstances, before or during the major examination period. The student should complete all requirements within

(i) 10 days of the last date of Major Tests; the request is to be made to the head of the department of the student’s programme who will notify the same to concerned course coordinators, or
(ii) with permission of the Dean (UGS)/Dean (PGS&R), the period can be extended to the first week of the next semester. A student will be eligible for an ‘I’ grade provided he/she has met the attendance criterion.

Upon completion of all course requirements, the ‘I’ grade is converted to a regular grade (A to F, NP or NF). ‘I’ grade does not appear permanently in the grade card.

Requests for I-grade should be made at the earliest but not later than the last day of major tests.

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 or extended I grade to appear for the re-major of the ‘E’ grade. On the basis of their performance a student having I grade or extended I grade can earn any permissible grade unlike students taking re-major after obtaining ‘E’ grade. Please see other requirements in Regulations and Procedures.

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 one week after the first Minor Tests. 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 ‘D’ grade. 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. The grades obtained in an audit course are not considered in the calculation of SGPA or CGPA.

For UG programmes: the credits will be counted in total earned credits in the respective category.
For PG programmes: the credits will not be counted towards degree completion credit requirements.

W grade
A ‘W’ grade is awarded in a course where the student has opted to withdraw from the course. Withdrawal from a course is permitted until one week after the first Minor Tests. Withdrawal from PG major project part 2 is allowed only if he/she is given semester withdrawal. The W grade stays on grade card.
X grade
The 'X' grade is awarded for incomplete work typically in a project-type course based on a request by the student. The separate regulations for UG and PG students are given below.

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 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 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/Z grades are awarded for 2003 and post-2003 entry undergraduate students are:

(i) Introduction to the Programme
(ii) Practical Training
(iii) NCC/NSO/NSS
(iv) Introduction to Humanities and Social Sciences
(v) Professional Practices

2.8 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).

A student who completes the course and credit requirements but has CGPA below the minimum required for award of degree will be evaluated in terms of Degree Grade Point Average (DGPA) which is calculated on the basis of the best valid credits; for all the completed semesters at any point of time until the maximum permissible period.

The Earned Credits (E.C.) are defined as the sum of course credits for courses in which students have been awarded grades between A to D or NP or S; for UG students, credits from courses in which NP or S grade has been obtained are also added.

Points earned in a semester = Σ (Course credits x Grade point) for courses in which A - D or NP or S grade has been obtained

The SGPA is calculated on the basis of grades obtained in all courses, except audit courses and courses in which S/Z grade is awarded, registered for in the particular semester.

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

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

\[
CGPA = \frac{\text{Cumulative points secured in all passed courses (A-D grade)}}{\text{Cumulative earned credits, excluding audit and S/Z grade courses}}
\]

An example of these calculations is given in table 6 (a).
Table 6(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>MALXXX</td>
<td>5</td>
<td>C</td>
<td>5</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>CSLXXX</td>
<td>4</td>
<td>C (-)</td>
<td>4</td>
<td>5</td>
<td>20</td>
</tr>
<tr>
<td>PHLXXX</td>
<td>4</td>
<td>A</td>
<td>4</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>PHPXX</td>
<td>2</td>
<td>B</td>
<td>2</td>
<td>8</td>
<td>16</td>
</tr>
<tr>
<td>MELXXX</td>
<td>4</td>
<td>E</td>
<td>0</td>
<td>2</td>
<td>08</td>
</tr>
<tr>
<td>TTNXXX</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 & S/Z grade courses = 15
Points secured in this semester *(total of column 6)* = 114
Points secured in this semester in all passed courses *(total of column 6 & A-D grade)* = 106

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

\[
\text{CGPA} = \frac{\text{Cumulative points secured in all passed courses (A-D grade)}}{\text{Cumulative earned credits, excluding audit and S/Z grade courses}} = \frac{106 + 154}{15 + 19} = \frac{260}{34} = 7.647
\]

Semester performance: Earned credits (E.C.) = 17 SGPA = 6.000
Cumulative performance: Earned credits (E.C.) = 17 CGPA = 7.067

Table 6(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>MALXXX</td>
<td>5</td>
<td>B</td>
<td>5</td>
<td>8</td>
<td>40</td>
</tr>
<tr>
<td>EELXXX</td>
<td>4</td>
<td>A (-)</td>
<td>4</td>
<td>9</td>
<td>36</td>
</tr>
<tr>
<td>CYLXXX</td>
<td>4</td>
<td>W</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>CYPXXX</td>
<td>2</td>
<td>B (-)</td>
<td>2</td>
<td>7</td>
<td>14</td>
</tr>
<tr>
<td>MELXXX</td>
<td>4</td>
<td>C</td>
<td>4</td>
<td>6</td>
<td>24</td>
</tr>
<tr>
<td>AMLXXX</td>
<td>4</td>
<td>A</td>
<td>4</td>
<td>10</td>
<td>40</td>
</tr>
<tr>
<td>HUNXXX</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 earned in all passed courses = 106 (past semesters) + 154 (this sem.) = 260
Cumulative earned credits = 17 (past semesters) + 20 (this sem.) = 37

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

\[
\text{CGPA} = \frac{\text{Cumulative points secured in all passed courses (A-D grade)}}{\text{Cumulative earned credits, excluding audit and S/Z grade courses}} = \frac{106 + 154}{15 + 19} = \frac{260}{34} = 7.647
\]
Semester performance : Earned credits (E.C.) = 20 SGPA = 8.105
Cumulative performance : Earned credits (E.C.) = 37 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. Further details are given in the Courses of Study.

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 form on the computer by indicating the slot-wise choice of courses. Web based registration facility is available only on the intranet of I.I.T. Delhi. The choice of courses must be approved by his/her adviser. The student must also take steps to pay his/her dues before the beginning of the semester by making use of internet banking facility of SBI through the intranet of I.I.T. Delhi. Students who do not make payments by a stipulated date will 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 (UGS)/Dean (PGS&R). In case of illness or absence during registration, the student should intimate the same to his/her course adviser and Dean (UGS)/Dean (PGS&R). A student must meet his/her advisor within the first week of the new semester for confirmation of his/her registration. A student’s registration record will be available on-line for reference.

Various activities related to registration are listed below. The relevant dates are included in the Semester Schedule that is available before the start of the semester.

3.2 Registration and student status

Registration by a student confirms his/her status as student at the Institute. 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.

Every registered student, except part-time postgraduate students, is considered as a full-time student at the institute. They are expected to be present at the Institute and devote full time to academics. Students registered only for a self-study course (only for undergraduates) or only for project or thesis are also considered as full-time students.

3.3 Advice on courses

At the time of registration, each student must consult his/her student adviser/programme coordinator to 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, work load and student’s interests, amongst others. Special provisions exist for academically weak students.

3.4 Registration validation

Before the first day of classes, every student is required to be present on campus and validate his/her registration by logging in at the website. The updated registration record will be available on the website and the hard copy will be available with the student’s advisor/programme coordinator. Students who do not do registration validation will not be permitted to add/drop courses.

3.5 Minimum student registration in a course

A 700 or 800 level course can run with minimum of 4 students; and in the case of a pre-Ph.D. course, a minimum of three students excluding those auditing the course are required. This checking will be done 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
Late registration is permitted under the following conditions:
(a) A student, who was not in the campus during the period of registration in the previous semester, needs to complete
the registration process on or before the first day of the semester before commencement of classes; or
(b) 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 (UGS)/Dean (PGS&R) for late registration. Dean (UGS)/
Dean (PGS&R) 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 one week after the start of the semester.

3.7 Addition, Deletion, Audit and Withdrawal from Courses
(a) Add/Drop: A student has the option to add a course(s) that he/she has not registered for, or drop a course(s) for
which he/she has already registered for. This facility is restricted to the first week of the semester.
(b) Audit: A student may apply for changing a credit course to an audit one within one week of the end of the
first minor test.
(c) Withdrawal: A student who wants to withdraw from a course should apply within one week of the end of first
minor test. A withdrawal grade (W) will be awarded in such cases.

Appropriate web-based applications are to be used at the academic web site from I.I.T. Delhi intranet for availing
the above options.

3.8 Semester Withdrawal
(a) 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,
& (iv) disciplinary condition should be clearly identified.
(b) Semester Withdrawal (SW) is proposed to reflect 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 at least 20 teaching days on these grounds. Under no circumstances an application for semester
withdrawal be acceptable after the commencement of major. A student is not permitted to request for withdrawal
with retrospective effect.
(c) Semester Leave (SL) is proposed to indicate the situation in which a student is permitted to take one or
more semester 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 HOD or HOC and the final
approving authority will be Dean UGS or Dean PGS as the case may be. All such applications must be
processed before the beginning of the semester in which the leave will be taken. The full-time 2 year M.Tech./
M.S. students 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.
(d) 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 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.
(e) When a student is suspended for one or more semesters on disciplinary grounds, the student status should
be called Disciplinay Withdrawal period (DW). Time spent in DW status will be counted towards the total
period permitted for completion of the degree.

3.9 Registration in special module courses
Special module courses, i.e. ‘V’-category courses, can be offered at the beginning of the semester in which case 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.

3.10 Registration for practical training
Before proceeding for practical training or training as part of the curricular requirement, the students should register for
the respective course after obtaining approval from the training coordinator and head of the department. On returning
after training, a continuation grade will be awarded and the students must register for the course in the regular
semester immediately following the training period. During this semester, evaluation of the training will be carried out
and a regular grade will be awarded.
3.11 Pre-requisite requirement for registration
A student should register for a course only if he/she fulfills the pre-requisite requirement(s). If the pre-requisite course is being done at the time of registration, the pre-requisite check will be performed after grading is done for the semester and those not fulfilling the pre-requisite will be deregistered from the course.

3.12 Overlapping/Equivalent Courses
A student is not allowed to earn credits from two overlapping/equivalent courses. Overlapping/equivalent courses are specified along with each course.

3.13 Limits on registration
A student is permitted to register for a specified minimum and maximum number of credits and/or lecture credits. Details are given in sections 4.3 and 5.4 for undergraduate and postgraduate students, respectively.

3.14 Registration and fees 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 will be de-registered from all courses and his/her name will be struck-off the rolls.

3.15 Registration record
In addition to web-based entries related to registration, the student should ensure that the same are entered on the Registration Record. Queries related to registration will be considered only when accompanied by the original Registration Record. This record must be preserved until the semester grade card is received by the student.

3.16 Continuous absence and registration status
If a student, whether full time, sponsored or part time, is absent from the Institute for more than four weeks without notifying the Head of Department/Centre or Dean (UGS)/Dean (PGS&R), his/her registration will be terminated and name will be removed from the Institute rolls.

3.17 Attendance rule
(i) It is mandatory for the students to attend all classes. Attendance Records of all students for each course will be maintained.
(ii) For all 1st year courses (100-level courses) the attendance will be taken and maintained by U.G. Section. If any student's attendance falls below 75% attendance in any of these courses, he/she will be put under academic probation. Henceforth, he/she will be governed by the rules for student under academic probation.
(iii) For all other courses, 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. The course coordinator will maintain and consolidate attendance record for the course (lectures, tutorials and practicals together, as applicable).

A faculty may choose any one or more of the following as attendance policy (approved by the Senate):
1. Faculty can assign 10% of the total marks to surprise quiz. 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.
2. Faculty can allocate specific marks for participation in discussions in the class on a regular basis.
3. 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.
4. A student can not get NP for an audit course if his attendance is less than 75%. A faculty can implement any other attendance policy provided the policy is approved by the Dean.

Attendance statistics will also be used in the following way:

(i) If a student’s attendance is less than 75% in more than two courses with out any valid reason in a semester 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.

(ii) If a student's attendance is less than 75% in any course and 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. POSTGRADUATE DEGREE REQUIREMENTS, REGULATIONS AND PROCEDURES

4.1 Degree requirements

The detailed degree requirements for M.Sc., D.I.I.T., M.B.A., M.Des. M.Tech., M.S. (Research) and Ph.D. degrees are listed in Table 9.

4.2 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 are listed in Table 9. 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 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:

(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.

4.3 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.

4.4 Lower and upper limits for credits registered

For full-time students pursuing M.Sc., M.B.A., M.Tech. and M.S.(Research), the minimum registration requirement in a semester is 12 credits, and for part-time students, the minimum registration requirement is 3 credits. These minimum credit requirements are not applicable for graduating students who require lower than the proposed minimum to graduate.

4.5 Audit requirement

a. 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.

b. A JEE entry student is eligible to audit a course provided he /she has earned 100 credits.

c. M.Tech./M.S./ Ph.D. students are eligible for auditing a course at any time before completion of the programme.
d. A student earns either a NP (audit pass) or a 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.

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

f. All JEE entry students (B.Tech., Dual-Degree, Integrated M.Tech.) can earn a maximum of 8 credits from elective course as audit, in any category out of total credits required for graduation.

g. M.Tech., M.Sc., M.S and Ph.D students can audit a course over and above their core requirements, as specified by the supervisor and SRC.

h. A student (UG/PG) is permitted to audit courses over and above their graduation requirement.

i. 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. should not be referred to as audit courses.

j. These courses should be treated like similar core requirements for UG programmes such as Introduction to Programme/Introduction to Humanities & Social Sciences. These courses should be numbered with N as the third letter, indicating the fact that these courses will not be considered for CGPA or SGPA calculation but are core requirements for the programmes. For example, HUL810, which is a core requirement for all Ph.D. students, should be numbered HUN810/. 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.

4.6 Award of D.I.I.T. to M.Tech./MBA students

In case a student after completing the maximum period available for the M.Tech. programme is not able to get the required minimum CGPA of 6.0 with at least 60 valid credits, 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 45 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 36 credits (9 courses from core and 3 courses from focus module) +4 compulsary audit courses.

4.7 Part-time students regulations

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.


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 Coordinator concerned and a proper leave account of each student shall be maintained by the Department/Centre/Programme Coordinator concerned.

4.9 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.

All students who are offered assistantship are required to register for a special course with Satisfactory/Unsatisfactory grade. The students are expected to put in 8 hours per week towards the work assigned by the Institute.
of assistantship in a subsequent semester would be conditional to obtaining a satisfactory grade in this course 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) in other courses registered in the same semester.

4.10 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 if and only if that is the only requirement for completion of the degree and is recommended by DRC/CRC. For projects, in case X or I 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 be offered by departments/centres for taking care of special situations subject to the availability of faculty.

4.11 Master of Science (Research) regulations

The M.S. (Research) programme comprises of 20 credits of course work (minor project is not allowed) and 40 credits of research work. 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 student will have to register for thesis (project course no. xxD895, ‘xx’ is department/school code) for 40 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 “Rules and Regulations for Master of Science (Research) Programme”.

4.12 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-doctoral courses are given by each department/centre. These courses can be prescribed from existing M.Tech. courses, 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 the Ph.D. student having completed 20 credits is unable to complete the research at the Ph.D. level for any reason whatsoever, he/she will be allowed to complete M.S. (Research) degree requirement.

M.Tech. or equivalent degree holders are required to complete a minimum of 6 credits. The departments/centres may require a larger number of credits in general or in specific cases. The course requirement will be determined by the Department/Centre’s Research Committee (DRC/CRC) 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, special pre-Ph.D. courses including laboratory, seminar, foreign language, etc. Normally, no independent study course will be allowed for Ph.D. students.

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, such credit transfer be recommended by the concerned DRC/CRC as relevant to their Ph.D. programme.

The minimum CGPA requirement for the course work is 7.50. If the CGPA at the end of any semester is above 7.00 but less than 7.50, he/she will be asked to take more courses in order to make up the required CGPA. If the SGPA at the end of the first semester and CGPA at the end of any subsequent semester is below 7.00, he/she will have to discontinue the doctoral programme. In some departments, the required performance level may be higher than that stated above. The admitted students must acquire a copy of departmental norms. The course work must be completed within the first two semesters of joining the programme.
<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>DJIT (Naval Construction)</td>
<td>Minimum 12 credits</td>
<td>CGPA ≥ 5.0 at the end of each semester.</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>Maximum 20 credits</td>
<td></td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6 sem. #</td>
</tr>
<tr>
<td>M.Sc., Chemistry</td>
<td>Minimum 20 credits</td>
<td>(i) 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>90</td>
</tr>
<tr>
<td></td>
<td>Maximum 28 credits</td>
<td>(ii) After the first registered semester, the minimum acceptable performance level in any registered semester is SGPA of 5.0 or more.</td>
<td>5.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iii) 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>6 sem.</td>
</tr>
<tr>
<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>
<td></td>
<td>(v) 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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<tr>
<td>M.Sc., Mathematics</td>
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<tr>
<td>M.Sc., Physics</td>
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</tr>
<tr>
<td>M.Tech., full time</td>
<td>Minimum 12 credits</td>
<td>(i) 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>60</td>
</tr>
<tr>
<td></td>
<td>Maximum 22 credits with the condition that no. of lecture courses to be not more than 6.</td>
<td>(ii) After the first registered semester, the minimum acceptable performance level in any registered semester is SGPA of 6.0 or more.</td>
<td>6.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(iii) 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>6 sem.</td>
</tr>
<tr>
<td></td>
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<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 12 credits and a maximum of 22 credits for full time students.</td>
<td></td>
</tr>
<tr>
<td></td>
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<td>(v) 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>M.Tech., part time</td>
<td>Minimum one course and/or Minor/ Major Project.</td>
<td>Maximum 12 credits with the condition that no. of lecture courses to be not more than 3.</td>
<td></td>
</tr>
<tr>
<td>M. Des.</td>
<td>Minimum 18 credits</td>
<td></td>
<td>91.5</td>
</tr>
<tr>
<td></td>
<td>Maximum 30 credits</td>
<td></td>
<td>6.0</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>6 sem.</td>
</tr>
<tr>
<td>M.B.A., full time</td>
<td>Same as M.Tech. full time</td>
<td></td>
<td>72 + 6 compulsory audit courses.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M.B.A., part time</td>
<td>Same as M.Tech. part time</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| M.S. (Res.) full time | See note + | (i) 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.  
(ii) After the first registered semester, the minimum acceptable performance level in any registered semester is SGPA of 7.0 or more.  
(iii) 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.  
(iv) 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.  
(v) During the research work period, each unsatisfactory performance grade would entail a warning and two consecutive warnings would result in termination of registration. | 60 including Thesis. | 7.0 | 6 sem. |
<table>
<thead>
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<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>M.S. (Res.) part time</td>
<td>See note ++</td>
<td>For details please refer to Ph.D. Ordinances and Regulations</td>
<td>CGPA ≥ 7.5. If, at the end of 1st semester, the SGPA is 7.0 or more but less than 7.5, he/she will be required to take more courses to attain a CGPA of 7.5.</td>
<td>12 for B.Tech./M.Sc., 6 for M.Tech. or equivalent; A Deptt./Centre may prescribe additional credits.</td>
<td>7.5 in the course work + Thesis</td>
</tr>
<tr>
<td>Ph.D.</td>
<td>For details please refer to Ph.D. Ordinances and Regulations</td>
<td>CGPA ≥ 7.5. If, at the end of 1st semester, the SGPA is 7.0 or more but less than 7.5, he/she will be required to take more courses to attain a CGPA of 7.5.</td>
<td>12 for B.Tech./M.Sc., 6 for M.Tech. or equivalent; A Deptt./Centre may prescribe additional credits.</td>
<td>7.5 in the course work + Thesis</td>
<td>14 sem.++</td>
</tr>
</tbody>
</table>

NOTE:

$ Detailed break-up of core, elective and open category courses are given in the *Courses of Study* bulletin.

£ If a student at the end of the M.Tech. programme fails to complete 60 valid credits with a CGPA of 6.00 or above, he/she still can get a D.I.I.T 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.

+ In the first semester the student has to register for a minimum of 15 and a maximum of 20 credits of course work only. In the subsequent 3-semesters the student shall complete the research work and the course work remaining, if any.

++ In the first two semesters the part-time student shall register only for the course work with the minimum and maximum limits of 6-12 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.

+++ 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 and approval by Dean, PGS&R.

@ 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 part-time, the maximum stay limit of 6 semester will be applicable.

# The summer semester will not be considered as a registered semester.
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.

4.12.2 Time limit

In addition to the information in Table 9, the time limits shown in Table 10 apply for Ph.D. work.

4.12.3 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. scholar 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 award.

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

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**Table 10 : Ph.D. Time limits.**

<table>
<thead>
<tr>
<th></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</td>
<td>Time limits for registration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.1</td>
<td>Minimum period of 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>5 years</td>
<td>5 years</td>
</tr>
<tr>
<td>1.3</td>
<td>Extended maximum period of registration</td>
<td>7 years</td>
<td>7 years</td>
</tr>
<tr>
<td>2</td>
<td>Conversion from Full-time to Part-time registration</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Employment outside the Institute – minimum period</td>
<td>3 years, with Dean (PGS&amp;R) approval</td>
<td>3 years, with Dean (PGS&amp;R) approval</td>
</tr>
<tr>
<td>2.2</td>
<td>Employment in a sponsored project in IIT Delhi</td>
<td>One year or Completion of course work and comprehensive, whichever is later</td>
<td>Two years or Completion of course work and comprehensive, whichever is later</td>
</tr>
</tbody>
</table>
4.12.4 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 required to register for a special course with Satisfactory/Unsatisfactory grade. They 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 obtaining a satisfactory grade in this course.

4.12.5 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:

1. 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 BPGS 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 BPGS if it is convinced that the candidate has spent adequate amount of time on research earlier.

2. The academic programme of all the Ph.D. candidates in a department/centre will be coordinated by the DRC/CRC appointed by BPGS&R.

3. 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. If necessary, the Board of Postgraduate Studies & Research on the recommendations of the Supervisor through the DRC/CRC, 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.

4. The DRC/CRC shall meet from time to time and review the progress of each candidate in 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 performance.

5. The progress of each candidate will be monitored by DRC/CRC. 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 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’ grade will be awarded. For the first appearance of ‘U’ grade, a warning would be issued to the candidate by Dean (PGS&R). If his/her performance does not improve after warning, the fellowship may be withheld.

   (f) If there are two consecutive ‘U’s, 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 as per semester schedule.
The above process will continue till the thesis is submitted.

6. The candidate may submit his thesis at any time provided that:
   (a) He/she has completed the minimum period of registration including any extension prescribed by the Board of Postgraduate Studies & Research.
   (b) He/she has completed the course work requirement as prescribed by the DRC/CRC with CGPA 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 and then forwarded to Dean (PGS&R).

7. 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.

8. On receipt of the title and synopsis of a thesis, the Dean (PGS&R) 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 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.

9. Each Examiner will submit a detailed assessment report recommending to the BPGS, 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 after 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 (PGS&R). However, in exceptional circumstances, this period may be extended by the BPGS&R 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 BPGS may, as a special case, appoint another external examiner, if the merit of the case so demands. The examiner will report independently to the BPGS.

10. 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 BPGS for this purpose only.

11. On the completion of all stages of the examination, the Oral Defence Committee shall recommend to the BPGS 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 case (a), the Oral Defence Committee shall also provide to the candidate a list of all corrections and modifications, if any, suggested by the examiners.
12. The degree shall be awarded by the Senate, provided that:
   (a) the Oral Defence Committee, through the BPGS 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, from amongst the same ones submitted by him earlier, 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’s Library and the other is for the Central Library.

13. 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 Right (IPRs) 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, repeat 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.

14. 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.

15. A member of the academic staff who has commenced his research before joining the Institute may, at the discretion of the BPGS and on the recommendation of the Supervisor through the DRC 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.

16. 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.
5. COURSES OF “ENVIRONMENTAL STUDIES” CATEGORY

ESL710   Energy, ecology and environment
ESL720   Energy conservation
ESL722   Integrated energy systems
ESL735   Hazardous waste management
ESL740   Non-conventional sources of energy
ESL745   Environmental audit and impact assessment
ESL777   Environmental science and engineering
ESL776   Industrial energy and environmental analysis
ESL778   Industrial waste management and recycling
ESL756   Energy policy and planning
ESL764   Environmental economics
ESL804   Pollution control in power plants

EEL746   Non-conventional energy systems and energy conservation
CEL736   Environmental dynamics and management
CEL744   Ground water flow and pollution
CEL745   Water management
CEL763   Environmental rock engineering
CEL705   Geo-environmental engineering
CEL714   Special topics in geo technical and geo environmental engineering
CHL724   Environmental engineering and waste management
BEL715   Biological waste treatment
6. POSTGRADUATE PROGRAMME STRUCTURES

The following pages give details of the programme definitions that includes courses in each category, for every M.Sc., M.B.A., M.Des., and M.Tech. programme.

The upper part lists the category-wise credits required, followed by a list of courses in each category.

The table on the lower part shows a typical plan for scheduling the courses. This plan is only suggestive and will vary from student-to-student. Each student is encouraged to make his/her individual plan in consultation with his/her programme coordinator.

<table>
<thead>
<tr>
<th>Programme</th>
<th>Page nos.</th>
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<tbody>
<tr>
<td>Postgraduate Diploma</td>
<td>72 to 73</td>
</tr>
<tr>
<td>Master of Science programmes</td>
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<td>Master of Business Administration programmes</td>
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<td>List of Specialisation Electives</td>
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<td>Master of Design programme</td>
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<td>Master of Technology programmes of departments/centres</td>
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**Postgraduate Diploma in Naval Construction**

Department of Applied Mechanics

The overall credits structure

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<td>AML702 Applied Computational Method</td>
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<td>AML706 Finite Elements Method &amp; Its Application to Marine Structures</td>
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<tr>
<td>AML713 Applied Fluid Mechanics</td>
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<td>AML732 Solid Mechanics</td>
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<tr>
<td>AML733 Dynamics</td>
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<tr>
<td>AML751 Materials for Marine Vehicles</td>
</tr>
<tr>
<td>AML791 Ship Resistance &amp; Propulsion</td>
</tr>
<tr>
<td>AML792 Structural Design of Ships</td>
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<tr>
<td>AML793 Ship Dynamics</td>
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<tr>
<td>AML794 Warship Design</td>
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<td>AML795 Submarine Design</td>
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<td>AML832 Applications of Theory of Plates and Shells</td>
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<tr>
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**Postgraduate Diploma in Naval Construction**

**AMX**

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**TOTAL = 53**
The overall credits structure

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Programme Core (PC)

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<td>CEL769</td>
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<tr>
<td>CEL781</td>
<td>Urban and Regional Transportation Planning</td>
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<tr>
<td>CEP770</td>
<td>Construction Engineering and Information Technology Lab</td>
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<tr>
<td>SML731</td>
<td>Human Resources Management</td>
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<tr>
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Total PC = 36

Programme Electives (PE)

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<td>Management of Quality and Safety in Construction</td>
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<td>CEL774</td>
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<td>CEL778</td>
<td>Public Transportation Systems</td>
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<td>CEL886</td>
<td>Environmental Systems Analysis</td>
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<td>Life Cycle Analysis and Design for Environment</td>
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<td>CEL761</td>
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Total PE = 18

P.G. Diploma in Metro Rail Transport

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TOTAL = 36
# Master of Science in Chemistry

## Department of Chemistry

### The overall credits structure

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### Programme Core (PC)

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<td>Stereochemistry and Organic Reactions</td>
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<td>Main Group Chemistry and Inorganic Solids</td>
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<td>CYL504</td>
<td>Biochemistry I</td>
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<td>CYL505</td>
<td>Instrumental Methods of Analysis</td>
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<td>CYL561</td>
<td>Quantum Chemistry</td>
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<td>Group Theory and Spectroscopy</td>
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<td>Chemistry of Macromolecules</td>
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<td>Selected Topics in Spectroscopy</td>
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<td>Statistical Mechanics and Molecular Simulation Methods</td>
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<td>Biophysical Chemistry I</td>
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<td>Chemistry of Heterocyclic Compounds and Natural Products</td>
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### Semester-wise Breakup

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# Master of Science in Mathematics

## Department of Mathematics

### The overall credits structure

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**Programme Core (PC)**

- MAD703 Project Part 1: 0-0-8 4
- MAD704 Project Part 2: 0-0-8 4
- MAL503 Linear Algebra: 3-1-0 4
- MAL509 Probability Theory: 3-1-0 4
- MAL513 Real Analysis: 3-1-0 4
- MAL517 Differential Equations: 3-1-0 4
- MAL519 Introduction to Computers & Programming: 3-0-2 4
- MAL514 Complex Analysis: 3-1-0 4
- MAL516 Algebra: 3-1-0 4
- MAL518 Methods of Applied Mathematics: 3-1-0 4
- MAL522 Statistical Inference: 3-1-0 4
- MAL524 Numerical Analysis: 3-1-0 4
- MAL526 Computer Oriented Operations Research: 3-0-2 4
- MAL601 Topology: 3-1-0 4
- MAL602 Functional Analysis: 3-1-0 4
- MAL609 Basic Computer Science: 3-0-2 4
- MAL630 Partial Differential Equations: 3-1-0 4
- MAP701 Computing Lab. I: 0-0-4 2
- MAP702 Computing Lab-II: 0-0-4 2

**Total PC**: 45-12-30 72

**Programme Electives (PE)**

- CYL665 Solid State Chemistry: 3-0-0 3
- MAL607 Mathematical Logic: 3-1-0 4
- MAL611 Principles of Fluid Mechanics: 3-1-0 4
- MAL614 Advanced Matrix Theory: 3-1-0 4
- MAL617 Combinational Methods: 3-1-0 4
- MAL621 Computational Methods for Ordinary Differential Equations: 3-1-0 4
- MAL638 Applied Nonlinear Programming: 3-1-0 4
- MAL665 Graph Theory: 3-1-0 4
- MAL668 Programming Languages: 3-1-0 4
- MAL725 Stochastic Processes and Applications: 3-1-0 4
- MAL726 Principles of Optimization Theory: 3-1-0 4
- MAL727 Applied Multivariate Data Analysis: 3-1-0 4
- MAL728 Category Theory: 3-1-0 4
- MAL729 Computational Algebra and its Applications: 3-0-2 4
- MAL730 Cryptography: 3-1-0 4
- MAL731 Introduction to Chaotic Dynamical Systems: 3-1-0 4
- MAL732 Financial Mathematics: 3-1-0 4
- MAL733 Stochastic of Finance: 3-1-0 4
- MAL734 Algebraic Geometry: 3-1-0 4
- MAL735 Number Theory: 3-1-0 4
- MAL737 Differential Geometry: 3-1-0 4
- MAL741 Fractal Geometry: 3-1-0 4
- MAV791 Special Module in Dynamical Systems: 1-0-0 1

### M.Sc. in Mathematics

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**Summer**

- MAL601 Topology: 3-1-0 4
- MAL609 Basic Comp Science: 3-0-2 4
- MAL630 Partial Differential Equations: 3-1-0 4
- MAP701 Computing Lab. 1: 0-0-4 2
- MAD703 Project Part 1*: 0-0-0 4
- MAD704 Project Part 2: (0-0-8) 4
- MAP702 Computing Lab 2: (0-0-4) 2
- PE-1: 0-0-0 4
- PE-2: (3-1-0) 4
- PE-3: (3-1-0) 4
- OE-2: 0-0-0 3

**IV**

- MAL602 Functional Analysis: 3-1-0 4
- MAD704 Project Part 2: (0-0-8) 4
- MAP702 Computing Lab 2: (0-0-4) 2
- PE-1: 0-0-0 4
- PE-2: (3-1-0) 4
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- OE-2: 0-0-0 3

**Total**: 90

**Course List**

1. **MAL503 Linear Algebra**
2. **MAL509 Probability Theory**
3. **MAL513 Real Analysis**
4. **MAL517 Differential Equations**
5. **MAL519 Introduction to Computers & Programming**
6. **MAL514 Complex Analysis**
7. **MAL516 Algebra**
8. **MAL518 Methods of Applied Mathematics**
9. **MAL522 Statistical Inference**
10. **MAL524 Numerical Analysis**
11. **MAL526 Computer Oriented Operations Research**
12. **MAL601 Topology**
13. **MAL602 Functional Analysis**
14. **MAL607 Mathematical Logic**
15. **MAL611 Principles of Fluid Mechanics**
16. **MAL614 Advanced Matrix Theory**
17. **MAL617 Combinational Methods**
18. **MAL621 Computational Methods for Ordinary Differential Equations**
19. **MAL638 Applied Nonlinear Programming**
20. **MAL665 Graph Theory**
21. **MAL668 Programming Languages**
22. **MAL725 Stochastic Processes and Applications**
23. **MAL726 Principles of Optimization Theory**
24. **MAL727 Applied Multivariate Data Analysis**
25. **MAL728 Category Theory**
26. **MAL729 Computational Algebra and its Applications**
27. **MAL730 Cryptography**
28. **MAL731 Introduction to Chaotic Dynamical Systems**
29. **MAL732 Financial Mathematics**
30. **MAL733 Stochastic of Finance**
31. **MAL734 Algebraic Geometry**
32. **MAL735 Number Theory**
33. **MAL737 Differential Geometry**
34. **MAL741 Fractal Geometry**
35. **MAV791 Special Module in Dynamical Systems**

**Programme Code**: MAS
**Programme Code: PHS**

**Master of Science in Physics**

Department of Physics

The overall credits structure

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**Note:** Students are required to take at least one course from each of the streams. A, B and C. Students are NOT allowed to take M.Tech. (PHM) and (PHA) programme courses as Open Electives.

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<tr>
<th>Course Code</th>
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# Independent Study and Selected / Special Topics will be permitted in Semester III or IV only. Students with CGPA of 8.0 and above will be permitted to do this course. It will be counted against a stream depending on the theme of the topics covered in the course.

**M.Sc. in Physics**

**PHS**

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**TOTAL = 90**
Master of Business Administration (Focus on Management Systems)
Department of Management Studies
The overall credits structure

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<th>Category</th>
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**CORE COURSES**

Programme Core (PC)

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Non-credit core (NC)

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**ELECTIVE COURSES**

Cross Focus Elective (FE)

A student must take one of these three courses:

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Specialization Elective (SE)

A student must specialize in one stream; the specialization streams are: Strategic Management, Organization Management, Manufacturing Management, Information Technology Management, Marketing, Finance, Public Sector Management, and Consultancy Management. The courses under each stream are listed on page No. 76.

Students specializing in one particular stream should take 12 credits from that stream; and she/he is allowed to take at most 9 credits from any other stream as open electives. Electives outside the specialization streams also form part of the open electives.

Non-credit Elective (NE)

A student must take one of the courses:

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<th>Contact h/week</th>
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**TOTAL = 72**

M.B.A. (Focus on Management Systems)
### Programme Code: SMT

**Master of Business Administration in Telecommunication Systems Management**

Department of Management Studies

The overall credits structure

<table>
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<tr>
<th>Category</th>
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<th>Non-credit core</th>
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<th>Specialization elective</th>
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<td>12</td>
<td>0</td>
<td>12</td>
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####-core Courses

- **Core Courses**
  - **SMD890** Major Project 0-0-12 6
  - **SML710** Creative Problem Solving 2-0-2 3
  - **SML720** Business Environment and Corporate Strategy 2-0-2 3
  - **SML723** Telecommunication System 3-0-0 3
  - **SML726** Telecom Systems Analysis 3-0-0 3
  - **SML728** International Telecommunication Management 3-0-0 3
  - **SML730** Organization Management 3-0-0 3
  - **SML731** Human Resource Management 3-0-0 3
  - **SML740** Quantitative Methods in Management 2-0-2 3
  - **SML745** Operations Management 3-0-0 3
  - **SML750** Marketing Management 2-0-2 3
  - **SML770** Managerial Accounting and Financial Management 2-0-2 3
  - **SML780** Managerial Economics 2-0-2 3
  - **EEL767** Telecommunication Systems 3-0-0 3

| Total PC | 27-0-24 | 45 |

#### Cross Focus Elective (FE)

- A student must take one of these three courses:
  - **SML700** Fundamentals of Management of Technology 3-0-0 3
  - **SML715** Quality and Environment Management 2-0-2 3
  - **SML802** Management of Intellectual Property Rights 3-0-0 3

#### Specialization Elective (SE)

- A student must specialize in one stream; the specialization streams are: Strategic Management, Organization Management, Manufacturing Management, Information Technology Management, Marketing, Finance, Public Sector Management, and Consultancy Management. The courses under each stream are listed on the page No. 76.

Students specializing in one particular stream should take 12 credits from that stream; and she/he is allowed to take at most 9 credits from any other particular stream as open electives. Electives outside the specialization streams also form part of the open electives.

#### Non-credit Elective (NE)

- **SMT893** Industrial Training -- NC

**TOTAL = 72**

### M.B.A. (Telecommunication Systems Management)

- **SMT**

#### ELECTIVE COURSES

- **Cross Focus Elective (FE)**
  - A student must take one of these three courses:
    - **SML700** Fundamentals of Management of Technology 3-0-0 3
    - **SML715** Quality and Environment Management 2-0-2 3
    - **SML802** Management of Intellectual Property Rights 3-0-0 3

- **Specialization Elective (SE)**
  - A student must specialize in one stream; the specialization streams are: Strategic Management, Organization Management, Manufacturing Management, Information Technology Management, Marketing, Finance, Public Sector Management, and Consultancy Management. The courses under each stream are listed on the page No. 76.

Students specializing in one particular stream should take 12 credits from that stream; and she/he is allowed to take at most 9 credits from any other particular stream as open electives. Electives outside the specialization streams also form part of the open electives.

- **Non-credit Elective (NE)**
  - **SMT893** Industrial Training -- NC

**TOTAL = 72**

### M.B.A. (Telecommunication Systems Management)

- **SMT**

#### Elective Courses

- **Programme Core (PC)**
  - **SMD890** Major Project 0-0-12 6
  - **SML710** Creative Problem Solving 2-0-2 3
  - **SML720** Business Environment and Corporate Strategy 2-0-2 3
  - **SML723** Telecommunication System 3-0-0 3
  - **SML726** Telecom Systems Analysis 3-0-0 3
  - **SML728** International Telecommunication Management 3-0-0 3
  - **SML730** Organization Management 3-0-0 3
  - **SML731** Human Resource Management 3-0-0 3
  - **SML740** Quantitative Methods in Management 2-0-2 3
  - **SML745** Operations Management 3-0-0 3
  - **SML750** Marketing Management 2-0-2 3
  - **SML770** Managerial Accounting and Financial Management 2-0-2 3
  - **SML780** Managerial Economics 2-0-2 3
  - **EEL767** Telecommunication Systems 3-0-0 3

| Total PC | 27-0-24 | 45 |

#### Cross Focus Elective (FE)

- **SMT893** Industrial Training 0-0-0 0

#### Specialization Elective (SE)

- A student must specialize in one stream; the specialization streams are: Strategic Management, Organization Management, Manufacturing Management, Information Technology Management, Marketing, Finance, Public Sector Management, and Consultancy Management. The courses under each stream are listed on the page No. 76.

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#### Non-credit Elective (NE)

- **SMT893** Industrial Training -- NC

**TOTAL = 72**

### Underlined = Compulsory audit; FE = Cross focus elective; SE = Specialization elective; OE = Open elective

---

**Notes:**

- Elective Courses
  - **PC** = Programme Core
  - **CA** = Compulsory Audit
  - **NC** = Non-credit core
  - **FE** = Cross Focus elective
  - **SE** = Specialization elective
  - **NE** = Non-credit elective
  - **OC** = Open elective

- **Total** = 72

- **Sem.**
  - **I**
    - **EEL767** Telecom Syst Management 3-0-0 3
    - **SML730** Organization Mgmt 3-0-0 3
    - **SML740** Quant Meth in Mgmt 2-0-2 3
    - **SML760** Marketing Mgmt 2-0-2 3
    - **SML770** Mngt Accting & Finan Mgmt 2-0-2 3
    - **SML780** Managerial Economics 3-0-0 3
    - **SML791** Computer Laboratory 0-0-2 1
    - **SMV795** Systems Thinking 1-0-0 1
    - **SMV895** Management Research Methodology 1-0-0 1
    - **SMV896** Human Values in Management 1-0-0 1

| Total Compulsory Audit | 5-0-3 | 6.5 |

- **II**
  - **SML720** Bus Environ & Corp Strategy 2-0-2 3
  - **SML723** Telecommunication Systems 3-0-0 3
  - **SML726** Tele Sys Anly Plng & Des 3-0-0 3
  - **SML728** International Tele Mgmt 3-0-0 3
  - **SML731** Human Reso Management 3-0-0 3
  - **SML745** Operations Management 3-0-0 3
  - **SMV793** Stats for Management 3-0-0 1
  - **SMV794** Comm Skills 1-0-0 1

| Total PC | 27-0-24 | 45 |

- **Summer**
  - **SMT893** Industrial Training 0-0-0 0

- **III**
  - **SML710** Creative Prof Solving 2-0-2 3
  - **SMV895** Mgmt Resrch Methodology 1-0-0 1
  - **FE** Cross Focus Elective 3-0-0 3
  - **SE-1** Specialization Elective 3-0-0 3
  - **SE-2** Specialization Elective 3-0-0 3
  - **OE-1** Ope Elective 3-0-0 3
  - **OE-2** Ope Elective 3-0-0 3

| Total PC | 18 |

- **IV**
  - **SMD890** Major Project 0-0-12 6
  - **SMV896** Human Values in Management 3-0-0 3
  - **SMC891** Strat Leader Practice 0-0-2 1
  - **SE-3** Specialization Elective 3-0-0 3
  - **SE-4** Specialization Elective 3-0-0 3
  - **OE-3** Ope Elective 3-0-0 3
  - **OE-4** Ope Elective 3-0-0 3

| Total PC | 18 |

**TOTAL = 72**

---

**Notes:**

- Underlined = Compulsory audit; FE = Cross focus elective; SE = Specialization elective; OE = Open elective

---

**Programme Code: SMT**
### Master of Business Administration in Focus on Technology Management (Part Time)

#### Department of Management Studies

The overall credits structure

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**Note:** Also see the stipulation under Specialization Elective above.

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### Core Courses

<table>
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### Elective Courses

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<td>SML720</td>
<td>Business Environment and Corporate</td>
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### Compulsory Bridge Core Courses (credits not to be counted for SGPA/CGPA calculation)

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<th>Cross Focus Elective</th>
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### M.B.A. in Focus on Technology Management (Part Time)

**SMN**

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### Notes:
- A student must take one of these three courses:
  - SML717 Business Systems Analysis and Design 2-0-2 3
  - SML723 Telecommunications Systems Management 3-0-0 3
  - SML802 Management of Intellectual Property Rights 3-0-0 3

- A student must specialize in one stream; the specialization streams are: Strategic Management, Organization Management, Manufacturing Management, Information Technology Management, Marketing, Finance, Public Sector Management, and Consultancy Management. The courses under each stream are listed on the page No. 76.

- Students specializing in one particular stream should take 12 credits from that stream; and she/he is allowed to take at most 9 credits from any other stream as open electives. Electives outside the specialization streams also form part of the open electives.

- Note: Also see the stipulation under Specialization Elective above.

### Summer

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<td>Buss Env &amp; CS (2-0-2)</td>
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### Winter

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### Spring

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### TOTAL = 72
### LIST OF SPECIALISATION ELECTIVES for SMF, SMT and SMN programmes.

#### Specialization- Strategic Management
- **SML820** Global Business Environment 3-0-0 3
- **SML821** Strategic Management 2-0-2 3
- **SML822** International Business 2-0-2 3
- **SML823** Strategic Change and Flexibility 2-0-2 3
- **SML824** Policy Dynamics and Learning Organization 2-0-2 3
- **SML825** Strategies in Functional Management 3-0-0 3
- **SML826** Business Ethics 3-0-0 3
- **SML827** International Competitiveness 3-0-0 3
- **SML828** Global Strategic Management 2-0-2 3
- **SML829** Current and Emerging Issues in Strategic Management 3-0-0 3

#### Specialization- Organization Management
- **SML830** Organization Structure and Processes 3-0-0 3
- **SML831** Management of Change 2-0-2 3
- **SML832** Managing Innovation for Organizational Effectiveness 3-0-0 3
- **SML833** Organization Development 3-0-0 3
- **SML835** Labour Legislation and Industrial Relations 2-0-2 3
- **SML839** Current and Emerging Issues in Organization Management 3-0-0 3
- **HUL710** Personality Structure and Dynamics 2-1-0 3

#### Specialization- Manufacturing Management
- **SML840** Manufacturing Strategy 3-0-0 3
- **SML843** Supply Chain Logistics Management 3-0-0 3
- **SML844** Systems Reliability, Safety and Maintenance Management 3-0-0 3
- **SML845** Total Project Systems Management 2-0-2 3
- **SML846** Total Productivity Management 3-0-0 3
- **SML849** Current and Emerging Issues in Manufacturing Management 3-0-0 3

#### Specialization- Information Technology Management
- **SML815** Decision Support and Expert Systems 2-0-2 3
- **SML850** Management of Information Technology 3-0-0 3
- **SML851** Database Design and Data Management 2-0-2 3
- **SML852** Network Systems: Application and Management 3-0-0 3
- **SML853** Software Project Management 3-0-0 3
- **SML855** Electronic Commerce 2-0-2 3
- **SML856** Business Intelligence 3-0-0 3
- **SML857** Database Management Information System 3-0-0 3
- **SML859** Current and Emerging Issues in Information Technology Management 3-0-0 3

#### Specialization- Marketing
- **SML861** Market Research 2-0-2 3
- **SML862** Product Management 3-0-0 3
- **SML863** Advertising and Sales Promotion Management 3-0-0 3
- **SML865** Sales Management 2-0-2 3
- **SML866** International Marketing 3-0-0 3
- **SML867** Industrial Marketing Management 3-0-0 3
- **SML869** Current and Emerging Issues in Marketing 3-0-0 3

#### Specialization- Finance
- **SML811** Management Control Systems 3-0-0 3
- **SML870** Advanced Financial Management 2-0-2 3
- **SML871** Accounting for Decision Making 2-0-2 3
- **SML872** Working Capital Management 3-0-0 3
- **SML873** Security Analysis and Portfolio Management 3-0-0 3
- **SML874** Indian Financial System 3-0-0 3
- **SML875** International Financial Management 3-0-0 3
- **SML879** Current and Emerging Issues in Finance 3-0-0 3

#### Specialization- Public Sector Management
- **SML881** Management of Public Sector Enterprises in India 3-0-0 3
- **SML889** Current and Emerging Issues in Public Sector Management 3-0-0 3

#### Specialization- Consultancy Management
- **SML822** International Business 2-0-2 3
- **SML833** Organization Development 3-0-0 3
- **SML845** Total Project Systems Management 2-0-2 3
- **SML897** Consultancy Process and Skill 3-0-0 3
- **SML898** Consultancy and Professional Practices 3-0-0 3
- **SML899** Current and Emerging Issues in Consultancy Management 3-0-0 3

### Open Electives**
- **SML704** Science and Technology Policy Systems 3-0-0 3
- **SML714** Organization Dynamics and Environment 3-0-0 3
- **SML734** Management of Small Scale Industrial Enterprises 3-0-0 3
- **SML783** Management Laboratory 0-0-6 3
- **SML801** Technology Forecasting and Assessment 2-0-2 3
- **SML802** Management of Intellectual Property Rights 3-0-0 3
- **SML803** Technical Entrepreneurship 3-0-0 3
- **SML816** Total Quality Management 2-0-2 3
- **SML817** Management of System Waste 2-0-2 3
- **SML818** Industrial Waste Management 2-0-2 3
- **SML819** Business Process Reengineering 2-0-2 3
- **SML880** Selected Topics in Management 2-0-2 3
- **SML887** Business Law 2-0-2 3

---

35
# Master of Design (Industrial Design)

**Interdisciplinary Programme**

## The overall credits structure

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### Programme Core (PC)

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<td>Framework of Design</td>
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<td>DIP721</td>
<td>Exploratory Product Design Methods</td>
<td>1-0-4</td>
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<td>DIL731</td>
<td>Applied Ergonomics</td>
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<td>DIP781</td>
<td>Engineering Function, Materials and Processes</td>
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<td>DIL782</td>
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<td>Creative Marketing Communication</td>
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<td>Animation</td>
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**TOTAL = 93.5**
# Master of Technology in Engineering Mechanics

## Department of Applied Mechanics

### The overall credits structure

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### M.Tech. in Engineering Mechanics

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Department of Chemical Engineering

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Department of Chemistry

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* Students opting for CYT735 in the summer of the first year register for CYD803 while the others do CYD802.
** CYD804 for students who registered for CYD803 and CYD802 for those who registered for CYD801 in III Semester.
*** Students choose between CYT735 during the summer or CYS801 in the III Semester.

M.Tech. in Molecular Engineering: Chemical Synthesis and Analysis

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*Optional

TOTAL = 60
The overall credits structure

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*To be offered for other specialisations only.

**M.Tech. in Geotechnical and Geoenvironmental Engineering CEG**

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TOTAL = 60

* CED701 (For Part time students only)
## M.Tech. in Rock Engineering and Underground Structures

### Programme Code: CEU

**Department of Civil Engineering**

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**Total PC**: 20-0-50 45

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* To be offered to other specialisations in Civil Engineering.

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#### Semester IV

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**OE-2**: (3-0-0) 3 12

**TOTAL = 60**

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## Master of Technology in Structural Engineering

### Department of Civil Engineering

The overall credits structure

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**Total PC**: 18-3-42

### Programme Electives (PE)

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### M.Tech. in Structural Engineering

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**Total PC** 19-0-42 40

### Programme Electives (PE)

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### Courses

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**Total PC Credits**: 42

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### M.Tech. in Construction Engineering and Management

#### Semester I

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**PE-1**: 6

**Total Semester I Credits**: 18

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<td>Construction Mgmt &amp; Contract Mgmt</td>
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<td>Construction Econ &amp; Finan</td>
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**PE-2**: 5

**Total Semester II Credits**: 21

#### Summer

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**Total Summer Credits**: 6

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**Total Semester III Credits**: 12

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**Total Semester IV Credits**: 24

**TOTAL Credits**: 60
**Master of Technology in Construction Technology and Management**  
Department of Civil Engineering

The overall credits structure

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**Programme Core (PC)**

- CED875 Major Project Part 1 (CEC) 0-0-12 6
- CED876 Major Project Part 2 (CEC) 0-0-24 12
- CEL767 Construction and Contract Management 3-0-0 3
- CEL769 Project Planning and Control 2-1-0 3
- CEL772 Quantitative Methods in Construction Management 2-1-0 3
- CEL773 Management of Quality and Safety in Construction 2-1-0 3
- CEL774 Construction Engineering Practices* 3-0-0 3
- CEL778 Construction Methods and Equipment 3-0-0 3
- CEL779 Construction Economics and Finance 3-0-0 3
- CEP770 Computation Laboratory for Construction Management 0-0-6 3
- EEL792 Power System Protection # 3-0-0 3
- ITL709 Maintenance Planning and Control ** 3-0-0 3

**Total PC** 18-3-42 42

**Programme Electives (PE)**

- CEL612 Construction Methods in Geotechnical Engineering* 3-0-0 3
- CEL616 Systems Design and Value Analysis* 3-0-0 3
- CEL618 Recent Advances in Construction Materials* 3-0-0 3
- CEL771 Civil Engineering Materials* 3-0-0 3
- CEL776 Functional Planning, Building Services and Maintenance Management* 3-0-0 3
- CEL777 Building Science* 3-0-0 3
- CES874 Independent Study (CEC)* 0-3-0 3
- EEL743 Power Electronic Devices and DC Converters# 3-0-0 3
- EEL744 AC Controllers# 3-0-0 3
- EEL745 Electrical Drives System# 3-0-0 3
- EEL746 Nonconventional Energy Systems and Energy Conservation# 3-0-0 3
- EEL747 Electrical Systems for Construction Industries# 3-0-2 4
- EEL790 Optoelectronic Instrumentation## 3-0-0 3
- EEL794 High Voltage DC Transmission## 3-0-0 3
- EEL841 Solid State Controllers of Drives## 3-0-0 3
- EEL749 Special Electromechanical Devices and Systems## 3-0-0 3
- EEL891 Selected Topics in Power System## 3-0-0 3
- EEL899 Distribution Automation## 3-0-0 3
- EEP841 Electrical Machines Laboratory## 0-0-3 1.5
- EEP842 Power Electronics Laboratory## 0-0-3 1.5
- EEP843 Electric Drives Laboratory## 0-0-3 1.5
- ITL752 Bulk Materials Handling** 2-0-2 3
- MEL661 Materials Management** 2-0-2 3
- MEL674 Principles of Management** 3-0-0 3
- MEL710 Air Conditioning** 3-0-2 4
- MEL711 Refrigeration and Air Conditioning Technologies** 3-0-2 4
- MEL752 Quality Assurance** 3-0-2 4
- MEL754 Operations Planning and Control** 3-0-2 4
- MEL778 Design and Metallurgy of Welded Joints** 3-0-2 4
- MEL787 Welding and Allied Processes** 3-0-2 4
- MEL808 Refrigeration Systems and Components Design** 2-0-4 4
- MEL866 Maintenance Management** 3-0-0 3

* For Civil Engg. background students
# For Electrical Engg. background students
** For Mechanical Engg. background students

Note: Students may take a course as OC from the above list of PE courses provided the course is not from their own background.

M.Tech. in Construction Technology and Management

CED875 Major Project Part 1 (CEC) 0

**TOTAL = 60**
Master of Technology in Environmental Engineering and Management
Department of Civil Engineering

The overall credit structure

<table>
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Programme Core (PC)

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Programme Electives (PE)

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TOTAL = 60

M.Tech. in Environmental Engineering and Management

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### Master of Technology in Transportation Engineering

Department of Civil Engineering

The overall credits structure

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**Programme Core (PC)**

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**M.Tech. in Transportation Engineering**

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**TOTAL =62**
### Master of Technology in Computer Science and Engineering

#### Department of Computer Science and Engineering

The overall credits structure

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<td>CSL847</td>
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**Programme Electives (PC)**

- CSL855 Mathematical Foundations of Computing
- CSL856 Mathematical Programming
- CSL857 Randomized Algorithms
- CSL859 Computer Graphics 2
- CSL860 Special Topics in Parallel Computation
- CSL861 Special Topics in Hardware Systems
- CSL862 Special Topics in Software Systems
- CSL863 Special Topics in Theoretical Computer Science
- CSL864 Special Topics in Artificial Intelligence
- CSL865 Special Topics in Computer Applications
- CSL866 Special Topics in Algorithms
- CSL867 Special Topics in High Speed Networks
- CSL868 Special Topics in Data Base Systems
- CSL869 Special Topics in Concurrency
- CSL799 Independent Study
- CSV880 Special Module in Parallel Computation
- CSV881 Special Module in Hardware Systems
- CSV882 Special Module in Software Systems
- CSV883 Special Module in Theoretical Computer Science
- CSV884 Special Module in Artificial Intelligence
- CSV885 Special Module in Computer Applications
- CSV886 Special Module in Algorithms
- CSV887 Special Module in High Speed Networks
- CSV888 Special Module in Database Systems
- CSV889 Special Module in Concurrency
- SIL765 Networks & System Security
- SIV861 Information and Communication Technologies for Development
- SIV864 Special Module in Media Processing and Communication
- SIV896 Special Module in Intelligent Information Processing

A student may opt for a specialization for which the requirements are: (a) project of 18 credits, and (b) 3 to 4 courses in the area of specialization. The areas of specialization are:

- **ii** Computer Networks and Distributed Systems, CSL724, CSL860, CSL867, CSL887, CSL838, CSL730.
- **iii** Algorithms and Complexity, CSL758, CSL705, CSL830, CSL847, CSL851, CSL852, CSL853, CSL854, CSL855, CSL856, CSL857, CSL858, CSL860, CSL863, CSL865.
- **iv** Formal Methods in Software, CSL728, CSL740, CSL750, CSL830, CSL831, CSL832, CSL847, CSL855, CSL862, CSL863, CSL869, CSV889.
- **v** Embedded Systems and Architecture, CSL718, CSL719, CSL812, CSL821, CSL861.
- **vi** Software Systems, CSL740, CSL771, CSL862, CSL865, CSL868, CSL732, CSL730, CSL728.

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- **iii** Algorithms and Complexity, CSL758, CSL705, CSL830, CSL847, CSL851, CSL852, CSL853, CSL854, CSL855, CSL856, CSL857, CSL858, CSL859, CSL860, CSL863, CSL865.
- **iv** Formal Methods in Software, CSL728, CSL740, CSL750, CSL830, CSL831, CSL832, CSL847, CSL855, CSL862, CSL863, CSL869, CSV889.
- **v** Embedded Systems and Architecture, CSL718, CSL719, CSL812, CSL821, CSL861.
- **vi** Software Systems, CSL740, CSL771, CSL862, CSL865, CSL868, CSL732, CSL730, CSL728.

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**M.Tech. in Computer Science and Engineering**

**MCS**

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**TOTAL = 60**
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### M.Tech. in Communications Engineering

#### Course Timetable

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**Total PC** 12-0-56 40

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**M.Tech. in Computer Technology**

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Programme Code : EET
M.Tech. in Control and Automation

**Programme Code:** EEA

Department of Electrical Engineering

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**M.Tech. in Control and Automation**

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# Master of Technology in Integrated Electronics and Circuits

Department of Electrical Engineering

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**TOTAL =60**
## Programme Code: EEP

**Master of Technology in Power Electronics, Electrical Machines and Drives**
Department of Electrical Engineering

The overall credits structure

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**Total PC: 18-0-48 42**

**Programme Electives (PE)**

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**TOTAL = 60**

### M.Tech. in Power Electronics, Electrical Mechanics and Drives

**EEP**

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*Ind. Training and seminar (EEP)

#Students opting for OE-1 in I Sem should take PE-1 in II Sem and vice versa
# Programme Electives (PE)

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# Credits Structure

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**TOTAL = 61**
**Master of Technology in Mechanical Design**

Department of Mechanical Engineering

The overall credits structure

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**Programme Core (PC)**

MEL731 Analytical Dynamics  
MEL732 Advanced Mechanical Design  
MEL733 Vibration and Noise Engineering  
MEL734 Instrumentation and Automatic Control Systems  
MEL735 CAD and Finite Element Analysis  
MEL739 Mechanics of Robots  
MEL742 Optimum Design of Mechanical Systems  
MEL831 Major Project Part 1 (MEM)  
MEL832 Major Project Part 2 (MEM)

Total PC: 21-0-48 45

**Programme Electives (PE)**

List A1:
- Design Elective
- MEL736 Automotive Design  2-0-2 3
- MEL737 Machine Tool Design  3-0-2 4
- MEL743 Plant Equipment Design  3-0-0 3
- MEL744 Design for Manufacture and Assembly  3-0-2 4
- MEL746 Design for Noise Vibration and Harshness  3-0-2 4
- MEL748 Tribological Systems Design  3-0-2 4
- MEL749 Mechatronic Product Design  2-0-2 3
- MEL750 Biomechanics of Trauma and Automotive Design  3-0-0 3
- MEL844 Designing with New Materials  3-0-0 3
- MEL849 Special Topics in Systems Design  3-0-0 3

List A2:
- Equipment Design Elective
- MEL738 Dynamics of Multibody Systems  2-0-2 3
- MEL740 Lubrication  3-0-0 3
- MEL745 Advanced Robotics  2-0-2 3
- MEL830 Independent Study (MED)  0-3-0 3
- MEL834 Vibroacoustics  2-0-2 3
- MEL835 Special Topics in Design Analysis  3-0-0 3
- MEL837 Advanced Mechanisms  2-0-2 3
- MEL838 Rotor Dynamics  3-0-2 4
- MEL840 Experimental Modal Analysis and Dynamic Design  2-0-2 3

[Any three courses should be chosen with at least one each from the categories A1 and A2 below (9-11 credits)]

**M.Tech. in Mechanical Design**

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*Course numbers are tentative and are likely to change.
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### M.Tech. in Industrial Engineering

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**TOTAL = 60**
# Master of Technology in Production Engineering

Department of Mechanical Engineering

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## Course Breakdown

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Master of Technology in Thermal Engineering
Department of Mechanical Engineering

The overall credits structure

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Programme Core (PC)

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Programme Electives (PE)

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M.Tech. in Thermal Engineering

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TOTAL = 60-62

59
Master of Technology in Applied Optics
Department of Physics

The overall credits structure

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M.Tech. in Applied Optics

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TOTAL = 60
**Master of Technology in Solid State Materials**

Department of Physics

The overall credits structure

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**Total PE**

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**TOTAL = 60**
**Master of Technology in Fiber Science and Technology**

Department of Textile Technology

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**M.Tech. in Fiber Science and Technology**

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**TOTAL = 60**
# Master of Technology in Textile Engineering

Department of Textile Technology

## The overall credits structure

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## M.Tech. in Textile Engineering

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**TOTAL = 60**
## Programme Code: CRF

### Master of Technology in Radio Frequency Design and Technology
Centre for Applied Research in Electronics

The overall credits structure

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**Programme Core (PC)**

| Course Code | Course Title                                      | Lectures | T-P | Contact h/week |
|-------------|--------------------------------------------------) |----------|-----|----------------|
| CRD811      | Major Project Part 1 (CRF)                        | 0-0-12   | 6   | 15 10 25      |
| CRD812      | Major Project Part 2 (CRF)                        | 0-0-24   | 12  |               |
| CRL702      | Architectures and Algorithms for DSP Systems      | 2-0-4    | 4   |               |
| CRL711      | CAD of RF and Microwave Devices                   | 3-0-2    | 4   |               |
| CRL713      | Fundamentals of RF Electronics                     | 2-0-2    | 3   |               |
| CRL724      | RF and Microwave Measurement System Techniques    | 3-0-0    | 3   |               |
| CRP718      | RF and Microwave Measurement Laboratory            | 0-0-6    | 3   |               |
| CRP723      | Fabrication Techniques for RF and Microwave Devices | 1-0-4   | 3   |               |
| EEL762      | Digital Communication                             | 3-0-0    | 3   |               |

**Total PC** 14-0-54 41

**Programme Electives (PE)**

| Course Code | Course Title                                      | Lectures | T-P | Contact h/week |
|-------------|--------------------------------------------------) |----------|-----|----------------|
| CRD802      | Minor Project (CRF)                               | 0-0-6    | 3   |                |
| CRL704      | Sensor Array Signal Processing                     | 3-0-0    | 3   |                |
| CRL705      | Advanced Sensor Array Signal Processing            | 3-0-0    | 3   |                |
| CRL707      | Human and Machine Speech Communication             | 3-0-0    | 3   |                |
| CRL712      | RF and Microwave Active Circuits                   | 3-0-0    | 3   |                |
| CRL715      | Radiating Systems for RF Communications            | 3-0-0    | 3   |                |
| CRL720      | SAW Devices and Applications                       | 3-0-0    | 3   |                |
| CRL721      | Analog/RF IC Modelling and Design                  | 2-0-2    | 3   |                |
| CRL722      | RF and Microwave Solid State Devices               | 3-0-0    | 3   |                |
| CRL725      | Technology of RF and Microwave Solid State Devices | 3-0-0    | 3   |                |
| CRL726      | RF MEMS Design and Technology                      | 3-0-0    | 3   |                |
| CRL728      | RF Electronic System Design Techniques             | 3-0-0    | 3   |                |
| CRL731      | Selected Topics in RFDT 1                          | 3-0-0    | 3   |                |
| CRL732      | Selected Topics in RFDT 2                          | 3-0-0    | 3   |                |
| CRL733      | Selected Topics in RFDT 3                          | 3-0-0    | 3   |                |
| CRL737      | Selected Topics in Radars and Sonars               | 3-0-0    | 3   |                |
| CRS735      | Independent Study (CRF)                            | 0-3-0    | 3   |                |
| EEL711      | Signal Theory                                     | 3-0-0    | 3   |                |
| EEL731      | Digital Signal Processing-1                       | 3-0-0    | 3   |                |
| EEL765      | Sonar Systems Engineering                          | 3-0-0    | 3   |                |
| EEL768      | Detection and Estimation Theory                    | 3-0-0    | 3   |                |
| IDL712      | Electronic Techniques for Signal Conditioning and Interfacing | 3-0-0 | 3 | |

M.Tech. in Radio Frequency Design and Technology

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Summer

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| III | CRD811 Major Proj Part 1 (CRF) *(0 - 0 - 12) 6* |
| IV  | CRD812 Major Proj Part 2 (CRF) *(0 - 0 - 24) 12* |

| PE-5 *(3 - 0 - 0) 3* | OIE-2 *(3 - 0 - 0) 3* | 2 | 6 | 0 | 12 | 18 |

| OIE-2 *(3 - 0 - 0) 3* | 0 | 0 | 24 | 24 |

**TOTAL = 62**

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64
# Master of Technology in Atmospheric-Oceanic Science and Technology

## Centre for Atmospheric Sciences

The overall credits structure

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### Programme Core (PC)

- **ASL701** Dynamics of Atmosphere and Ocean 3-0-0 3
- **ASL703** Physics of Atmosphere and Ocean 3-0-0 3
- **ASL705** Boundary Layer Meteorology and Air Pollution 3-0-0 3
- **ASL706** Parameterization of Physical Processes 3-0-0 3
- **ASP751** Simulation L-I: Weather Analysis & Forecasting 0-0-4 2
- **ASP752** Simulation L-II: Obj. Analysis & Data Assimilation 0-0-6 3
- **ASP801** Simulation L-III: Ocean-Atmosphere Forecast Methodology 0-1-4 3
- **ASL808** Atmospheric Chemistry & Aerosols 3-0-0 3
- **ASD891** Major Project Part – 1 0-0-12 6
- **ASD892** Major Project Part – 2 0-0-24 12
- **ASC861** Atmospheric Science Colloquium 0-1-0 1

**Total PC** 15-2-50 42

### Programme Electives (PE)

- **ASL707** Mathematical and Statistical Methods in Atmospheric Sciences 3-0-0 3
- **ASL712** Air-Sea Interaction 3-0-0 3
- **ASL715** Science of Climate Change 3-0-2 4
- **ASL718** Tropical Meteorology 3-0-0 3
- **ASL720** Satellite Meteorology and Remote Sensing 3-0-0 3
- **ASL722** Biological Oceanography 3-0-0 3
- **ASL724** Atmospheric Diffusion and Air Pollution 3-0-0 3
- **ASL803** Advanced Dynamic Oceanography 3-0-0 3
- **ASL804** Air Pollution Monitoring and Health Risk Assessment 2-0-2 3
- **ASL813** Climate Variability 3-0-0 3
- **ASL814** Modelling of Dynamic Processes of Oceans and Atmosphere 3-0-0 3
- **ASL815** Marine Pollution and Coastal Zone Management 3-0-0 3

### M.Tech. in Atmospheric-Oceanic Science and Technology

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**TOTAL = 62**
Master of Technology in Computer Applications
Interdisciplinary Programme

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Note : # Courses for non-CS background students.  * Courses for CS background students.

Programme Electives (PE)

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M.Tech. in Computer Applications

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TOTAL = 60

Programme Code: JCA
### Master of Technology in Energy Studies

**Interdisciplinary Programme**

#### The overall credits structure

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**Total PC 21-0-42 42**

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**TOTAL = 60**

### Notes

- The overall credits structure includes both Programme Core (PC) and Programme Electives (PE) courses.
- The total credits for the programme are 60.
- Courses are offered in different semesters as indicated.

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**Programme Code:** JES
### Master of Technology in Energy and Environment Management

#### Interdisciplinary Programme

The overall credits structure

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# For Non-Mechanical Engineering

* For Non-Electrical Engineering

+ For Non-Chemical/Environmental engineering students

#### Module-wise courses (included in PC)

A student must take all courses from one of the four modules:

- **Module – A**
  - ESL776 Industrial Energy and Environmental Analysis 3-0-0 3
  - ESL778 Industrial Waste Management and Recycling 3-0-0 3
  - ESL784 Cogeneration and Energy Efficiency 3-0-0 3

- **Module – B**
- **Module – C**
- **Module – D**

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PC-M1, PC-M2 and PC-M3 and PC-M4 are four course sets from Module A, B, C or D as part of programme core.

#### Interdisciplinary Programme

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JND802 Major Project Part 2 (JEN) 0-0-12 6

#### Module-wise courses (included in PC)

- **Module – B**
- **Module – C**
- **Module – D**

#### Module-wise courses

A student must take all courses from one of the four modules:

- **Module – A**
  - ESL776 Industrial Energy and Environmental Analysis 3-0-0 3
  - ESL778 Industrial Waste Management and Recycling 3-0-0 3
  - ESL784 Cogeneration and Energy Efficiency 3-0-0 3

- **Module – B**
- **Module – C**
- **Module – D**

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PC-M1, PC-M2 and PC-M3 and PC-M4 are four course sets from Module A, B, C or D as part of programme core.

#### Interdisciplinary Programme

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#### Programme Core (PC)

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JND802 Major Project Part 2 (JEN) 0-0-12 6

#### Module-wise courses (included in PC)

- **Module – B**
- **Module – C**
- **Module – D**

#### Module-wise courses

A student must take all courses from one of the four modules:

- **Module – A**
  - ESL776 Industrial Energy and Environmental Analysis 3-0-0 3
  - ESL778 Industrial Waste Management and Recycling 3-0-0 3
  - ESL784 Cogeneration and Energy Efficiency 3-0-0 3

- **Module – B**
- **Module – C**
- **Module – D**

#### Programme Electives (PE)

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PC-M1, PC-M2 and PC-M3 and PC-M4 are four course sets from Module A, B, C or D as part of programme core.
### Master of Technology in Industrial Tribology and Maintenance Engineering

#### Interdisciplinary Programme

**The overall credits structure**

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*Total PC* 21-0-44 42

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**M.Tech. in Industrial Tribology and Maintenance Engineering**

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**Master of Technology in Instrument Technology**  
Interdisciplinary Programme

The overall credits structure

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Programme Core (PC)

- **IDP703** Instrument Technology Laboratory 1 0-0-6 3
- **IDP704** Instrument Technology Laboratory 2 0-0-6 3
- **IDP705** Advanced Instrument Technology Laboratory 0-0-8 4
- **IDL711** Instrumentation Transducers 3-0-0 3
- **IDL712** Electronic Techniques for Signal Conditioning and Interfacing 3-0-0 3
- **IDL714** Instrument Design and Simulations 2-0-2 3
- **IDL734** Laser Based Instrumentation 3-0-0 3
- **JTD801** Major Project Part 1 (JID) 0-0-12 6
- **JTD802** Major Project Part 2 (JID) 0-0-24 12
- **Total PC** 11-0-58 40

Programme Electives (PE)

- **AML710F** Computer Aided Design 3-0-2 4
- **IDL713** Advanced Electronic Components and Circuits 3-0-0 3
- **IDL716** Quality Control and Standardization 3-0-0 3
- **IDL720N** Independent Study 0-3-0 3
- **IDL721N** Material and Mechanical Design 3-0-2 4
- **IDL722** Precision Measurement Systems 3-0-0 3
- **IDL724** Advanced Fabrication and Finishing 3-0-0 3
- **IDL730** Photochemical Machining 2-0-2 3
- **IDL731** Optical Components and Basic Instruments 3-0-0 3
- **IDL732** Optical Material and Techniques 3-0-0 3
- **IDL735** Scientific and Engineering Applications of Moiré Patterns 2-0-2 3
- **EEL736** Medical Electronics 3-0-0 3
- **IDL741** Instrument Organization and Ergonomics 2-0-2 3
- **IDP742** Industrial Design Practice 1-0-4 3
- **PHL754** Optical Instrumentation and Metrology 3-0-0 3
- **IDL811** Selected Topics in Instrumentation 3-0-0 3
- **IDC812** Term Paper and Seminar (JID) 0-3-0 3
- **EEL801** Microprocessor Based System Design 3-0-0 3
- **MEL731N** Design of Mechanism and Manipulators 3-0-2 4
- **MEL788F** Industrial Inspection 3-0-1 3.5
- **PHL790** Integrated Optics (PH) 3-0-0 3

M.Tech. in Instrument Technology

**JID**

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**TOTAL = 61**
**Programme Code: JOP**

**Master of Technology in Optoelectronics and Optical Communication**

Interdisciplinary Programme

The overall credits structure

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**M.Tech. in Optoelectronics and Optical Communication**

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**TOTAL = 60**
**Master of Technology in Polymer Science and Technology**

Interdisciplinary Programme

The overall credits structure

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**Total PC** 20-0-44 42

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**M.Tech. in Polymer Science and Technology**

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**TOTAL = 60**
**Master of Technology in VLSI Design Tools and Technology**

Interdisciplinary Programme

Overall credits structure of the two streams

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**Total PC** 3-0-42 24

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**Programme Electives (PE)**

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**VLSI Design Stream**

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**VLSI Systems Stream**

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73
### Master of Technology in Power Generation Technology

#### Interdisciplinary Programme

The overall credits structure

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#### Note

# for C&I; * for EE; + for ME

TOTAL = 61
### Interdisciplinary Programme

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M.Tech. in Telecommunication Technology and Management

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**TOTAL = 60**
7. 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 there are not mentioned, the default pre-requisites shall be applicable for UG students (see sections 2.6 and 3.12).

For additional information see the website or contact the concerned course coordinator or head of the department/centre/school/programme coordinator.
AML700 Experimental Methods for Solids and Fluids
4 credits (3-0-2)
Basic principles of experimental analysis, strain gauges and strain gauge circuits. Rosettes. Photoelasticity. Brittle coating method. Moire fringe methods, holography, etc.

AML701 Engineering Mathematics & Mechanics
3 credits (3-0-0)

AML702 Applied Computational Methods
4 credits (3-0-2)

AML704 Flow of Non-Newtonian Fluids and Complex Mixtures
3 credits (3-0-0)

AML705 Finite Element Methods
4 credits (3-0-2)
Pre-requisites: AML140 / AML150 / AML160 / AML170 / AML180 / CHL231 / CHL204
Overlaps with: MAL381

AML706 Finite Element Methods and its Applications to Marine Structures
3 credits (3-0-0)

AML710 Computer Aided Design
4 credits (3-0-2)
Pre-requisites: EC 60
Overlaps with: MEL414

AML711 Advanced Fluid Mechanics
4 credits (3-1-0)

AML712 Numerical Methods in Fluid Flows
3 credits (3-0-0)
Review of numerical methods. Application of finite difference methods to different fluid flows such as inviscid flow, boundary layer development flow through fluid machines etc. Introduction of finite element methods, different approaches for deriving element equation. Application to different fluid flow situations.

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.

AML714 Fluid Flow Analysis and Applications to Power Plants
3 credits (3-0-0)

AML715 Viscous Fluid Flow
3 credits (3-0-0)

AML730 Reliability Engineering for Power Plants
3 credits (3-0-0)
using existing quality components, weight, volume and other constraints, Allocation of failure and repair rates. Availability, Instantsaneous, average uptime and steady state availability, Maintainability concepts. Good as new and bad as old concepts.

**AML731 Applied Elasticity**  
4 credits (3-1-0)  

**AML732 Solid Mechanics**  
3 credits (3-0-0)  

**AML733 Dynamics**  
3 credits (3-0-0)  

**AML734 Advanced Dynamics**  
4 credits (3-1-0)  

**AML750 Modern Engineering Materials**  
3 credits (3-0-0)  

**AML751 Materials for Marine Vehicles**  
3 credits (3-0-0)  

**AML771 Decision Theory and Design Optimization**  
3 credits (3-0-0)  

**AMP772 Feasibility Study**  
3 credits (1-0-4)  
This is a short project to be completed in one semester wherein a student will carry out a feasibility study for the manufacture of a given product.

**AML773 Modelling & Analysis-I**  
3 credits (3-0-0)  

**AML774 Modelling & Analysis-II**  
3 credits (3-0-0)  

**AML775 Design Methods**  
3 credits (3-0-0)  
Design problem and design process. Place of design activity in the production- consumption cycle. Design cycle including need analysis. Feasibility study, preliminary design, detailed design and planning for complete production-consumption cycle.

**AMP776 Product Design Project I**  
3 credits (1-0-4)  
**AMP777 Product Design Project II**  
2 credits (0-0-4)  
The above two courses would be run in successive semesters. The combined project work would comprise the following: Application of systematic design procedure for the design of a chosen industrial product. Students are expected to carry out all the three phases of the design cycle including fabrication and testing. Lectures will deal with ergonomic factors in product design.

**AML791 Ship Resistance & Propulsion**  
3 credits (3-0-0)  

**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)  
AML924 Warship Design
3 credits (3-0-0)

AML925 Submarine Design
3 credits (3-0-0)

AMS801 Independent Study
3 credits (0-3-0)

AMS802 Independent Study
3 credits (0-3-0)

AML803 Continuum Mechanics
3 credits (3-0-0)

AML805 Advanced Finite Element Methods
3 credits (3-0-0)

AMD811 Major Project Part-I
6 credits (0-0-12)

AML811 Advanced Computational Fluid Dynamics
3 credits (3-0-0)
Transport equation in rotating reference frame, finite volume methods including higher order upwinding, grid generation, Galerkin & upwind finite-element methods, considerations in discretization of turbulence models, rotating reference frame, hybrid methods gridding methods, multigrid method, special topics chosen from phase change problem, two-phase flow, compressible flow and numerical simulation.

AMD812 Major Project Part-II
12 credits (0-0-24)

AML812 Turbulent Shear Flows
3 credits (3-0-0)

AMD813 Major Project Part-I
6 credits (0-0-12)

AML813 Impeller Pumps
3 credits (3-0-0)

AML814 Fluid Transportation Systems
3 credits (3-0-0)

AML815 Hydrodynamic Stability
3 credits (3-0-0)

AML816 Compressible Fluid Flow and Gas Dynamics
3 credits (3-0-0)

AML820 Advances in Fluid Engineering
3 credits (3-0-0)
A course on any advanced topic in the area of Fluid Engineering may be floated under this number.

AML821 Flow Induced Vibrations
3 credits (3-0-0)

AML831 Theory of Plates and Shells
3 credits (3-0-0)

AML832 Applications of Theory of Plates and Shells
2 credits (2-0-0)

AML833 Applied Plasticity
3 credits (3-0-0)

AML834 Structural Stability
3 credits (3-0-0)
Types of instability, static, dynamic and energy criterion of buckling. Imperfection sensitive structures. Applications to columns, beams, plates and shells. Follower forces, non-conservative loads.
AML835 Mechanics of Composite Materials
3 credits (3-0-0)

AML836 Non-linear Vibration and Chaos
3 credits (3-0-0)
Prerequisite: AML701/AML734/CEL719/MEL733

AML837 Structural Mechanics
3 credits (3-0-0)

AML838 Non-linear Systems
3 credits (3-0-0)

AML840 Advances in Solid Mechanics
3 credits (3-0-0)
An advanced course on any specialized topic in the area of Solid Mechanics may be given under this number. The course content will be announced by the teacher. An advanced course on any specialized topic in the area of Solid Mechanics may be given under this number. The course content will be announced by the teacher.

AML841 Advanced Theory of Elasticity
3 credits (3-0-0)

AML851 Fracture Mechanics
3 credits (3-0-0)

AML852 Engineering Failure Analysis and Prevention
3 credits (3-0-0)

AML854 Advances in Physical Metallurgy
3 credits (3-0-0)
Recent developments in phase transformations. Phase equilibrium in ternary alloys. Fracture resistant design.

AML855 Solid State Phase Transformations
3 credits (3-0-0)
Classification of solid state phase transformations. Nucleation and growth concepts. Spinal decomposition. Specific transformations such as martensitic, polymorphic, re-crystallization, particle coarsening, etc. Crystallographic aspects of phase transformations.

AML856 Electron Metallography and Electron Diffraction
3 credits (3-0-0)

AML857 Quantitative Metallography
3 credits (3-0-0)

AML871 Product Reliability and Maintenance
3 credits (3-0-0)

AML872 Optimization Techniques
3 credits (3-0-0)

AML873 Design for Production
3 credits (3-0-0)

AML874 Critical Product Evaluation
3 credits (3-0-0)
Value analysis. Quality standards in electronic, optical, mechanical and other products. Critically examining product literature, raising questions, filling gaps in information and discovering hidden details from product literature. Identifying areas of design action by identifying limitations in existing products and gaps in market segment. Examining an existing product for appreciation and detailing.

AML883 Properties and Selection of Engineering Materials
3 credits (3-0-0)
Properties and uses of ferrous and non-ferrous metals, ceramics and polymers in product design.

AMD895 Major Project (M.S. Research)
40 credits (0-0-80)

AMD897 Minor Project
3 credits (0-0-6)

AMD899 Design Project
10 credits (0-0-20)
BEL701 Biotechnology Resource Planning and IPR Issues
2 credits (2-0-0)
Pre-requisites: BEL401 & BEL403
Economic, social and product benefits of modern biotechnology; Resource base for process biotechnology; Typical stages in commercialization of process/product; Commercial and financial aspects of bioprocessing; Financial appraisal of bioprocessing projects.

TRIPS agreement; IPR issues in relation to biotech products/processes; Architecture of Patent application.

Alternative models of technology transfer and licensing; Good manufacturing practices; Funding mechanisms of commercial projects.

Biosafety Principles - environment and health risk assessment; biosafety regulatory guidelines and controlling agencies, Environmental law for hazardous microorganisms and GMOs; Biotechnology Related Issues of Public Concern - Bioethics.

BEL702 Bioprocess Plant Design
5 credits (3-0-2)
Pre-requisites: AML110 & MEL110 & CHL203 & CHL204 & BEL401 and EC 90
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 of fermenters; 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; Design of facilities for cleaning of process equipment used in biochemical 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.

BEL703 Downstream Processing in Biotechnology
5 credits (3-0-2)
Pre-requisites: BEL301 & BEL401
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 electro dialysis, Electrophoresis, Crystalization, Drying.

Laboratory: Conventional filtration, centrifugation in batch and continuous centrifuge, Cell disruption, Ion-exchange chromatography, Membrane based filtration- ultrafiltration in cross flow modules and microfiltration.

BEL711 Recombinant DNA Technology
4 credits (2-0-2)
Pre-requisites: BEL204
Restriction and modification phenomena, Other enzymes used in rDNA research, Plasmid, l phage, M13 biology, Vectors – plasmid, phage, phagemid, Cosmid, Expression vectors, Construction of libraries, DNA Sequencing, PCR, Genome mapping, Stability of recombinant cells in the production of biochemicals.

BEL712 Plant Cell Technology
3 credits (2-0-2)
Pre-requisites: BEL301

Laboratory: Development of callus and suspension cultures of plant cells; shear sensitivity; growth and product formation kinetics in suspension cultures; production of secondary metabolites in bioreactors using suspension cultures / immobilized cells; development of hairy root cultures.

BEL713 Microbial Engineering
3 credits (3-0-0)
Pre-requisites: BEL403
Non-ideality and RTD in bioreactors; stability analysis; analysis of multiple interacting microbial populations; stability of recombinant cells; physiology of immobilised cells; special reactors for animal and plant cells; integrated systems of bioreaction and bioseparation; biosensors.

BEL714 Protein Science and Engineering
3 credits (3-0-0)
Pre-requisites: BEL204
Introduction-Definition, Aims; Basic structural principles of proteins-amino acids, Motifs of protein structure and their packing: alpha domain, beta/parallel b structures; Protein folding and assembly – protein folding pathways in prokaryotes and eucaryotes; Folding of BPTI, 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; X-ray and NMR analysis of proteins-basic principles; Drug-protein interactions and design, Rational protein design.

BEL715 Biological Waste Treatment
4 credits (3-0-2)
Pre-requisites: BEL301
Qualitative and quantitative characterization of wastes; Waste disposal norms and regulations; Indian regulations; Principles of biological treatment; Aerobic and anaerobic biological wastewater treatment systems; Suspended and attached cell biological wastewater treatment systems; Biological nutrient removal; Treatment plant design calculations; Treatment and disposal of sludges; biological means for stabilization and disposal of solid wastes; Treatment of hazardous and toxic wastes; Degradation of xenobiotic compounds; bioremediation.

Laboratory: Characterization of wastes; Design calculations for various types of wastes using various types of biological processes.

BEL716 High Resolution Methods in Biotechnology
3 credits (2-0-2)
Pre-requisites: BEL301
Need for high resolution separation for biologicals; Difficulties with traditional methodologies; Affinity precipitation and partitioning; MF/ UF/NF for high resolution separation; chromatography techniques; Affinity chromatography and electrophoresis, Separation by gene amplification (PCR), Molecular imprinting.

BEL717 Animal Cell Technology
4 credits (3-0-2)
Characterization of animal cell, metabolism, regulation and nutritional requirements; Kinetics of cell growth and product formation and effect of shear force; Product and substrate transport; Perfusion bioreactors, hollow fiber bioreactor, operational strategies and integrated approach; Micro and macro carrier culture; Hybridoma technology; Genetic engineering in animal cell culture; Scale-up and large scale operation; Case studies.

Laboratory: Cell culture in static phase (T-flask), quantification of cell growth, monolayer culture, determination of critical shear stress, micro carrier and perfusion culture, product formation.

BEL718 Combinatorial Biotechnology
3 credits (3-0-0)
Pre-requisites: BEL204
Introduction, solid phase synthesis, solution phase synthesis.

**BEL719 Current Topics in Biochemical Engineering and Biotechnology**
3 credits (3-0-0)
Pre-requisites: BEL403
Topics of current interest in various areas of Biochemical Engineering and Biotechnology will be covered. The faculty offering the course will specify the contents at the time of offering.

**BEL720 Biotechnology in Food Processing**
3 credits (3-0-0)
Pre-requisites: BEL301
Microbial role in food process operations and production; new protein foods-SCP, mushroom, food yeasts, algal proteins; fermentation as a method of preparing and preserving foods. Food additives like colouring, flavours and vitamins. Organisms and their use in pickling, producing colours and flavours, alcoholic beverages and other products. Mechanism of enzyme functions and reactions in process techniques-starch and sugar conversion processes, baking by amylases, deoxygenation and desugaring by glucose oxidase, beer mashing and chill-proofing cheese making by proteases and various other enzyme catalytic actions in food processing. Process wastes-whey, molasses, starch substrates and other food wastes for bioconversion to useful products, Genetically Modified Food.

**BEL721 Bionanotechnology**
3 credits (3-0-0)
Pre-requisites: BEL101 and EC 60
Introduction; Scanning probe microscopy (SPM), Self-assembly of biomolecules in nanotechnology; Tailoring nanometer scale objects to mimic and interact with natural materials; Biological nanomaterials and biomimetic machinery; Molecular motors: natural molecular motors like kinesin, dynein, flagella, RNA and DNA helicases, topoisomerases; Ion channels as molecular switches; patch clamp technique; Photoreceptors as single photon optical detector; Manipulating redox systems application in nanotechnology; Microfabricated devices in biotechnology e.g. micro reactors; Protein array technology; Exploiting enzymes in bionanotechnology; Nanoscale devices for biosensors, Biodegradable nanoparticles for drug and gene delivery to cells and tissues.

**BEL722 Genomics and Proteomics**
3 credits (3-0-0)
Pre-requisites: BEL204
Genomics and proteomics- introduction, DNA sequencing, DNA fingerprinting, ESTs and SNPs, Application in pharmacogenomics, Structural and functional genomics, DNA microarrays and expression profiling, protein isolation and purification, protein expression – methodologies, proteome analysis – various techniques, 2D gel electrophoresis, FPLC, MALDI-TOF etc., Protein structure determination.

**BEL723 Data Analysis for DNA Microarrays**
4 credits (3-0-2)
Pre-requisites: BEL204
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.

**BEL724 Advanced Biochemistry**
3 credits (3-0-0)
Pre-requisites: BEL204
Overview of carbohydrate and fatty acid metabolism and linkage to Bioenergetics, Biosynthesis of Amino acids, Protein Synthesis and Targeting, Protein Degradation and turnover, Enzymatic reaction mechanism and role of transition metal ions, Allosteric transitions and cellular controls, Signal Transduction, Peptide synthesis and peptide sequencing, Protein folding and stabilization, Molecular chaperones and neurodegenerative disorders, and Biosynthesis of Lipids and nucleotides.

**BEC750 Seminar (BB)**
1 credit (1-0-0)
Pre-requisites: EC 165

**BED800 Major Project**
40 credits (0-0-80)
This involves research component of the M.S degree requirement. An R&D project covering literature, experimental and analytical work over two/three semesters.

**BEL810 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.

**BEL820 Downstream Processing**
3 credits (3-0-0)
Characteristics of biological materials; Pretreatment; Microbial separation: Centrifugation and filtration, Cell disruption methods, Protein precipitation, Extraction, Adsorption, Electrophoresis, Chromato-graphy, Ultrafiltration, Reverse osmosis, Isoelectric focussing, Affinity based separations, Case Studies.

**BEL830 Microbial Biochemistry**
3 credits (3-0-0)
Structure and function of biomolecules aminoacids, 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-feed back inhibition, induction, catabolite repression; Nucleic acid and protein biosynthesis.

**BEP840 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.

**BEL850 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
Department of Chemical Engineering

CHL603 Advanced Transport Phenomena
3 credits (3-0-0)

CHL604 Fluid Solid Reaction Engineering
4 credits (3-0-2)

CHL626 Multi Phase Contactors
3 credits (3-0-0)

CHL634 Management of R&D in Chemical Industries
3 credits (3-0-0)

CHL653 Application of Programming in Chemical Engineering
4 credits (3-0-2)
Basic concept of OOP using C++, elements of C++ language, variables and constants, data types, operators, control statements, functions, reference variables and arguments, classes and objects, constructors and destructors, operator overloading, data and type conversions, derived classes and inheritance, pointers, virtual functions, streams, templates.

Elements of visual C++, dialogs and controls, Messages and commands, documents and views, reading and writing file, working with menus, bars and toolbars, common controls, multitasking with windows threads, building an ActiveX control, creating an ODBC Database access.

CHL702 Plant Design
4 credits (3-0-2)
Pre-requisites: CHL471
Plant layout, auxiliaries, materials handling, offsite facilities, selection and detailed design of equipments, e.g., mixers, conveyers, heat exchangers, separation equipments, pumps, compressors, etc.

CHL704 Polymer Composite Process Modelling
4 credits (3-1-0)
Introduction to Chemical Engineering principles involved in polymer matrix composite processes and their applications; A brief review of numerical methods and their application to various manufacturing processes of PMCs. Modelling and simulation of the physicochemical reactions, fluid solid reactions involved in these manufacturing processes and parametric optimization applicable to these manufacturing processes. Modelling and simulation of the flow processes involved in the manufacturing processes like resin transfer molding, vacuum assisted resin transfer molding.

CHL705 Electrokinetic Transport Phenomena
4 credits (3-0-2)
Pre-requisites: CHL331
Definition of colloidal state and implications, intermolecular and surface forces, electrostatics, transport equations in electrolytic solution, electrokinetic phenomena, electrophoresis, sedimentation potential, coagulation of particles, particle deposition and aggregation, electrochemistry and electrochemical engineering, electrode and redox potential, over voltages electro analytical techniques – cyclic voltammetry, chrono amperometry, chrono coulometry, applications of these concepts in fuel cell technology, fuel cell modeling.

CHL707 Adsorption Separation Processes
3 credits (3-0-0)
Pre-requisites: EC90 and CHL251
Microporous adsorbents/ Physical adsorption and characterization of porous adsorbents, Adsorption equilibria, Diffusion in porous media, kinetics of adsorption in batch systems, Column processes, Chromatographic separation processes, Pressure swing adsorption, Structure and properties of ion exchange resins, Ion-exchange equilibrium, Ion-exchange kinetics, Ion-exchange columns, Behaviour of ion-exchangers in non-aqueous and mixed solvents.

CHL710 Process Dynamics and Control
5 credits (3-1-2)
Pre-requisites: CHL261
Lumped parameter systems—classical and multivariable control theory, Distributed parameter systems, Measurement of process variables such as temperature, pressure, composition, flow rate, level, density, etc. Dynamics of process instruments and loops, Analogue and digital signals, process actuators and control equipment.

CHL711 Numerical Methods in Chemical Engineering
4 credits (3-0-2)
Pre-requisites: (CSL101/CSL102) & MAL110 and EC90 and CHL110
Efficient and recent numerical techniques applied to problems of chemical engineering interests, Solution of linear and non-linear simultaneous algebraic equations, Interpolation, extrapolation and finite difference, Numerical integration and differentiation, coupled ordinary differential and partial differential equations, curve fitting, spline, regression analyses, molecular simulations.

CHP711 Process Development Laboratory
3 credits (0-0-6)
Pre-requisites: CHL221 & CHL351

CHL712 Computer Aided Design in Chemical Engineering
3 credits (2-0-2)
Pre-requisites: CHL351 and MAL110 and CSL101/CSL102
Software development for design of various chemical equipments.
Design of energy heat exchanger network, sequencing and energy integration in distillation column simulation of process flow sheets using software package, Aspen Plus.

**CHL714 Advanced Heat Transfer**  
3 credits (3-0-0)  
Pre-requisites: CHL251 & MAL260  
Formulation and solution of transient and steady-state conduction, heat transfer in fixed beds, fluidized beds, magneto fluid dynamic systems, transpiration cooling in non-Newtonian fluids, heat pipes, solar collectors.

**CHL717 Mechanical Design of Process Equipment**  
4 credits (3-0-2)  
Pre-requisites: CHL471  
Specification and design of simple structural members, Design of spherical/ cylindrical shells and heads/ closures for cylindrical shells under internal and external pressure, Design of a self- supporting tall vertical cylindrical vessel under wind/ seismic loading, Design of RCC foundation for a tall vessel; Compensation for openings in cylindrical shells, Design of special flanges, Design of storage tanks for liquids.  
Laboratory/ design activities could also be included.

**CHL721 Advanced Chemical Engineering Thermodynamics**  
4 credits (3-1-0)  
Pre-requisites: CHL121 & 90 credits  
This course provides a thorough understanding of chemical engineering thermodynamics, with emphasis in the following areas - Vapor - Liquid equilibria, Liquid-Liquid Equilibria, Statistical Thermodynamics, Chemical Reaction Equilibria in multi-component systems, encountered in most chemical systems. We expect that students use their fundamental understanding of thermodynamic principles and learn to solve several complex problems in the above-mentioned areas.

**CHL722 Fundamentals of Fuel Cell Technology**  
4 credits (3-0-2)  
Pre-requisites: UC/Dual- EC 120  
Overview of fuels cells: Low and high temperature fuel cells: Fuel cell thermodynamics – heat, work potentials, prediction of reversible voltage, fuel cell efficiency; Fuel cell reaction kinetics – electrode kinetics, overvoltages, Tafel equation, charge transfer reaction, exchange currents, electrocatalyses – design, activation kinetics, Fuel cell charge and mass transport – flow field, transport in electrode and electrolyte; Fuel cell characterization: - in-situ and ex-situ characterization techniques, i-V curve, frequency response analyses; Fuel cell modeling and system integration: - 1D model – analytical solution and CFD models, Balance of plant; Hydrogen production and storage; safety issues, cost expectation and life cycle analysis of fuel cells.

**CHL723 Chemical Reaction and Reactor Engineering**  
3 credits (3-0-0)  
Pre-requisites: CHL251 & CHL221  
Theory of mass transfer with chemical reaction, irreversible reaction, enhancement factor for single irreversible and reversible reactions, enhancement factor for reversible and other complex reaction schemes, modeling of solid catalyses gas-liquid reactors, stability and control of chemical reactors, modeling of solid catalyses gas-liquid reactors.

**CHL724 Environmental Engineering and Waste Management**  
4 credits (3-1-0)  
Pre-requisites: CHL251  

**CHL727 Heterogeneous Catalysis and Catalytic Processes**  
4 credits (3-0-2)  
Pre-requisites: CHL221  
Basic concepts in heterogeneous catalysis, Green catalysis concept, catalyst preparation and characterization, poisoning and regeneration, Industrially important catalysts and processes such as oxidation, processing of petroleum and hydrocarbons, synthesis gas and related processes, commercial reactors (adiabatic, fluidized bed, trickle-bed, slurry, etc.), Heat and mass transfer and its role in heterogeneous catalysis, Calculations of effective diffusivity and thermal conductivity of porous catalysys, Reactor modeling. Emphasizes the chemistry and engineering aspects of catalytic processes along with problems arising in industry, Catalyst deactivation kinetics and modeling.

**CHL731 Intro to Soft Matter**  
3 credits (3-0-0)  
Soft matter an overview, forces, energies and timescales in soft matter, phase transitions in soft matter, spinodal decomposition, nucleation, colloidal dispersions, polymers, gelation, liquid crystals, polymer crystals, self assembly in soft materials, soft materials in nature.

**CHL735 Design of Separation Processes**  
4 credits (3-0-2)  
Pre-requisites: CHL351 and CHL121  
Multicomponent distillation, extraction, adsorption-short-cut method, rigorous calculations, design of tray and packed columns, economic analyses of columns, crystalization, membrane separation, challenges in new technologies, Separation processes based on micro-emulsion, micelles, micro-gas bubble, electrical charges, design of such processes with special emphasis on separation technology in petroleum refinery and petrochemicals.

**CHL740 Selected Topics in Chemical Engineering**  
3 credits (3-0-0)  
Various advanced topics in chemical engineering of interest to research and/or of industrial importance.

**CHL743 Petrochemical Technology**  
3 credits (3-0-0)  
Pre-requisites: CHL221  

**CHL751 Multi-component Mass Transfer**  
3 credits (3-0-0)  
Pre-requisites: CHL351  
Diffusion: Maxwell-Stefan’s, Fick’s and Irreversible Thermodynamics approaches to multicomponent diffusion, Estimation of multicomponent Diffusion Coefficients, Effect of nonideality of fluids, Linearized theory for multicomponent diffusion problems, Interphase mass transfer, mass transfer coefficients, bootstrap matrix, Film Theory, Surface renewal models, mass transfer in turbulent flows.  
Laboratory/design activities could also be included.
CHP754 Applications of Simulation Software
2 credits (1-0-2)
Pre-requisites: CHL351 & CHL121 & CHL111

CHD760 Minor Project (CHD)
3 credits (0-0-6)

CHL761 Chemical Engineering Mathematics
3 credits (3-0-0)
Pre-requisites: MAL110 and EC 90 and CHL110
Data Analysis: Classification, estimation and propagation of errors, Presentation of data, Statistical methods, sample and population distributions, testing of hypothesis, analysis of variance.


CHL762 Modeling, Simulation and Control
4 credits (3-0-2)
Pre-requisites: CHL351&CHL221&CHL261
Development of conservation and constitutive equations for a variety of chemical engineering unit operations and processes under steady state and unsteady state conditions, their analysis and solution. Concept of lumped and distributed parameter models. Introduction to steady state and dynamic simulation software. Study of plant wide control schemes.

CHL763 Computer Process Control
3 credits (3-0-0)
Pre-requisites: MEL432
16 bit microprocessor architecture, overview of IBM PC to Pentium Computer, Computer- Process Interface equipment, DDC, Distributed Process Control, Supervisory Control, PLC, Fuzzy Logic and Neural Networks, Applications in Control of Chemical Processes.

CHL766 Interfacial Engineering
3 credits (3-0-0)
Pre-requisites: CHL351&CHL110&CHL121
Concept and definition of interface, Physical surfaces, Surface chemistry and physics of colloids, thin films, dispersions, emulsions, foams, polyphosphates, Interfacial processes such as crystalization, epitaxy, froth flotation, adsorption, absorptive bubble separation, catalysis, reaction-injection moulding, microencapsulation, Industrial aspects of interfacial engineering.

CHL768 Fundamentals of Computational Fluid Dynamics
3 credits (2-0-2)
Pre-requisites: CHL110 and CSL101/CSL102 and EC90
Overlaps with: AML811
Review of basic fluid mechanics and the governing (Navier-Stokes) equations, Techniques for solution of PDEs – finite difference method, finite element method and finite volume method, Finite volume (FV) method in one-dimension, Differencing schemes, Steady and unsteady calculations, Boundary conditions, FV discretization in two and three dimensions, SIMPLE algorithm and flow field calculations variants of SIMPLE, Turbulence and turbulence modeling, illustrative flow computations, Commercial softwares FLUENT and CFX – grid generation, flow prediction and post-processing.

CHD771 Minor Project
4 credits (0-0-8)

CHL771 Process Operations Scheduling
4 credits (3-0-2)
Course Contents
(i) Classification of scheduling formulations; various storage policies, objective functions, network representations, time representations.
(ii) Short-term scheduling of batch processes: discrete-time and continuous-time based models.
(iii) Cyclic and short-term scheduling of continuous processes.
(iv) Optimization: Introduction to Linear Programming (LP) and Mixed-Integer Linear Programming (MILP).
(v) Solution of resulting models using GAMS modeling language.

CHL773 Planning of Experiments and Analysis of Engineering Data
4 credits (3-0-2)
Graphical method of model selection from experimental data, Two variable equations, Linear and logarithmic plots, modified Logarithmic and semi-logarithmic plots, Reciprocal plots, Equations for bumped data. Elongated “S” curve, Sigmoid curves.....Three variable empirical equations, Multivariable empirical equation.....Dimensionless numbers. Nomography, Introduction, modulus and scale and principle of construction, Application of logarithmic charts, Equations of the form $F_1(x) + F_2(x) = F_3(x)$, Selection of empirical equation for fitting experimental data Testing of hypothesis, Testing of means and variances, Planning of experiments as per factorial design to estimated significant variables which affect the process, Fractional factorial design to use significant variables to estimates the relationship between the significant variables and independent variable. Response surface analysis by reducing the equations developed to canonic order with interaction factor, Case studies on application to research and industrial data analysis.

CHL774 Process Optimization
4 credits (3-0-2)
Pre-requisites: CHL221&CHL471
Overlaps with: MAL210, MAL704, MAL726
Formulation of an optimization problem, Convexity Analysis, Linear Programming, Nonlinear Programming, Optimality Conditions, Dynamic Optimization, Dynamic Programming, Introduction to Mixed Integer Programming. Laboratory/design activities could also be included.

CHL777 – Bioprocessing and Bioseparations
3 credits (3-0-0)
Overlaps with: BEL703, BEL820
Introduction to the different unit operations utilized in production of biotech drugs in the areas of upstream processing, harvest, and downstream processing; Introduction to analytical methods used for characterization of biotech products and processes (high performance liquid chromatography, mass spectrophotometry, capillary electrophoresis, near infrared spectroscopy, UV spectroscopy); Optimization of biotech processes – unit operation specific optimization vs. process optimization, process intensification, statistical data analysis; Scale-up of different unit operations utilized in bioprocessing: procedures, issues that frequently occur and possible solutions; Good Manufacturing Practices (GMP): need, principles and key practical issues; Process Validation : basics, planning and implementation; Industrial case studies in bioprocessing; Current topics in bioprocessing and bioseparations: Quality by Design and Process Analytical

CHS780 Independent Study
3 credits (0-3-0)

CHD781 Major Project Part-1 (CHC)
6 credits (0-0-12)
Formulation of the problem, literature search, design of the experimental setup and study of experimental techniques in the
case of experimental projects, formulation of design equations in development of solution techniques and familiarization with relevant software in the case of design or theoretical projects.

**CHD782 Major Project Part-2 (CHC)**
3 credits (0-0-24)
Theoretical or design projects: to arrive at a complete design of a chemical plant in particular give complete design detail of major process equipment or to develop computer simulation models for industrial processes at macro or micro level.

Experimental Projects: Collect and data and model the experimental work.

**CHL792 Structure and Properties of Polymers in Solution**
3 credits (3-0-0)
Pre-requisites: CHL110 & Total credit : 90
Overview of Polymer Science and Engineering with reference to Polymer Solution, Chain dimension; variation of chain dimension with concentration, solvency etc., Scaling theory, Molecular weight distribution and its effect on properties of polymer solution, Polymer solution thermodynamics, Flory-Huggins eqn. and its development, phase separation, Polymer in good, theta and poor solution, colligative properties of polymer solution, Phase Morphology of Block-co-polymer in solution and its applications, Flow phenomena in polymeric liquids, material functions for polymeric liquids, general linear viscoelastic fluid, Rouse dynamics, Zimm dynamics, Hyper branched polymer and its physical properties in various solutions, Polyelectrolyte and its properties in various solutions.

**CHL793 Membrane Science and Engineering**
3 credits (3-0-0)
Pre-requisites: CHL110&CHL351
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, ultrafiltration electrodialysis, dialysis, liquid membrane separation, gas permeation and pervaporation.

**CHL794 Petroleum Refinery Engineering**
4 credits (3-0-2)
Pre-requisites: CHL351 and CHL122

**CHL795 Agro Process Technology**
3 credits (3-0-0)
Pre-requisites: CHL351

Food preservation: principles and methods, Fruits and fruit products, Vegetables and vegetable products.


**CHL807 Population Balance Modeling**
3 credits (3-0-0)
Pre-requisites: MAL120 and CHL221 and CHL331 and CHL351 & EC120
Particle size distribution, Crystal size distribution, Commination processes and other particulate processes, Representation of distribution, Properties of distributions, Particle phase space, Population fluxes distributions, Particle phase space, Population fluxes-conversions, Birth and death, Particle number continuity equation, Population balance over a macroscopic external coordinate region, Moment transformation of population balance over a macroscopic external coordinate region, Macro-moment equations, Recovery of particle size distribution function, Steady state MSMR crystalliser, Significance of distribution representation, Exponential distribution, Mass Balance, Dynamic population balance, CSD transients, Transient moment equations, Transient size distribution by method of characteristics, Stability of CSD, Crystallisation kinetics, Nucleation, Crystal growth, Comminuton Processes, Microbial population, Residence-time distribution, Dispersed-phase mixing.

**CHL813 Thermodynamics and Process Design**
3 credits (2-0-2)
Pre-requisites: CHL121 and EC120
Thermophysical properties of pure fluids, Equilibrium properties such as vapour pressure, latent heats, critical constants and PVT behaviour, Transport properties such as viscosity, thermal conductivity and diffusivity, estimation and correlation methods, Properties of multicomponent systems, V-L-E using equations of state and group contribution methods, L-I-E correlation and prediction, Homogeneous and heterogeneous chemical equilibria with competing chemical reactions.

**CHL830 Advanced Computational Techniques in Chemical Engineering**
3 credits (2-0-2)
Pre-requisites: CHL711

**CHL864 Applications of AI and ANN in Chemical Engineering**
4 credits (3-0-2)
Pre-requisites: EEL758
AI and Chemical Engineering, Expert System and Chemical Engineering-CONPHYDE and OPSS, KBs for Process Synthesis and Design, Design problem solving (Exsee), Product design methodologies – polymeric composites, molecules, developing design support environment, Process plant diagnosis and safety analysis (Falcon), Expert system tools and shells for Chemical Engineering – critical evaluation of KBs tools such as KEE, ART, INSIGHT2 +, NEXPERT, etc. from the perspective of Chemical Engineers.

**CHL869 Applications of Computational Fluid Dynamics**
3 credits (2-0-2)
Pre-requisites: CHL768
Brief review of CFD for single phase flows; Solution of scalar equations – heat and mass transfer; Application to heat exchanger and stirred
tank flows; CFD for multiphase systems – Lagrange-Euler and Euler – Euler approaches; Multiphase models – granular kinetic theory; Reaction modeling; Volume of Fluid (VOF) method for two-phase flow with interfaces; Current status of multiphase flow simulation in various chemical process equipment—bubble column, phase separator, packed bed, fluidized bed, polymerization reactor, cyclones etc.

**CHD871- Major Project Part 1 (CM)**
6 credits (0-0-12)
*Overlaps with : CHD873*
Formulation of the problem; Literature search; Design of the experimental setup and study of experimental techniques in the case of experimental projects; Formulation of design equations in development of solution techniques and familiarization with relevant software in the case of design or theoretical projects.

**CHD872-Major Project Part 2 (CM)**
14 credits (0-0-28)
*Overlaps with : CHD874*
Formulation of the problem; Literature search; Design of the experimental setup and study of experimental techniques in the case of experimental projects; Formulation of design equations in development of solution techniques and familiarization with relevant software in the case of design or theoretical projects.

**CHL792-Structure and Properties of Polymers in Solution**
3 credits (3-0-0)
*Overlaps with : CYL666, PTL703, PTL705, PTL707*
Overview of polymer science & engineering with reference to polymer-solution, Chain dimension; Variation of chain dimension with concentration, solvency etc., Scaling theory, Molecular weight distribution and its effect on properties of polymer solution, Polymer solution thermodynamics, Flory-Huggins equation and its development, phase separation, Polymer in good, theta and poor solution, colligative properties of polymer solution, Phase Morphology of block-co-polymer in solution and its applications, Flow phenomena in polymeric liquids, material functions for polymeric liquids, general linear viscoelastic fluid, Rouse dynamics, Zimm dynamics, Hyper branched polymer and its physical properties in various solutions, Polyelectrolyte and its properties in various solutions.

**CHD895 Major Project (M.S. Research-CH)**
40 credits (0-0-80)
development of solution techniques and familiarization with relevant software in the case of design or theoretical projects.

**CHD874-Major Project Part 2 (CM)**
16 credits (0-0-32)
*Overlaps with CHD 874*
Formulation of the problem; Literature search; Design of the experimental setup and study of experimental techniques in the case of experimental projects; Formulation of design equations in development of solution techniques and familiarization with relevant software in the case of design or theoretical projects.
Chemistry computer simulations. Students are exposed to various classical and modern methods for following the kinetics of chemical reactions. Computer simulation methods as applied to chemistry are introduced.

CYL562 Organic Synthesis 3 credits (3-0-0)

CYP562 Organic Chemistry Laboratory II 2 credits (0-0-4)
Synthesis and characterization of organic molecules will be given in this course.

CYL563 Transition and Inner-transition Metal Chemistry 3 credits (3-0-0)

CYP563 Inorganic Chemistry Laboratory II 2 credits (0-0-4)
Developing experimental skills in inorganic chemistry applied to organometallics and bioinorganic chemistry.

CYL564 Biochemistry I 3 credits (3-0-0)

CYP564 Biochemistry Laboratory II 2 credits (0-0-4)
Enzyme characterization and applications; DNA & RNA isolation.

CYL565 Chemical Dynamics and Surface Chemistry 3 credits (3-0-0)

CYL566 Physical Methods of Structure Determination of Organic Compounds 3 credits (3-0-0)
Applications of UV, IR, NMR and mass spectral methods in structure determination of organic compounds.

CYL601 Group Theory & Spectroscopy 3 credits (3-0-0)

CYL602 Pericyclic Reactions and Photochemistry 3 credits (3-0-0)

CYL603 Basic Organometallic Chemistry 3 credits (3-0-0)
Organometallic compounds of main group, transition and inner transition elements. Synthesis, structure and bonding in metal carbonyls, nitrosyls and alkyls, allyls and cyclopentadienyl derivatives.
Organometallic clusters. Homogeneous catalysis (hydrogenation and hydroformylation) by organometallic species.

**CYL604 Biochemistry III**
3 credits (3-0-0)

**Departmental Electives** [Any four to be selected: Two in III semester and two in IV semester]

**CYD660 Project Part 1**
3 credits (0-0-6)

**CYL665 Solid State Chemistry**
3 credits (3-0-0)
Solid state chemistry is a subject that is very relevant to modern technology from solid catalysts to superconducting magnets. The course is aimed at giving an overview of modern developments in solid state chemistry.

Contents: Crystal chemistry (8 lectures); bonding in solids (3 lectures); defects and non stoichiometry (3 lectures); X-ray diffraction of solids (6 lectures); synthesis of solids (5 lectures); electronic and magnetic properties of solids (5 lectures); superconductivity (2 lectures); optical properties (3 lectures); luminescence and lasers (1 lecture); recent trends in solid state chemistry (6 lectures)

**CYL666 Chemistry of Macromolecules**
3 credits (3-0-0)
Polymers from a large class of materials that have varied applications. This course provides insight into the physical chemistry of polymers.

Contents: Kinetics of condensation, free radical, and ionic polymerization (15 lectures); molecular weight determination (8 lectures); thermodynamics of polymer solutions (7 lectures); characterization of polymers by spectroscopic and thermal techniques (12 lectures).

**CYL667 Selected Topics in Spectroscopy**
3 credits (3-0-0)

**CYL668 Statistical Mechanics & Molecular Simulation Methods**
3 credits (3-0-0)

**CYL669 Biophysical Chemistry I**
3 credits (3-0-0)

**CYD670 Project Part 2**
8 credits (0-0-16)

**CYL675 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.

**CYL676 Bio-Organic and Medicinal Chemistry**
3 credits (3-0-0)

**CYL677 Supramolecular Chemistry**
3 credits (3-0-0)

**CYL678 Recent Trends in Organic Chemistry**
3 credits (3-0-0)
Recent advances in Organic Synthesis, spectroscopy and reaction mechanisms.

**CYL685 Applied Organometallic Chemistry**
3 credits (3-0-0)

**CYL686 Inorganic Polymers**
3 credits (3-0-0)

**CYL687 Bio-Inorganic Chemistry**
3 credits (3-0-0)

**CYL688 Physical Methods in Inorganic Chemistry**
3 credits (3-0-0)
Spectroscopic methods in inorganic chemistry: Multinuclear NMR (119Sn, 131I, 195Pt), EPR and Mossbauer spectroscopy; X-ray diffraction methods (powder and single crystal), Finger printing of solids from powder data and determination of crystal structures by Rietveld analysis and single crystal studies. Electrochemical methods (cyclic voltammetry; differential pulse voltammetry, coulometry).

**CYL695 Applied Biocatalysis**
3 credits (3-0-0)

**CYL696 Nonaqueous Enzymology**
3 credits (3-0-0)

**CYL701 Electroanalytical Chemistry**  
5 credits (3-0-4)  
Principles of electro-chemical methods, electrochemical reactions, electroanalytical voltammetry as applied to analysis and the chemistry of heterogeneous electron transfers, electrochemical instrumentation.

**CYL702 Chemical Separations**  
5 credits (3-0-4)  
Theory and applications of equilibrium and nonequilibrium separation techniques. Extraction, countercurrent distribution, gas chromatography, column and plane chromatographic techniques, electrophoresis, ultra-centrifugation, and other separation methods.

**CYL703 Spectrochemical Methods**  
5 credits (3-0-4)  
Principles of atomic and molecular spectrometric methods especially UV-visible, IR, fluorescence, AAS, AES, CD, and ORD; discussion of instrumentation, methodology, applications.

**CYL704 Chemical Computations**  
3 credits (2-0-2)  
Introduction to programming; solution of numerical problems in equilibrium, kinetics, and spectroscopy; overview of molecular modeling, molecular simulations, molecular design, and bioinformatics; use of spectroscopic and structural databases.

**CYL705 Environmental Analytical Chemistry**  
3 credits (3-0-0)  
Introduction to environmental analysis; Sampling methods; Environmental pollution from industrial effluents, radiochemical waste, nuclear waste, trace elements; Water and waste water analysis; Measurement, detection and monitoring of radiation; Air pollution and monitoring.

**CYL707 Electronics and Chemical Instrumentation**  
3 credits (3-0-0)  
Models of electronic systems, frequency response of inactive networks, amplification and amplifier feedback, signal processing, fundamental measuring operation, analog instrument design, digital instruments.

**CYL711 X-ray and Electron Microscopic Methods**  
3 credits (3-0-0)  
X-ray diffraction techniques of powders and single crystals; X-ray emission, absorption, fluorescence spectroscopy; Electron Microscopy (SEM, TEM).

**CYL712 Characterization of Surfaces**  
3 credits (3-0-0)  
Introduction to Surfaces, UHV Instrumentation, Photoelectron Spectroscopy: UV, XPS, Auger; Secondary Ion Mass Spectrometry, Scanning Probe Microscopies (STM, AFM), Vibrational Spectroscopies (Raman, IR, SFG); Mossbauer spectroscopy.

**CYL713 Characterization of Polymers**  
3 credits (3-0-0)  
Introduction to polymers; molecular weight and molecular size determination; thermoanalytical methods of characterization including TGA, DTA, and DSC; spectroscopy (IR, NMR, UV-visible) of polymers.

**CYL714 NMR and Mass Spectrometric Methods**  
3 credits (3-0-0)  
Modern NMR and mass spectrometry including fundamentals, instrumentation, and analytical applications.

**CYL715 Bioanalytical Chemistry**  
3 credits (3-0-0)  
Modern analytical and separation techniques used in biochemical analysis; free and immobilized proteins, dry enzyme chemistry, enzyme electrodes, immunochemical analysis, protein sequencing, nucleic acid sequencing, DNA fingerprinting.

**CYL716 Data Analysis, Experimental Design, and Chemometrics**  
3 credits (3-0-0)  
Error propagation, Descriptive statistics, introduction to regression, factor and principal component analysis, simplex and factorial experimental design, optimization, fourier transform.

**CYL717 Principles of Chemical and Biosensors**  
3 credits (3-0-0)  
General principles of molecular recognition, thermal, mass, electrochemical (potentiometric, amperometric, chemiresistors, micro-electrodes), optical sensors.

**CYL718 On-line Methods of Chemical Analysis**  
3 credits (3-0-0)  
Introduction to batch and continuous processes; Material and energy balance; Unit operations and unit processes; dynamics of unit operations and instruments; measurement and recording of pressure, temperature, concentration, flow rates, conductivity, and pH in processes, automatic and feedback control, Industrial research problems.

**CYL721 Design, Synthesis and Characterization of Organic Molecules**  
3 credits (3-0-0)  

**CYP722 Laboratory on Design, Synthesis and Characterization of Organic Molecules**  
3 credits (0-0-6)  
Single and double stage preparation of organic compounds, experiments involving the concepts of protecting groups and selectivity in organic synthesis, purification of organic compounds using column chromatography and their identification by thin layer chromatography. Synthesis of some polymers of industrial importance. Characterization of synthesized organic compounds and polymers using IR, UV and NMR, and mass spectroscopic techniques.

**CYL723 Principles and Practice of Optical and NMR Spectroscopy**  
3 credits (3-0-0)  
Fundamentals of FT NMR spectroscopy, relation between structure
and NMR properties, one-dimensional spectroscopy (1H, 13C, DEPT, steady state NOE, saturation transfer) and an introduction to two-dimensional NMR (COSY, NOESY, and HSQC) and their use in structure elucidation. Principles and analytical applications of optical spectroscopic methods including atomic absorption and emission, UV-Visible, IR absorption, scattering, and luminescence.

**CYL725 Molecules to Materials**  
3 credits (3-0-0)  
Principles of self assembly, overview of intermolecular interactions, kinetics and thermodynamics of self assembly, organic-inorganic self assembly, biological self assembly, mesoscale self assembly, molecular assembly for selected applications.

**CYL726 Cheminformatics and Molecular Modeling**  
3 credits (3-0-0)  

**CYL727 Inorganic Synthesis and Analysis**  
3 credits (3-0-0)  
Modern methods applied in inorganic and organometallic synthesis. Handling of air and moisture sensitive compounds, drybox, glove bag, schlenk line and vacuum line techniques. Methods of purification and drying of blanket gases and preparation, purification and handling of reactive industrial gases such as HCl, SO2, acetylene, O2, Cl2, F2 etc. Purification and storage methods for oxygen and moisture free solvents. Methods of purification and crystallization of solids for X-ray analysis. General strategies, brief outline of theory and methodology used for synthesis of main group compounds, transition metal complexes, organometallic compounds, inorganic materials and macromolecules. A few examples of detailed specific synthesis in each type of compounds with justification of the methodology adopted. Characterization methods adopted for main group compounds, metal complexes, organometallic compounds, inorganic materials and macromolecules. Multinuclear NMR methods, Mass spectroscopic methods used in Inorganic chemistry, Determination of magnetic properties, Application of electro analytical tools in characterization of transition metal based compounds. Principles and methodology of elemental analysis, powder and single crystal X-ray diffractometer.

**CYP728 Inorganic Synthesis and Analysis Laboratory**  
2 credits (0-0-4)  
Experiments based on the synthesis of complexes, organometallic compounds and inorganic materials. Characterization of the synthesized compounds with an emphasis on instrumental methods of analysis (emphasis on electrochemical, spectrosopic, and diffraction methods).

**CYL729 Materials Characterization: Diffraction, Microscopy, and Thermal Analysis**  
3 credits (3-0-0)  
Basic concepts of diffraction techniques (powder and single crystal) in elucidating the crystal structures of inorganic, organic and hybrid materials. Use of computer techniques, including molecular graphics for studying structural problems, data collection and data analysis. Analysis and creation of interactive databases bases for finding structural correlation. Applications of electron microscopic techniques (scanning and transmission) for morphological and nanostructural features. Thermal analysis (TGA, TMA, DTA & DSC) for correlating the structural information accompanied by dehydration, decomposition and phase transformation. Emphasis will be placed on hands-on application of X-ray crystallography, electron microscopy and thermal techniques for industrially important materials and the interpretation and evaluation of results obtained by structure determinations.

**CYL731 Analytical Separations**  
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, ultra-centrifugation, and other separation methods.

**CYL732 Electroanalytical Chemistry**  
3 credits (3-0-0)  
Principles of electro-chemical 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.

**CYL733 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.

**CYL734 Chemistry of Nanostructured Materials**  
3 credits (3-0-0)  
Introduction; fundamentals of 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).

**CYT735 Industrial Training**  
4 credits (0-0-8)  
**CYD799 Minor Project**  
3 credits (0-0-6)  
**CYS801 Independent Study**  
4 credits (0-0-4)  
**CYD801 Major Project I**  
6 credits (0-0-12)  
**CYD802 Major Project II**  
12 credits (0-0-24)  
**CYD803 Major Project I**  
4 credits (0-0-8)  
**CYD804 Major Project II**  
14 credits (0-0-28)  
**CYP803 Glass Blowing**  
1 credit (0-0-2)  
Experiments in glass blowing using burner, hand torch and lathe.  
**CYC805 Seminar**  
2 credits (0-2-0)

**CEL610 Foundation Engineering**

3 credits (3-0-0)

Note: This course is not meant for students specializing in Geotechnical and Geoenvironmental Engineering; Classification, Engineering behaviour of soils – effective stress concept, permeability, compressibility, shear strength. Parameters for short and long term stability, Stress distribution, Field explorations - scope and depth of investigations, SPT, DCPT, SCPT; Analysis of bearing capacity of shallow foundations, Plate load test; Settlement computations - Immediate and Consolidation; Codal provisions; Types of pile foundations, load carrying capacity of pile foundations including group effects and negative skin friction. Pile load test.

**CEL612 Construction Methods in Geotechnical Engineering**

3 credits (3-0-0)

(To be offered to specialization in Construction Technology and Management) Ground Engineering-Earthwork, earth-moving equipments, soil compaction and stabilization with additives. Ground improvement-Deep-in-situ improvement by (a) Vibrolation stone column, (b) compaction piles, (c) impact/dynamic compaction, (d) blasting, (e) pre-loading and drains, (f) in-situ mixing, cement and lime columns; Geotechnical Processes in Soil and Rocks-drilling, blasting, grouting, dewatering; Foundation-piles: (a) precast driven, (b) driven cast in-situ, (c) bored cast in-situ, (d) under-reamed. Caissons; Dams and Embankments-earth dams, earth cum-rock-fill dams, road and rail embankments; Earth Retaining Structures- retaining walls including reinforced earth, braced excavations, sheet piles, diaphragm walls; Underground Structures-tunneling in rock, soil, and in soft ground. Micro-tunneling.

**CEL614 Geoenvironmental and Geohazards Engineering**

3 credits (3-0-0)

Note: This Course is not meant for Students Specializing in Geotechnical and Geoenvironmental Engineering.

Geoenvironmental Engineering; Waste generation; subsurface contamination, waste containment; Types of landfills, design and operation of landfills, subsurface contamination control and remediation; Geotechnical Earthquake Engineering: Engineering seismology. Strong ground motion, Seismic hazard analysis, Local site effects and design ground motions, liquefaction hazard evaluations and remedial measures; Landslides: Causes and phenomenon associated with landslides, effect of rainfall on slope stability, earthquake triggered landslides, landslide prevention - control and remedial measures; Other Hazards: ground subsidence, ground heave, erosion.

**CEL651 Rock Engineering**

3 credits (3-0-0)

Note: This course is not meant for students specializing in Rock Engineering and Underground Structures.


**CED701 Minor Project in Geotechnical and Geoenvironmental Engineering**

3 credits (0-0-6)

**CEL701 Engineering Behaviour of Soils**

3 credits (3-0-0)


**CEP701 Soil Engineering Laboratory**

3 credits (0-0-6)


**CEL702 Slope Stability and Earth Dams**

3 credits (3-0-0)

Slope Stability: Short term and long term stabilities; Limit equilibrium methods; Infinite slopes; Finite height slopes – Swedish method, Bishop’s simplified method, other methods; Stability charts; Conditions of analysis – steady state, end of construction, sudden draw down conditions; Factor of safety; Codal 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; Construction; Instrumentation – piezometer; settlement gauge, inclinometer; Road and rail embankments. Reinforced Slopes: Steep slopes; Embankments on soft soils; Reinforcement design; Landslides: Remedial measures for unstable slopes – soil nailing, gabions, drainage.

**CEP702 Geoenvironmental and Geotechnical Engineering Laboratory**

3 credits (0-0-6)


**CEL703 Site Investigations and Ground Improvement**

3 credits (3-0-0)

Site Investigations:
Planning of investigation programmes, Information required for planning different stages of investigations. Geophysical methods: electrical resistivity, and seismic refraction methods. Methods of site investigations: Direct methods, semi-direct methods and indirect methods; Drilling methods; Boring in soils and rocks, methods of stabilizing the bore holes, measurement of water table, field record. Field tests: In-situ shear test, in-situ permeability test, SPT, DCPT, SCPT, in-situ vane shear test, pressure meter test, plate load test. Codal provisions; Sampling techniques, Sampling disturbances, storage, labeling and transportation of samples, sampler design, influence on properties; Report writing. Safety measures; Geotechnical Processes: Principles of compaction, Laboratory compaction, Engineering behaviour of compacted clays, field compaction techniques- static, vibratory, impact, Earth moving machinery, Compaction control. Shallow Stabilization with Additives: Lime, flyash, cement and other chemicals and bitumen; Deep Stabilization: sand column, stone column, sand drains, prefabricated drains, electro-

**CEL704 Shallow and Deep Foundations**
3 credits (3-0-0)

**CEL705 Geoenvironmental Engineering**
3 credits (3-0-0)
Sources and effects of subsurface contamination; Physical, chemical and biological characteristics of solid wastes; Soil-waste interaction; Contaminant transport; Laboratory and field evaluation of permeability; Factors affecting permeability; Waste disposal on land; Types of landfills: Siting criteria; Waste containment principles; Types of barrier materials; Planning and design aspects relating to waste disposal in landfills, in ash ponds and tailing ponds, and in rocks; Environmental monitoring around landfills; Detection, control and remediation of subsurface contamination; Engineering properties and geotechnical reuse of waste materials such as coal ash, mining waste, demolition waste etc; Reclamation of old waste dumps; Regulations; Case studies.

**CEL706 Geosynthetics**
3 credits (3-0-0)
Geosynthetics and Reinforced Soil Structures: Types and functions; Materials and manufacturing processes; Testing and evaluations; Principles of soil reinforcement; Design and construction of geosynthetic reinforced soil retaining structures – walls and slopes; Coadal provisions; Bearing capacity improvement; embankments on soft soils; Indian experiences; Geosynthetics in Pavements: Geosynthetics in roads and railways; separations, drainage and filtering in road pavements and railway tracks; overlay design and construction; AASHTO and other relevant guidelines; french drains; Geosynthetics in Environmental Control: Liners for ponds and canals; covers and liners for landfills – material aspects and stability considerations; Landslides – occurrences and methods of mitigation; Erosion – causes and techniques for control.

**CEL707 Soil Dynamics and Geotechnical Earthquake Engineering**
3 credits (3-0-0)
Engineering problems involving soil dynamics; Role of inertia; Theory of Vibrations: Single and two-degree freedom systems, vibration measuring instruments, vibration isolation, Wave propagation in elastic media; General nature of soil behaviour under cyclic/dynamic loading; Field and Laboratory tests for measurement of small strain and large strain, dynamic properties of soils; Design criteria for machine foundations, elastic homogeneous half space solutions, lumped parameter solutions. Coadal provisions; Strong Ground Motion: Measurement, characterization and estimation; Amplification theory and ground response analysis. Densification and liquefaction of granular soils, Seismic slope stability analysis, Seismic bearing capacity and earth pressures. Coadal provisions.

**CEL708 Earth Pressures and Retaining Structures**
3 credits (3-0-0)
Earth Pressure: Types – at rest, active and passive; Rankine’s theory; Backfill features – soil type, surface inclination, loads on surface, soil layers, water level; Coulomb’s theory; Effects due to wall friction and wall inclination; Graphical methods; Earthquake effects; Rigid Retaining Structures: Types; Empirical methods; Stability analysis; Flexible Retaining Structures: Types; Material; Cantilever sheet piles; Anchored bulkheads – free earth method, fixed earth method, moment reduction factors, anchorage; Braced Excavation: Types; Construction methods; Pressure distribution in sands and clays; Stability – bottom heave, seepage, ground deformation; Reinforced Soil Walls: Elements; Construction methods; External stability; Internal stability; Laterally Loaded Piles: Short and long piles; Free head and fixed head piles; Lateral load capacity of single piles; Lateral deflection; Elastic analysis; Group effect; Lateral load test; Coadal provisions; Underground Structures in Soils: Pipes; Conduits; Trenchless technology; Tunnelling techniques – cut-and-cover method, shield tunnelling.

**CEL709 Offshore Geotechnical Engineering**
3 credits (3-0-0)

**CEL710 Landfills and Ash Ponds**
3 credits (3-0-0)
Integrated solid waste management of municipal solid waste, hazardous waste, coal ash and other wastes; Landfilling practice for different types of solid wastes; Municipal solid waste landfills: acceptability of waste; planning, design, construction, operation and closure including management of leachate and gas; Hazardous waste landfills: Waste compatibility and acceptability; planning, design, construction, operation, closure and environmental monitoring; Ash ponds: Slurry disposal versus dry disposal; Engineering properties of bottom ash, fly ash and pond ash; planning and design; incremental raising of height by upstream and downstream methods; closure and reclamation.

**CEL711 Special Topics in Geotechnical and Geoenvironmental Engineering**
3 credits (3-0-0)
A course which will vary from year to year to study new and existing developments in the broad spectrum of Geotechnical and Geoenvironmental Engineering. The course will also focus on new offshoots of Geotechnical and Geoenvironmental Engineering.

**CEL712 Soil-Structure Interaction Analysis**
3 credits (3-0-0)
Introduction: Analysis of foundations and flexible retaining structures by conventional method: isolated and combined footings, mats, pile caps, eccentrically loaded foundations, transmission tower foundations, sheet pile walls; Soil-structure interaction: Subgrade reaction method; Beam and plate theories; Analysis of footings, mats, pile caps, laterally loaded piles, sheet pile walls, water front structures; Elastic half-space method: Closed form solutions, charts and FEM-footings, mats, reinforced foundations and embankments. Evaluation of relevant material parameters. Use of appropriate software packages.

**CEL713 Advanced Structural Analysis**
3 credits (3-0-0)

**CEL714 Design of Steel Structures**
3 credits (3-1-0)
**CEL721 Design of Concrete Structures**
3 credits (2-1-0)
Limit state design concepts in flexure, shear, torsion and combined stresses; slender columns. Safety and serviceability: control of cracks and deflections. Yield line analysis of slabs: work and equilibrium methods. Introduction to limit design of beams and frames. Design of statically determinate prestressed concrete structures for flexure and shear.

**CEL722 Solid Mechanics in Structural Engineering**
3 credits (3-0-0)
Theories of stress and strain; Finite deformations and linearization; Compatibility relations; Equations of motion; General theory of constitutive equations; Stress-strain relations for linear elastic solids. Types of elasticity problems and methods of their solution with illustrative examples for isotropic solids. Displacement potentials and stress functions; Torsion; Mechanical principles; Energy theorems; Hypoelastic and hyperelastic solids; Conservative structures. St. Venant’s principle; Limitations of the structural theory; Elastic waves; Thermoelasticity; Theory of perfect plasticity; Yield criteria, and Flow rules; Viscoelasticity; Rheological models; Superposition and correspondence principles. Viscoplasticity.

**CEL724 Earthquake Analysis and Design**
3 credits (3-0-0)
Seismology, seismic risk and hazard, Soil dynamics and seismic inputs to structures, Response spectrum analysis, Spectral analysis, Nonlinear and push over analysis, Dynamic soil-structure interaction. Earthquake design philosophy, codal provisions for seismic design; retrofitting and strengthening of structures; concept of base isolation design and structural control.

**CEP724 Water Resources Management Laboratory**
3 credits (1-0-4)
Field based experiments: Soil moisture tension measurement, Capillary pressure, Soil moisture, Infiltration capacity, Soil salinity, Soil nutrients, Water quality; Map reading, impact of changes in land use through map preparation, Use of GIS and remote sensing, Computer based simulation/design, Database design, Water hammer analysis, Design of water distribution network, Applications of Kriging and Neural networks in water resources.

**CEP726 Structural Engineering Laboratory**
3 credits (0-0-6)
Concrete: Concrete mix design and testing, non-destructive testing of concrete. Reinforced concrete: under-reinforced and over-reinforced beams, columns under eccentric loading, two-way reinforced slabs. Model testing: Models of plates and shells and frames under static and dynamic loading, free and forced vibrations using MTS, dynamic modulus. Stress analysis: two and three-dimensional photoelasticity.

**CEL727 Design of Industrial Structures**
3 credits (2-1-0)

**CEL729 Advanced Design of Bridges**
3 credits (2-1-0)

**CEL731 Prestressed/ Composite Structures**
3 credits (3-0-0)
Need for prestressing; Pretensioning and Post-tensioning methods; Behaviour of prestressed concrete beams; Loss of prestress; Deflections; Bursting forces in anchorage zone; Design methods; Partial prestressing; Analysis of indeterminate structures. Need of composite construction; Design methods for composite beams, slabs, columns and box-girders; Behaviour of masonry elements and walls; Design methodology; Stability of columns and walls; Seismic design of reinforced and prestressed masonry.

**CEL733 Finite Element Method in Structural Engineering**
3 credits (2-1-0)
Review of principles of virtual work and minimum potential energy. Elements of theory of elasticity. Various types of finite elements. Solution procedures. Detailed study of application to structures such as dams, frame-shear walls, grid floors and rafts. Application to vibration and buckling problems.

**CEL734 Mathematical and Numerical Methods**
3 credits (2-1-0)

**CEL735 Hydrologic Processes and Modeling**
3 credits (3-0-0)

**CEL736 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.

**CEL737 Optimisation Techniques in Water Resources**
3 credits (3-0-0)
Optimization techniques; Linear programming, Non-linear programming, Geometric programming, Dynamic programming, Network flow algorithm and Goal programming, Introduction to modern heuristic methods like generic algorithm and simulated annealing.

**CEL738 Advanced Hydraulics**
3 credits (3-0-0)
Energy and momentum principles in open channel, Curvilinear flows, Backwater computations, Controls, Rapidly varied flows, Spatially varied flows, Unsteady flow, Surges, Flood wave passage, Roll waves, Sediment transport, Incipient motion criteria, Resistance to flow and bed forms, Bed load theory, Stratified flows, Fluvial Systems, Industrial Hydraulics.

**CEL739 Groundwater Hydrology**
3 credits (3-0-0)
Occurrence and movement of groundwater. Surface and subsurface investigation of groundwater, Flowthrough saturated porous medium. Mechanics of well flow, Aquifer parameters, Pumping tests, Design of
water wells, Monitoring well design and construction, Well development, well maintenance and rehabilitation, Natural and Artificial recharge, Unconfined and confined groundwater. Salt water intrusion, Introduction to analog and numerical models to solve ground water problems, Application of finite difference method in ground water.

**CEP740 Simulation Laboratory**
4 credits (1-0-6)
Hydrological database design and its management, Basics of computing, Discrete event simulation, Random number generation, Monte Carlo simulation, Simulation of queuing systems, Computer based hydraulic and hydrologic simulation exercises, Application of specific hydrologic and hydraulic software packages, Real time operation and online forecasting.

**CEL741 Surface Water Quality Modeling and Control**
3 credits (3-0-0)
River hydrology and derivation of the stream equation, Derivation of the estuary equation, Distribution of water quality in rivers and estuaries, Integration of hydrological and pollution models, Difference steady state river, Estuary and lake models, Dissolved oxygen models in rivers, estuaries and lakes, Fate of indicator bacteria, pathogens and viruses in water, Basic mechanisms of eutrophication, Lake phytoplankton models, River eutrophication analysis, finite segment models, Elements of toxic substance analysis.

**CEL742 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, Incompressible turbulent flow in pipes.

**CEL743 Economic Aspects of Water Resources Development**
3 credits (3-0-0)
Data requirements and survey: topographical, geological, hydrological, socioeconomic, technological; market survey; identification of alternate options and associated data requirements and survey, Project feasibility, Demand assessment: planning period and time horizon, Economic-demographic projections, integrated and disaggregated analysis and model building; demand resilience and consumer behaviour, Basic economic concepts: present worth, future worth, annuities, discounting techniques, deprivation, Production function and cost curves: components of cost curves, learning curve, expansion path, long term and short term, Estimation of project benefits and costs, Tangible and intangible values, Indifference curves, Pricing concepts: oligopolies, kinked demand curve model, skimming price and penetration price, Economics of natural resources management, Fields of finance, Financial analysis, Economic and financial models, Analysis of water resources projects in real-world settings, Benefit-cost analysis, Risk considerations, Project optimality, Mathematical models for multipurpose and multi-objective projects; Technological forecasting, Welfare and environmental economics, Capital budgeting and cost allocation.

**CEL744 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, Infiltration and Wetting front, Groundwater contamination, Sources and causes of groundwater pollution, Pollution dynamics, Hydrodynamics dispersion, 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.

**CEL745 Water Management**
3 credits (3-0-0)
Moisture-crop relationship, Irrigation requirements, Irrigation efficiencies, Design of conventional and modern methods of irrigation, Irrigation of arid lands, Drainage of irrigated land, Salinity of soil, Salinity control, Quality of irrigation water, Contaminants and their effects on various crop types, Rain water management, Planning and operation of irrigation systems, Conjunctive use of water, Participatory irrigation management, Water management policy during droughts, Predicting effect of water shortage on crops.

**CEL746 Hydroelectric Engineering**
3 credits (3-0-0)
Planning of hydropower development, Hydropower potential, Operation of power plants for peaking and base load, Characteristics of power analysis, Rule curves, Reservoir zoning, Models, Augmented plants, Pump storage plants, Small hydro power, Surge tanks and hydraulic transients, Penstocks and pressure shafts, Intakes, Reservoir operation for hydropower generation in a multipurpose projects, Basin scale hydropower generation in a multipurpose projects, Basin scale hydropower development, Mathematical models for reservoir sizing and operation.

**CEL747 Geographical Information Systems (GIS)**
3 credits (2-0-2)
Introduction to Geographical Information Systems (GIS), Databases and database management systems, Spatial databases, Coordinate systems and georeferencing, Interpolation methods: Deterministic and Statistical, Digital elevation models and their applications, Strategies for development, implementation and management of GIS, Case studies on use of GIS selected from various areas such as water and land resources, environment, transportation, etc., Projects involving creation of small GIS modules related to water resources problems and other generic areas.

**CEL748 Hydrologic Applications of Remote Sensing Technology**
3 credits (2-0-2)
Data capture for simulation of land surface processes, inventory, Geomorphology, Landuse classification, Landuse planning and landcover mapping, Flood plain mapping, Flood plain zoning, Principles of remote sensing and its applications in water resources, agriculture and environmental monitoring, Applications in snow and glacier studies, Snow line, Ice cover, Snow-pack properties, Integrated use of remote sensing and GIS, Database preparation and Decision support analysis, Estimation of damages due to hydrologic extremes and preparation of contingency plans, Case studies.

**CEL749 Water Resources Systems**
3 credits (3-0-0)
Systems concepts and its application in irrigation, flood control, hydropower generation, water supply and drainage, Storage-yield analysis, Rule curves, Reservoir zoning, Models, Augmented plants, Pump storage plants, Small hydro power, Surge tanks and hydraulic transients, Penstocks and pressure shafts, Intakes, Reservoir operation for hydropower generation in a multipurpose projects, Basin scale hydropower generation in a multipurpose projects, Basin scale hydropower development, Mathematical models for reservoir sizing and operation.

**CEL751 Engineering Properties of Rocks and Rock Masses**
3 credits (3-0-0)

Strength and deformation behaviour of discontinuities. Rockmass behaviour, Shear strength of jointed rocks, roughness, peak and residual strengths. Strength criteria for rockmass.

Intact and rockmass classifications, Terzaghi, RQD, RSR, RMR and Q
CEP751 Rock Mechanics Laboratory
3 credits (0-0-6)
Tests and test procedures, Specimen preparation, coring, cutting and lapping. Tolerance limits.
Physical Properties: Water absorption, density, specific gravity, porosity, void index, electrical resistivity and sonic wave velocity tests.
Mechanical Properties: Uniaxial compression, Point load index and Brazilian strength tests, Elastic properties. Effect of L/D ratio and saturation. Strength anisotropy.

CEL752 Slopes and Foundations
3 credits (3-0-0)

CEP752 Rock Mechanics Laboratory II
3 credits (0-0-6)
Pre-requisite: (CEP751) Project based Laboratory

CEL753 Structural Geology
3 credits (2-0-2)


CEL754 Geotechnical Processes in Rock Engineering
3 credits (3-0-0)


CEL756 Excavation Methods and Machinery
3 credits (3-0-0)
Principles of rock breakage, explosive energy, energy balance, blasting mechanism. Types of explosives, initiators, delay devices, primer and booster selection. Blast hole design. Drilling methods and machines

Blast hole timing. Pattern design, open pit and underground blasting, production, estimation and damage criteria of ground vibrations. Controlled blasting. Directional blasting. Safety aspects. Case histories.


CEL757 Field Exploration and In situ Measurements
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: percussion, rotary drilling, drill bits. Core samplers, Core boxes, Core orientations.
Deformability, plate load, pressure tunnel and bore hole tests. Strength tests, insitu compression, tension and direct shear tests. Pull out tests. Borehole extensometers, piezometers, embedment gauges, inclinometers, Slope indicators, packer tests for insitu permeability, Codal provisions.

CEL758 Analysis and Design of Underground Structures
3 credits (3-0-0)
Design : Design based on analytical methods; Empirical methods based on RSR, RMR, Q systems; Design based on Rock support interaction analysis; Observational method- NATM, Convergence-confinement method.
Design based on Wedge failure and key block analysis. Design of Shafts and hydraulic tunnels. Stability of excavation face and Tunnel portals. Use of appropriate software packages.

CEC760 Seminar
3 credits (0-0-6)

CEN760 Metro Professional Practices
2 credits (0-2-0)

CET760 Practical Training
2 credits (0-2-0)

CED760 Minor Project in Rock Engineering Under Ground Structures
3 credits (0-0-6)

CEL760 Finite Element Method in Geotechnical Engineering
3 credits (3-0-0)
Introduction. Steps in FEM. Stress-deformation analysis: One-, Two-dimensional formulations; Three-dimensional formulations; Boundary conditions; Solution algorithms; Descretization; use of FEM2D Program and Commercial packages. Analysis of foundations, dams, underground structures and earth retaining structures. Analysis of flow (seepage) through dams and foundations.

**CEL761 Underground Space Technology**  
3 credits (3-0-0)  

Ventilation, provisions, equipment. Control and monitoring system, services, operations and maintenance. Lighting, specifications, maintenance, emergency lighting. Power supply and distribution, Water supply and distribution.


**CEL762 Special Topics in Rock Engineering**  
3 credits (3-0-0)  
A course which will vary from year to year to study new and emerging developments in the broad spectrum of Rock Engineering. The course will also focus on new offshoots of Rock Engineering.

**CEL763 Environmental Rock Engineering**  
3 credits (3-0-0)  
Hazardous Earth processes. Temperature, pressure and water related problems, stress relaxation, high ground stresses, rock bursts, subsidence. Karst formations. Landslides and rock falls, slopes stabilization, mitigation, Case studies.


**CEL766 Systems Design and Value Analysis**  
3 credits (3-0-0)  

**CEL767 Construction and Contract Management**  
3 credits (3-0-0)  
Project cost estimation, rate analysis, overhead charges, bidding models and bidding strategies. Qualification of bidders, Owner's and contractor's estimate.


Contract administration, Claims, compensation and disputes, Dispute resolution techniques, Arbitration and Conciliation Act 1996, Arbitration case studies, Professional ethics, Duties and responsibilities of parties.

Management Information systems.

**CEL768 Recent Advances in Construction Materials**  
3 credits (3-0-0)  
of structures including heavy structures, Prefab construction, Industrialized construction, Modular coordination.

Special construction methods: Construction in Marine environments, High rise construction, Bridge construction including segmental construction, incremental construction and push launching techniques, River valley projects.

CEP775 Construction Engineering and Information Technology Laboratory
3 credits (0-0-6)
Test related to quality control at site, In-situ test methods, Tests related to damage assessment and performance monitoring of structures.

Spreadsheet software application in construction management, AUTOCAD, Estimation of project costs, Application of project planning software.

CEL776 Functional Planning, Building Services and Maintenance Management
3 credits (3-0-0)
Components of urban forms and their planning. Concepts of neighbourhood unit. Street system and layout in a neighbourhood.

Functional planning of buildings, optimization of space: Spatial Synthesis graphical techniques, heuristic procedures, formulation of linear and non-linear optimization problem. Space requirements and relationships for typical buildings, like residential offices, hospitals, etc.

Standard fire, fire resistance, classification of buildings, means of escape, alarms, etc.

Engineering services in a building as a systems. Lifts, escalators, cold and hot water systems, water systems, and electrical systems.


CEL777 Building Science
3 credits (3-0-0)

CEL778 Construction Methods and Equipment
3 credits (3-0-0)
Factors affecting selection of equipment - technical and economic, construction engineering fundamentals, Analysis of production outputs and costs, Characteristics and performances of equipment for Earth moving, Erection, Material transport, Pile driving, Dewatering, Concrete construction (including batching, mixing, transport, and placement) and Tunneling.

CEL779 Construction Economics and Finance
3 credits (3-0-0)

Work pricing, cost elements of contract, bidding and award, revision due to unforeseen causes, escalation. Turnkey activities, Project appraisal and project yield. Working capital management, financial plan and multiple source of finance. International finance, Budgeting and budgetary control, Performance budgeting, appraisal through financial statements, Practical problems and case studies, Project cash flow.

CEL781 Urban and Regional Transportation Planning
3 credits (2-0-2)
Fundamentals of transportation planning. Components of transportation system and their interaction. Historical development and current status of techniques used in travel demand forecasting; Economic and Social Theory of travel demand forecasting; Trip generation, trip distribution, mode choice, traffic assignment. Dimension of the widening role of urban transportation systems planning, the planning process and use, and transport system models.

CEL782 Pavement Materials and Construction Techniques
3 credits (2-0-2)

CEL783 Traffic Engineering
4 credits (3-0-2)

CEL784 Design and Maintenance of Pavements
4 credits (3-0-2)
Pavement structure. Stresses in rigid and flexible pavements, subgrade evaluation. Design of flexible, semi-flexible and rigid pavements. Temperature stresses and Joints. Pavement management System; Rehabilitation of Pavements; Pavement Inventories and Evaluation; Quality Control; Pavement Lifecycle and cost analysis. Finite Element Approach.

CEL785 Advanced Transportation Modelling
3 credits (2-0-2)

CEL786 Geometric Design of Streets and Highways
3 credits (2-0-2)
Design control and criteria, relationship of traffic to highway design, design speed, design vehicle. Highway classification, sight distances. Superrelevation, highway curves: horizontal and vertical, highway alignment and profile. Geometric design of intersections; grade separation and interchanges. Relevant IRC standards for urban and rural roads.

CEL787 Transportation Safety and Environment
3 credits (3-0-0)
Multidisciplinary approach to planning for traffic safety and injury control; precrash, crash and post crash models; roles of vehicle, roadway traffic, driver, and environment, crash and injury causations; Road Safety Audit; Mixed traffic flow; Transport related pollution; Technology Vision-2020; Urban and non-urban traffic noise sources, Noise level factors, Noise pollution; Energy related aspects of different transport technologies. Traffic Calming Measures. Road transport related air pollution, Sources
of air pollution, effects of weather conditions, Vehicular emission parameters, pollution standards, measurement and analysis of vehicular emission; Mitigative measures; EIA requirements of Highway projects, procedure; MOEF World Bank/RC/UK guidelines; EIA practices in India.

**CEL788 Public Transportation Systems**
3 credits (3-0-0)
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.

**CEL789 Transportation Systems Management**
3 credits (3-0-0)
Quick response travel evaluation procedure, TSM actions: Traffic management techniques for improving vehicular flow, preferential treatment for high occupancy modes, demand management technique for reduced traffic demand, staggered hours, vehicle restrictions. Small area management: individual sites, residential neighbourhoods, planning for pedestrians, parking planning. Travel demand management and telematics in travel planning.

**CEP789 Environmental Chemistry and Microbiology**
3 credits (1-0-4)
Chemical Equilibria and Kinetics Fundamentals. Acids and Bases; Titration; Acidity; Alkalinity; Buffers and Buffer Intensity; Chemical equilibrium calculations; pC-pH diagram, Langlier index, Solubility diagram; Oxidation and Reduction reactions. Structure of cell; Types of microorganisms found in the environment; Metabolic classification of organisms. Laboratory Procedures for determining the physical, chemical and microbial parameters of water and wastewater.

**CEP790 Advanced Environmental Engineering Laboratory**
4 credits (1-0-6)

**CEL793 Air Pollution and Control**
4 credits (3-0-2)

**CEL794 Solid and Hazardous Waste Management**
3 credits (3-0-0)

**CEL795 Water and Wastewater Treatment Processes**
3 credits (3-0-0)

**CEL796 Advanced Wastewater Treatment**
3 credits (3-0-0)
Microbiological concepts; cells, classification and characteristics of living organisms, characterisation techniques, reproduction, metabolism, microbial growth kinetics and kinetics of biochemical operations; Modelling of suspended growth systems, techniques for evaluation of kinetic and stoichiometric parameters. Optimal selection of water and waste water treatment chain, Engineered systems, concepts and principles of carbon oxidation, nitrification, denitrification, methanogenesis. Biological nutrient removal; Anaerobic treatment (process options, components of anaerobic reactions that influence process design); Attached growth reactors (process description, design and applications). Decentralised wastewater treatment systems; Low cost options, constructed wetlands. Reliability and cost effectiveness of wastewater systems.

**CEL797 Environmental Impact Assessment**
3 credits (3-0-0)

**CEL801 Advanced Rock Mechanics**
3 credits (3-0-0)

**CES810 Independent Study (Geotechnical and Geoenvironmental Engineering)**
3 credits (0-3-0)

**CED811 Major Project in Geotechnical and Geoenvironmental Engineering Part I**
6 credits (0-0-12)

**CED812 Major Project in Geotechnical and Geoenvironmental Engineering Part II**
12 credits (0-0-24)

**CEL817 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 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.

**CEL818 Design of Plates and Shells**
3 credits (2-1-0)
CEL819 Concrete Mechanics
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; Static and dynamical analysis of R.C. Structures; Trends.

CES820 Independent Study
(Structural Engineering)
3 credits (0-3-0)

CED821 Major Project Part-1
(Structural Engineering)
6 credits (0-0-12)

CED822 Major Project
Part-2 (Structural Engineering)
12 credits (0-0-24)

CEL822 Stability Theory in Structural Engineering
3 credits (3-0-0)
Finite deformation of structures elastic buckling of columns; Statical, dynamical and energy-based approaches. Eccentric loading; Nonlinear viscoelastic and elasto-plastic buckling; Flexural-torsional and lateral buckling of beams; Imperfection sensitivity; Post-buckling and catastrophe theories; Stability of nonconservative structures; Nonlinear dynamical systems theory; Chaos theory; Recent trends.

CEL824 Design of Offshore Structures
3 credits (2-1-0)

CEL826 Advanced FEM and Programming
3 credits (2-0-2)
Isoparametric formulation for plate and shell elements; various types of elements; Hybrid elements; FEM in dynamic problems, consistent mass matrix; vibration of bars, beams and plate elements; FEM in buckling problems, geometric matrix, buckling of struts and plate elements; Structural modeling by FEM for structures such as shear walls, core walls, bridges and cooling towers; Computational aspects; Interpretation of results; Comparison with other methods.

CEL828 Wind Resistant Design of Structures
3 credits (3-0-0)
Causes and types of wind; atmospheric boundary layer and turbulence, wind velocity measurements and distribution, Bluffbody aerodynamics, random vibrations and spectral analysis, alongwind and acrosswind response of tall buildings, towers and slender structures, aeroelastic phenomena, vibration of cable supported bridges and power lines due to wind effects, wind pressure on cooling towers, design of cladding and wind damping devices, wind tunnel simulations and tornado effects.

CEL832 Design of Tall Buildings
3 credits (2-1-0)

CEL836 Structural Health Monitoring
3 credits (2-0-2)
Pre-requisite: CEL719/AML734/MEL733/MEL831/MEL841/EEL731
Concept of structural health monitoring, sensor systems and hardware requirements, local and global techniques, computational aspects of global dynamic techniques, experimental model shapes, damage localization and quantification, piezo-electric materials and other smart materials, electro-mechanical impedance (EMI) technique, adaptations of EMI technique. Laboratory: Sensor installation and diagnostics, model shape extraction, location and quantification of damage using global dynamic techniques, damage detection using electro-mechanical impedance technique, remote monitoring.

CEL840 Stochastic Hydrology
3 credits (3-0-0)

CES840 Independent Study (Water Resources Engineering)
3 credits (0-3-0)

CED841 Major Project Part-1
(Water Resources Engineering)
6 credits (0-0-12)

CED842 Major Project Part-2
(Water Resources Engineering)
12 credits (0-0-24)

CEL843 Traffic Modelling and Simulation
3 credits (2-0-2)
Evaluation of various qualitative and quantitative descriptors of traffic flow, car-following analogy, Theories of Traffic Flow: Catastrophe theory, Modelling Process; Taxonomy of model types: Primitive Models; Forecasting pattern Recognition Static Equilibrium; Model's Linear Dynamical Structure; Pedestrian Flow Modelling and dynamics; Simulation of Discrete and Continuous processes; Application of macro and micro simulation packages.

CEL844 Transportation Economics and Finance
3 credits (3-0-0)
Overview of Transportation Economics; Transportation Investments and Economic Development, Basics of Engineering economics. Money value of time, discounted cash flow, NPV, ROR, PI, Bases of comparison, incremental rate of return, benefit-cost analysis, replacement analysis, break even analysis, risks and uncertainties and management decision in capital budgeting. Road User Costs; Public Transportation economics; Social Cost of Transportation; project appraisal and project yield. Legal Framework in transport Sector. Financing Transport Infrastructure; Appraisal through financial statements, practical problems and case studies.

CEL845 Transportation and Traffic Infrastructure Design
3 credits (3-0-0)
Design and drawing of grade intersections, Rotaries, Mini- roundabouts, interchanges (cloverleaf, trumpet), multilevel intersections; On-street parking facilities; Off-street parking facilities (parking lots and garages); Layout for buses and trucks; Bridges and Fly-overs; Guard rails; Culverts; Retaining Sides; Mix wells; Pedestrian sidewalks; Foot bridges; River Spans; Tunnels and Underpasses; Design of Superstructures (T-beam slab, Solid slab right skew and curved spares). Airport Terminal, Sea Port Infrastructure, Railway and Metro Structure.

CES850 Independent Study (Rock Engineering and Underground Structures)
3 credits (0-3-0)
CED851 Major Project Part-1 (Rock Engineering and Underground Structures) 6 credits (0-0-12)

CED852 Major Project Part-2 (Rock Engineering and Underground Structures) 12 credits (0-0-24)

CEL866 Infrastructure Development and Management 3 credits (3-0-0)
Introduction of Indian infrastructure programme, qualitative and quantitative description of various sectors of infrastructure; life cycle; methodologies for planning - economic evaluation and feasibility study; Issues related to environmental and social impact of infrastructure projects; Regulatory framework for different sectors.

Financial modeling - life cycle cost; cash flow; internal rate of return; Benefit cost analysis. Financing schemes; Grant, Government policies and incentives; Fixing of Toll charges/Tariff; Option pricing.

Infrastructure risks - type and impacts. Assessment of impacts through Earned value analysis, Kalman Filter and time series analysis techniques. Risk Modeling - Monte Carlo simulation; decision tree; fault tree; utility theory, AHP. Policies and guidelines.

Private sector participation - public-private-partnership models, BOT, BOOT, BOO. Forms of concession agreement, financial closure.

Domestic and international experiences; case studies.

CEL867 Sustainable Materials and Green Buildings 3 credits (3-0-0)

CES870 Independent Study (Construction Engineering & Management) 3 credits (0-3-0)

CED871 Major Project Part-1 (Construction Engineering & Management) 6 credits (0-0-12)

CED872 Major Project Part-2 (Construction Engineering & Management) 12 credits (0-0-24)

CES874 Independent Study (Construction Technology & Management) 3 credits (3-0-0)

CED875 Major Project Part-1 (Construction Technology & Management) 6 credits (0-0-12)

CED876 Major Project Part-2 (Construction Technology & Management) 12 credits (0-0-24)

CEL879 Industrial Waste Management and Audit 3 credits (3-0-0)
Nature and characteristics of industrial wastes; Prevention versus control of industrial pollution; Linkage between technology and pollution prevention; Tools for clean processes, reuse, recycle, recovery, source reduction, raw material substitution, toxic use reduction and process modifications; Flow sheet analysis; Energy and resource (material and water) audits for efficient usage and conservation; Waste audits, emission inventories and waste management hierarchy for process industries; Environmental performance indicators; Concept of industrial ecology and symbiosis of eco-parks; Case studies of various industries, e.g., dairy, fertilizer, distillery, sugar, pulp and paper, iron and steel, metal plating, refining, thermal power plants.

CED881 Major Project Part-1 6 credits (0-0-12)

CED882 Major Project Part-2 (Transportation) 12 credits (0-0-24)

CEL886 Environmental Systems Analysis 4 credits (3-0-2)
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. Introduction to Water pollution and transport and atmospheric processes. Strategies for analyzing and using environmental systems models. Application of optimization methods such as search techniques, linear programming, dynamic programming and integer programming. Integrated management strategies addressing multi-objective planning: Optimization over time. Laboratory – Simulation of Environmental Processes, Application of Environmental Databases and Environmental Software Packages, including systems Optimisation.

CEL887 Fundamentals of Aerosol : Monitoring and Modelling 3 credits (2-0-2)
Pre-requisite : CEL793/ASL808/MEL818/CHL724/ESL777
Fundamental of aerosol Technology. Principles of sampling for particles and gases in the field of air pollution; Techniques of design of air sampling systems. Laboratory experiments; Aerosol collection, methods of air sample analysis, Determination of bioaerosol. Aerosol modelling and statistical data analysis. Importance of aerosol properties in industries. Environmental impact of gases and aerosol.

CEL889 Emerging Technologies for Environmental Management 3 credits (3-0-0)
Identification and evaluation of current and emerging technological issues that impact environmental decision-making. Linkages between technology, environmental quality, economic gain, and societal goals; Contemporary issues: Environmentally sound technology transfer, emission trading, international resources sharing issues, climate change, international environmental treaties and protocols.

CES890 Independent Study (Environmental Engineering and Management) 3 credits (3-0-0)

CEL891 Thermal Techniques for Waste Treatment 3 credits (3-0-3)

CED892 Major Project Part-1 (Environmental Engineering and Management) 6 credits (0-0-12)

CED892 Major Project Part-2 (Environmental Engineering and Management) 12 credits (0-0-24)

CEL892 Air Quality Modelling 3 credits (3-0-3)
Introduction to Air Quality Modelling. Approaches to model formulation. Model classification, criteria for model selection. Air pollution meteorology – meteorological parameters, stability classification; plume
CE894 Management of Water, Waste and Sanitation Utilities
3 credits (3-0-0)

CE895 Ecology and Eco-System Dynamics
3 credits (3-0-0)
Concepts of diversity. Diversity in eco-systems and habitat classification, important types of eco-systems (e.g. Wetland eco-system including estuaries, tidal marsh lands, swamps, lakes, etc.), Forest eco-system (including tropical forests, Himalayan and sub-Himalayan forest eco-system etc.), Desert eco-system, Coastal shelf eco-system, Temperature and Tundra eco-system, Grasslands etc. Abiotic factors affecting the distribution and productivity of various terrestrial life forms. Leibig’s law of minimum. Census techniques, random sampling, various indices of species dominance, richness and abundance, species evenness and diversity. Statistical models, cluster and principal component analysis for similarity studies. Links between diversity and stability. Concept of succession and its use in reclamation. Facilitation, enablement, Trophic structure, food webs, energy flow diagram, nutrient cycles. Restoration, Reclamation, and Regeneration of Degraded or Destroyed Ecosystems.

CE896 Design of Water and Wastewater Facilities
3 credits (3-0-0)

CE897 Membrane Processes for Water and Waste Treatment
3 credits (3-0-0)

CE898 Life Cycle Analysis and Design for Environment
3 credits (3-0-0)

CE899 Environmental Risk Assessment
3 credits (3-0-0)
Basic concepts of environmental risk and definitions; Hazard identification procedures; Environmental Risk Zonation; Consequence analysis and modeling (discharge models, dispersion models, fire and explosion models, effect models etc). Estimation of incident frequencies from historical data, frequency modeling techniques e.g., Fault Tree Analysis (FTA) and Event Tree analysis (ETA). Case studies. Human factors in risk analysis; Calculation and presentation of risk (individual risk, societal risk); Risk management. Rules, regulations and conventions.
CSL630 Data Structures and Algorithms
4 credits (3-0-2)
Review of basic data structures and their realization in object oriented environments. The following topics will be covered with emphasis on formal analysis and design. Dynamic Data structures: 2-3 trees, Red-black trees, binary heaps, binomial and Fibonacci heaps, Skip lists, universal hashing. Data structures for maintaining ranges, intervals and disjoint sets with applications. Basic algorithmic techniques like dynamic programming and divide-and-conquer. Sorting algorithms with analysis, integer sorting, selection. Graph algorithms like DFS with applications, MSTs and shortest paths.

CSL632 Introduction to Data Base Systems
4 credits (3-0-2)
Evolution and architecture of DB systems, DB models. The relational DB model, operations on the relational model. The database language SQL, constraints and triggers in SQL, system aspects of SQL. Object-oriented query languages. XML databases.

CSL633 Resource Management in Computer Systems
4 credits (3-0-2)
Overview: functions of operating systems, layered architecture; basic concepts; interrupt architecture, system calls and notion of a process and threads; synchronization and protection issues; scheduling; memory management including virtual memory management and paging techniques; I/O architecture and device management; file systems; distributed file systems; Case studies of Unix, Windows NT. Design and implementation of small operating systems.

CSL671 Artificial Intelligence
4 credits (3-0-2)

CSL672 Computer Networks
4 credits (3-0-2)
Networks, goals, applications, classification, layered architecture. Open system interconnection model. Statistical multiplexing; Point to point and broadcast communications, multi access protocols: Aloha, CSMA and its variations, Token Ring; Error Control techniques; Flow control; Data link layer protocols; Bridges, Repeaters, switches and the spanning tree protocol. Routing, Congestion control, Internet protocols; Multiple Routing and reliable Multicast. Mobile IP Laboratory exercises will focus on the students ability to use these protocols in practical systems.

CSP701 Software Systems Laboratory
3 credits (0-0-6)
A set of four 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 (noweb and LaTeX), lex, yacc, perl and other scripting languages, sockets and RPCs, usage of standard libraries like ptthreads, numerical packages, XML and semi-structured data, simulation environments, testing and validation tools.

CSL705 Theory of Computation
4 credits (3-1-0)
Pre-requisites: CSL105 & EC90
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.

CSL718 Architecture of High Performance Computers
4 credits (3-0-2)
Pre-requisites: CSL373
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.

CSL719 Synthesis of Digital Systems
4 credits (3-0-2)
Pre-requisites: CSL316
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.

CSL724 Advanced Computer Networks
4 credits (3-0-2)
Pre-requisites: CSL374
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.

CSL728 Compiler Design
4.5 credits (3-0-3)
Pre-requisites: CSL302
Overlaps with: EEL702
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. Algorithms and implementation techniques for type-checking, code-generation and optimization. Students will design and implement translators, static analysis, typechecking, and optimization.

CSL730 Modern Parallel Programming
4 credits (3-0-2)
Pre-requisites: CSL201 and CSL373
Parallel performance metrics, Models of parallel computation, Parallel computer organization, Parallel programming environments, Load distribution, Throughput, Latency and Latency hiding, Memory and Data Organizations, Inter-process communication, Distributed memory architecture, Interconnection network and routing, Shared memory architecture, Memory consistency, Non-uniform memory, Parallel Algorithm techniques: Searching, Sorting, Prefix operations, Pointer Jumping, Divide – and – Conquer; Partitioning, Pipelining, Accelerated Cascading, Symmetry Breaking, Synchronization (Locked/Locked-free).

CSL732 Virtualization and Cloud Computing
4 credits (3-0-2)
Pre-requisites: CSL373
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.

**CSL740 Software Engineering**  
4 credits (3-0-2)  
Pre-requisites: CSL201 & CSL302  
Overlaps with: MAL745  

**CSL759 Cryptography and Computer Security**  
4 credits (3-0-0)  
Pre-requisites: CSL356 or equivalent, MAL250 or equivalent  
Overlaps with: MAL724, MAL730, MAL786  
Classical ciphers; private key encryption; hash functions; SHA1, MD5; message authentication; HMAC; pseudorandom permutations: AES, DES; theoretical foundations: one-way functions, pseudorandom generators, number theory; public key encryption: RSA, Rabin, knapsack; digital signatures: RSA, El Gamal, Rabin; key distribution: Diffie-Hellman; protocols: oblivious transfer, bit commitment, coin flipping, secret sharing, digital cash, elections; other topics: payments, biometrics, virus & worms, large scale cryptanalysis, identity based encryption etc.

**CSL765 Introduction to Logic and Functional Programming**  
4 credits (3-0-2)  
Introduction to declarative programming paradigms. The functional style of programming, paradigms of development 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 pattern-matching and programming of higher order functions within a logic programming framework. Introduction to symbolic processing. The use of resolution and theorem-proving techniques in logic programming. The relationship between logic programming and functional programming.

**CSS799 Independent Study**  
3 credits (0-3-0)  
Research oriented activities or study of advanced subjects outside the department, is undertaken by one or two students.
regular course offerings under the guidance of a faculty member. Prior to registration, a detailed plan of work should be submitted by the student, in concurrence with a faculty guide, to the Head of the Department for approval.

**CSL812 System Level Design and Modelling**
3 credits (3-0-0)
Pre-requisites: CSL719
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.

**CSL821 Reconfigurable Computing**
3 credits (3-0-0)
Pre-requisites: CSL316 and EC 120
FPGA architectures, CAD for FGAs: 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.

**CSL830 Distributed Computing**
3 credits (3-0-0)
Pre-requisites: CSL73 & CSL705

**CSL831 Semantics of Programming Languages**
3 credits (3-0-0)
Pre-requisites: CSL302 & CSL303 and EC 120
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.

**CSL832 Proofs and Types**
3 credits (3-0-0)
Pre-requisites: CSL302 & CSL303 and EC 120

**CSL838 Wireless Networks**
3 Credits (3-0-0)
Pre-requisites: CSL374 / CSL672
Radio signal propagation, advanced modulation and network coding, medium access techniques, cross layer interactions, self – configurable networks, mesh networks, TCP over wireless, mobility, wireless security, emerging applications and pervasive computing.

**CSL840 Computer Vision**
4 credits (3-0-2)
Pre-requisites: EC 120
Overlaps with: EEL806

**CSL847 Distributed Algorithms**
3 credits (3-0-0)
Pre-requisites: CSL356 & CSL373 and EC 120
Models of synchronous and asynchronous distributed computing systems: synchronous networks, asynchronous shared memory, asynchronous networks etc.; basic algorithms for synchronous and asynchronous networks: leader election, breadth first search, shortest path, minimum spanning tree etc.; advanced synchronous algorithms: distributed consensus with failures, commit protocols; asynchronous shared memory algorithms: mutual exclusion and consensus; relationship between shared memory and network models; asynchronous networks with failures.

**CSD851 Major Project Part 1 (CO)**
6 credits (0-0-12)
Pre-requisites: EC 165
Overlaps with: CSD853
This project spans also the course CSD852. Hence it is expected that the problem specification and the milestones to be achieved in solving the problem are clearly specified.

**CSL851 Algorithmic Graph Theory**
3 credits (3-0-0)
Pre-requisites: CSL356 and EC 120
Overlaps with: MAL376

**CSD852 Major Project Part 2 (CO)**
14 credits (0-0-28)
Pre-requisites: CSD851
Overlaps with: CSD854
The student(s) who work on a project are expected to work towards the goals and milestones set in CSD851. 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 by each student.

**CSL852 Computational Geometry**
6 credits (3-0-3)
Pre-requisites: CSL356
Visibility problems and triangulation. Line sweep and angle sweep: segment intersection, area, perimeter, diameter, width. Planar Point location: Kirkpatrick’s hierarchy, Persistent data structure, Multidimensional data structures: Segment trees, range trees, orthogonal range searching, Convex hulls and Voronoi diagrams: 2d, 3d hulls, 2d Voronoi diagrams, dynamic maintenance, Duality between hulls and Voronoi diagrams, Duality between lines and points, higher order Voronoi diagrams Arrangements : Construction and bounds, k-sets, Zone theorem Algebraic lower bounds: Linear Decision model Ben-Or’s theorem Randomized algorithms: Random sampling, Incremental construction, Backward analysis Optimization : Monge matrices, Fixed dimensional linear programming, Prune and Search Parametric search: kth intersection, k-th nearest neighbour. Recent topics : Instructor’s choice.

**CSD853 Major Project Part 1 (CO)**
4 credits (0-0-8)
Pre-requisites: EC 165
Overlaps with: CSD851
This project spans also the course CSD854. Hence it is expected that the problem specification and the milestones to be achieved in solving the problem are clearly specified.

**CSL853 Complexity Theory**
3 credits (3-0-0)
Pre-requisites: CSL705 & CSL356
Turing machines and non-determinism, models of computation like RAM and pointer machines, Relations between complexity classes,

**CS854 Major Project Part 2 (CO)**
16 credits (0-0-32)
Pre-requisites: CS853
Overlaps with: CS852
The student(s) who work on a project are expected to work towards the goals and milestones set in CS853. 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 by each student.

**CS854 Approximation Algorithms**
3 credits (3-0-0)
Pre-requisites: CS356 and EC 120

**CS855 Models of Computation**
3 credits (3-0-0)
Pre-requisites: EC 120, CLS 356 / CLS 630

**CS856 Mathematical Programming**
3 credits (3-0-0)
Pre-requisites: EC 120, CS 356 or ( CS 105 and MAL 124)
Overlaps with: MAL 365

**CS857 Randomized Algorithms**
3 credits (3-0-0)
Pre-requisites: CSL356
Overlaps with: CSL630, CSL758, CSL851, CSL854
Moments and deviations; Chernoff bounds; Occupancy problems; The probabilistic method; Markov chains and random walks; Martingales; Randomized Rounding; Hashing; Randomized data structures and geometric algorithms; Approximation algorithms and approximate counting; Randomized graph algorithms; Online algorithms.

**CS859 Advanced Computer Graphics**
4 credits (3-0-2)
Pre-requisites: CSL781

**CS860 Special Topics in Parallel Computation**
4 credits (3-0-2)
Pre-requisites: CSL201, CSL737 and EC 120
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.

**CS861 Special Topics in Hardware Systems**
3 credits (3-0-0)
Pre-requisites: EC 120
Under this topic one of the following areas will be covered: Fault Detection and Diagnosability. Special Architectures. Design Automation Issues. Computer Arithmetic, VLSI.

**CS862 Special Topics in Software Systems**
3 credits (3-0-0)
Pre-requisites: EC 120
Special topic that focuses on state of the art and research problems of importance in this area.

**CS863 Special Topics in Theoretical Computer Science**
3 credits (3-0-0)
Pre-requisites: EC 120
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.

**CS864 Special Topics in Artificial Intelligence**
3 credits (3-0-0)
Pre-requisites: CSL433
Under this topic one of the following areas will be covered: Issues in Expert Systems. Theorem Proving. Natural Language Processing. AI in Speech and Computer Vision. Higher Order Logic Programming, Machine Learning, Advanced Neural Networks.

**CS865 Special Topics in Computer Applications**
3 credits (3-0-0)
Pre-requisites: EC 120
Special topic that focuses on special topics and research problems of importance in this area.

**CS866 Special Topics in Algorithms**
3 credits (3-0-0)
Pre-requisites: EC 120
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.

**CS867 Special Topics in High Speed Networks**
3 credits (3-0-0)
Pre-requisites: EC 120
Research level issues and problems of current interest in the area.

**CS868 Special Topics in Database Systems**
3 credits (3-0-0)
Pre-requisites: EC 120
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.

**CSL869 Special Topics in Concurrency**  
3 credits (3-0-0)  
Pre-requisites: EC 120  
The course will focus on research issues in concurrent, distributed and mobile computations. Some of the following topics will be covered: 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.

**CSV880 Special Module in Parallel Computation**  
1 credit (1-0-0)  
Pre-requisites: EC 120  
Special module that focuses on special topics and research problems of importance in this area.

**CSV881 Special Module in Hardware Systems**  
1 credit (1-0-0)  
Pre-requisites: EC 120  
Special module that focuses on special topics and research problems of importance in this area.

**CSV882 Special Module in Software Systems**  
1 credit (1-0-0)  
Pre-requisites: EC 120  
Special module that focuses on special topics and research problems of importance in this area.

**CSV883 Special Module in Theoretical Computer Science**  
1 credit (1-0-0)  
Pre-requisites: EC 120  
Special module that focuses on special topics and research problems of importance in this area.

**CSV884 Special Module in Artificial Intelligence**  
1 credit (1-0-0)  
Pre-requisites: EC 120  
Special module that focuses on special topics and research problems of importance in this area.

**CSV885 Special Module in Computer Applications**  
1 credit (1-0-0)  
Pre-requisites: EC 120  
Special module that focuses on special topics and research problems of importance in this area.

**CSV886 Special Module in Algorithms**  
1 credit (1-0-0)  
Pre-requisites: EC 120  
Special module that focuses on special topics and research problems of importance in this area.

**CSV887 Special Module in High Speed Networks**  
1 credit (1-0-0)  
Pre-requisites: EC 120  
Special module that focuses on special topics and research problems of importance in this area.

**CSV888 Special Module in Database Systems**  
1 credit (1-0-0)  
Pre-requisites: EC 120  
Special module that focuses on special topics and research problems of importance in this area.

**CSV889 Special Module in Concurrency**  
1 credit (1-0-0)  
Pre-requisites: EC 120  
Special module that focuses on special topics and research problems of importance in this area.

**CSD893 Major Project - Part 1**  
5 credits (0-0-12)  
Research and development projects based on problems of practical and theoretical interest. First part of a two semester long project activity. Problem definition, background research, development of overall project plan (detailed design, milestones, etc.), and meeting the research and development targets set up for the first part. Evaluation will be based on student seminars, written reports, and evaluation of the developed system and/or theories.

**CSD894 Major Project - Part 2**  
12 credits (0-0-24)  
Second part of the two semester project. The primary objective is to meet the milestones defined in the first part. Evaluation will be held periodically, and will be based on written reports, oral presentations and demonstration of results. The project will culminate in the production of a thesis by each individual student. Final evaluation will be according to the M.Tech. project evaluation guidelines.

**CSD895 Major Project (M.S. Research)**  
40 credits (0-0-80)
Department of Electrical Engineering

**EEL601 Computer Architecture**  
3 credits (3-0-0)  

**EEL602 Operating Systems**  
4 credits (3-0-2)  

**EEL641 Electrical Equipments in Power Plants**  
3 credits (3-0-0)  
Review of Electromechanical energy conversion, synchronous generator: constructional features, excitation systems, factors affecting emf generation, armature windings, armature reaction, synchronous reactance, voltage regulation, effect of saliency, grid connected operation, cooling system, capability chart, basic concepts of stability. 3-phase induction motors: constructional features, rotating magnetic field, torque-equation, equivalent circuit, starting, speed control, braking modes of operation, solid state control of induction motors; abnormal operation of induction motors. DC supply system in power plants, circuit breakers, condition monitoring of power plant equipment.

**EEP691 Basic Electrical Engineering Lab**  
1 credit (0-0-2)  
Basic experiments related to basic electrical networks, electrical machines, power systems and power electronics.

**EED701 Minor Project (Computer Technology)**  
2 credits (0-0-4)  
EEP701 Digital System Lab  
2 credits (0-0-4)  
Students will design, implement and experiment with digital systems. This will include ASIC design, FPGA based design and micro-controller/processor/DSP based embedded system design and relevant hardware and software development and experimental evaluation and verification.

**EEL702 Computer System Software**  
4 credits (3-0-2)  
Pre-requisites: CSL201 & EEL308  
Overlaps with: CSL728  
Introduction to Object Oriented Programming and Object Oriented Design. Use of UML in Software design. System software design issues. Language Translators, Assemblers, Linkers and Loaders. Runtime environment management. Lab exercises related to these topics.

**EEP702 Software Laboratory**  
2 credits (0-0-4)  
Students are expected to work under Windows and/or LINUX/UNIX environments on experiments related to the following topics: advanced data structures and algorithms, compilers, GUI, component-based software design, distributed and web based applications, database applications.

**EEL703 Computer Networks**  
3 credits (3-0-0)  
Pre-requisites: EEL306  
Overlaps with: CSL374, CSL858  

**EEP703 Computer Networks Lab**  
2 credits (0-0-4)  
Simulation and Hardware Experiments on different aspects of Computer Networks. Like simple queues, queues with feedback, network of queues, discrete event simulation techniques, etc.

**EEL704 Robotics and Automation**  
3 credits (3-0-0)  
Pre-requisites: EEL301  

**EEV704 Special Module in Computers**  
1 credit (1-0-0)  
Pre-requisites: CSL201 and EC 90  
Details will be decided by the course coordinator.

**EEL705 Embedded Systems and Applications**  
3 credits (3-0-0)  
Pre-requisites: EEL308  
Overlaps with: CSP413, MEL432, EEL375  

**EEL706 Soft Computing**  
3 credits (3-0-0)  
Pre-requisites: MAL220 / MAL250  
Overlaps with: MAL717, MAL720, EEL781  
Introduction to Soft Computing: Rationale and Basics of Learning: Neural Networks: Multi-layer Feed-forward Networks, Recurrent Networks, Self-organising Networks; Fuzzy Logic: Basics, inferencing scheme, Neuro-Fuzzy systems; Evolutionary Algorithms: GA and Optimisation, Evolutionary Systems, Genetic Programming; Introduction to Rough Sets, Rough-Fuzzy representations, Belief Networks; Principles of SVM; Applications.
EEL707 Multimedia Systems
4 credits (3-0-2)
Pre-requisites: EEL205 & EEL258

EEL708 Information Retrieval
3 credits (3-0-0)
Pre-requisites: CSL201
Introduction – What is IR; Applications and significance; retrieval evaluation; Query Modeling and Query Languages; Indexing and Searching Text; Multimedia IR: Models, indexing, searching; User Interfaces and Visualisation; Distributed IR; Web Search Engines; Digital Libraries.

EEL709 Pattern Recognition
3 credits (3-0-0)
Pre-requisites: MAL250
Introduction – What is Pattern Recognition? Applications and Relation with other fields like Data Mining, Information Retrieval, etc.; Linear Discriminant Functions and its Applications; Bayesian Decision Theory; Maximum-Likelihood and Bayesian Parameter Estimation; Component Analysis, Expectation Maximisation, Hidden Markov Model; Non-parametric Techniques; Nearest Neighbour, K-NN; Non-metric Methods; Decision Trees, ID3, Grammar based Methods; Neural Network Based Approaches; Introduction to Fuzzy Logic Based Techniques; Support Vector Machine; Applications.

EEL710 Coding Theory
3 credits (3-0-0)
Pre-requisites: EEL306
Measure of information; Source coding; Communication channel models; Channel Capacity and coding; Block codes; Cyclic codes; BCH codes; Reed Solomon codes; Convolutional codes; Trellis coded modulation; Introduction to cryptography.

EEL711 Signal Theory
3 credits (3-0-0)
Pre-requisites: EEL306
Deterministic and random signals; 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 Ricean; exponential; chi-squared; gamma; Signal spaces: convergence and continuity; linear spaces, inner product spaces; basis, Gram-Schmidt 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.

EEL712 Optical Communication Systems
3 credits (3-0-0)
Introduction to optical communications, Optical signaling schemes viz., IM, PL, PCM, PCM/PL, digital PPM, PRM, PFM etc., video signal, electro-optic modulators; Various receiver configurations, noise sources in optical communication, direct detection receiver, optimum gain in APD, signal-to-noise ratio (SNR) calculations, Optimization of SNR, optical preamplifier design, Optical line coding schemes, performance evaluation of various optical receivers and their comparative study, Applications of optical amplifier in the system, Optical fiber link design, power budget, noise budget and maximum link length calculation, hybrid fiber co-axial/microwave links, fiber-in-the loop (FITL)- FTTH/FFTB, FTTC. WDM Systems. Energy efficient machines. Special induction generators for renewable energy-Wind, bio and small hydro systems.

EEL713 Microwave Theory and Circuits
3 credits (3-0-0)
Pre-requisites: EEL207

EEL714 Information Theory
3 credits (3-0-0)
Pre-requisites: EEL205
Entropy, relative entropy, and mutual information. Asymptotic equipartition property. Entropy rates of a stochastic process, Markov chains. Data compression: Kraft inequality, Huffman codes. Channel capacity: symmetric channels, channel coding theorem, Fano’s inequality, feedback capacity. Differential entropy. The Gaussian channel: bandlimited channels, channels with coloured Gaussian noise, Gaussian channels with feedback. Rate distortion theory: rate distortion function, strongly typical sequences, computation of channel capacity. Network information theory: Gaussian multiple user channels, the multiple access channel, encoding of correlated sources, the broadcast channel, the relay channel, source coding and rate distortion with side information, multiterminal networks.

EEL715 Image Processing
4 credits (3-0-2)
Pre-requisites: EEL205 and EC 90
Overlaps with: MAL715, CSL783

EEL716 Telecommunication Switching and Transmission
3 credits (3-0-0)
Pre-requisites: EEL306
Basic line circuits, long haul circuits, signaling, switching exchanges, analysis of telecom switching networks, teletraffic engineering, management protocols, multi-service telecom protocols and networks.

EEL717 Signals & Communications
3 credits (3-0-0)
Pre-requisites: EEL306
Representation of one- and two-dimensional deterministic signals, transmission of signals through linear networks, convolution theorem, probabilistic concepts and random signals, density and distribution functions, statistical averages, transformation, random processes, noise, representation of narrowband noise, review of linear and exponential modulations, sampling theorem, pulse modulation systems, PCM and DM, noise performance of analog modulation schemes.

EEL718 Statistical Signal Processing
3 credits (3-0-0)
Pre-requisites: MAL250 & EEL205
To provide an introduction to fundamentals of statistical characterization and analysis of signals, ideas of estimation, optimal linear filtering, geometric ideas, autocorrelation matrices and their properties, eigen-analysis, linear prediction, KL-expansion, factorization of autocorrelation matrices, Kalman filtering, least-squares filtering, adaptive filtering theory, LMS, RLS, and other algorithms, Singular Value Decomposition (SVD), fundamentals of array signal processing.

EEL719 Communication Laboratory I
2 credits (0-0-4)
Experiments related to Communication.

EEL720 Communication Laboratory II
2 credits (0-0-4)
Experiments related to Microwaves.
EEP719 Communication Engineering Laboratory - II
2 credits (0-0-4)
Pre-requisites: EEL713
Experiments on microwave measurement techniques, antennas and design of microwave circuits.

EE5720 Independent Study (Control & Automation)
3 credits (0-3-0)

EEL721 Linear System Theory
3 credits (3-0-0)
Review of matrices and linear vector space including semigroup, group, rings and fields, state variable modelling of continuous and discrete time systems, linearization of state equations, solution of state equations of linear time-invariant and time-varying systems. Controllability and observability of dynamical systems. Minimal realization of linear systems and canonical forms. Liapunov's stability theory for linear dynamical systems.

EEL723 Microprocessor Based Industrial Control
3 credits (3-0-0)
Process Control Computer Systems: Minis, micros, classification by hardware features and software facilities, performance evaluation techniques.
Characteristics of Digital Processors: Organization, instruction set, characteristics for process control, input/output arrangements, addressing techniques, memory systems.
Process Control System Software: Review of availability of process control languages, application packages, operating system for real-time process control.
Development Tools: Development systems for micros, software tools, logic analyser, cross assemblers and compilers, simulators, emulators, in-house vs. turn-key trade off.

EEP725 Control Laboratory
3 credits (0-0-6)

EEV729 Special Module in Advanced Control
1 credits (1-0-0)
Pre-requisites: EEL301 and EC 90

EEL731 Digital Signal Processing
3 credits (3-0-0)

EEL732 Microelectronics
3 credits (3-0-0)
Other devices: High frequency transistors. Metal Semiconductor contacts (Schottky diodes) and MESFET.
Device Modelling: Bipolar devices Gummel Poon model and RC distributed model.
MOS devices: Long channel modes, short channel structures and scaled down device models, sub-threshold conduction.

EEL734 MOS VLSI
3 credits (3-0-0)
The basic MOS inverter, transfer characteristics, logic threshold. NAND and NOR logic. Transit times and inverter pair delay. Depletion and enhancement loads. Technological options in MOS processing. CMOS. Design considerations in combinational logic, shift register arrays. Register to register transfers. MOS memories and programmable logic arrays. Non-volatile memories with MOS technology. Short channel structures. Scaled down MOS performance. Other MOS LSI considerations.

EEP735 I.E.C. Laboratory I
3 credits (0-0-6)
Design and development of electronic circuits using analog and digital ICs (Application Lab).

EEL736 Medical Electronics
3 credits (3-0-0)
Pre-requisites: EEL204

EEP736 Physical Design Lab
3 credits (0-0-6)

EEL741 Modelling and Analysis of Electrical Machines
3 credits (3-0-0)
Pre-requisites: EEL203
Energy state functions, Modelling of electromechanical systems Matrix method and use of generalised circuit theory of machines. Different methods of transformation, phase variable instantaneous symmetrical component techniques. Development of basic performance equation and analysis of different rotating machines such as D.C., synchronous and induction machines, Dynamics and transients in electric machines. Switching transients and surges. Transient and short circuit studies on alternators Run-up resetting and other transients in induction machines relevant computer techniques for machine analysis. Modelling of special electrical machines.

EEL742 Physical Phenomena in Machines
3 credits (3-0-0)

EEL743 Power Electronics Devices and D.C. Converters
3 credits (3-0-0)

EEL744 A.C. Controller
3 credits (3-0-0)

Concept of three-phase to single phase and single phase to three-phase cyclo-converter envisaged.

Symmetrical and asymmetrical control. Harmonic analysis of the output voltage. Effect of source inductance. Line commutated inverter: Single phase and three-phase inverters, configurations of VSI & CSI. Concept of PWM techniques single and multiple pulse form, periodic and DC level modulation strategies. Reduction of harmonics. Software and hardware methods of generating firing pulses. Approach to basic design of inverters. VSCF concept as applied to inverters. STATCON, SVC, UPS, SMPS.

EEL745 Electrical Drives System
3 credits (3-0-0)

EEL746 Non-conventional Energy Sources and Energy Converters
3 credits (3-0-0)
Review of various energy sources. Importance of unconventional sources such as solar, biogas, wind, tidal etc. Study of typical energy converters such as high performance motors, special generators driven by biogas engines, wind turbines etc. Mini-hydro generators.

Modern state-of-the art and futuristic systems in this area.

EEL747 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 FKW 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.

EEL748 Power Quality
3 credits (3-0-0)
Pre-requisites: EEL303
Overview and definition of power quality (PQ) Sources of pollution, international power quality standards, and regulations, Power quality problems: rapid voltage fluctuations voltage unbalance, voltage dips and voltage swells, short duration outages, Power system harmonics: harmonic analysis, harmonic sources: the static converters, transformer magnetization and non-linearities, rotating machines, arc furnaces, fluorescent lighting. Harmonic effects within the power system, interference with communication Harmonic measurements. Harmonic elimination-harmonic filters.

EEL749 Special Electromechanical Devices and Systems
3 credits (3-0-0)
Pre-requisites: EEL203
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.
EEL762 Digital Communications
3 credits (3-0-0)


Layered architecture. Packet networks and multiple-access communication.

EEL763 Monolithic Microwave Integrated Circuits & Technology
3 credits (3-0-0)

History of Monolithic Microwave Integrated circuits. Monolithic circuit components Planar Transmission Lines, Lumped and Distributed Passive Elements, GaAs MESFET. Other active devices. Metal semi-conductor functions and their characterisation. Physical and Modelling of GaAs MESFET & HEMT.


EEL764 Sonar Signal Processing
3 credits (3-0-0)


EEL765 Sonar System Engineering
3 credits (3-0-0)


EEL766 Numerical Techniques in Electromagnetics
3 credits (3-0-0)


Variational method: Derivation of variational expression; Euler-lagrangian equation: Rayleigh-Ritz method.

Finite element method: Discretization of solution region: shape functions: element matrices and global matrix; method of solution. Method of moments; Basis functions; weighted residuals; method of least squares; numerical integration.

EEL767 Telecommunication Systems
3 credits (3-0-0)

Fundamentals of signals, signal transmission and media, modulation techniques, equalization, amplification, crosstalk, attention, switching principles, telephony, signaling, transmission systems-DSL, optical radio.

EEL768 Detection and Estimation Theory
3 credits (3-0-0)

Pre-requisites: EEL306


EEL769 Digital Communication and Information Systems
3 credits (3-0-0)


Information Theory, Concept of information, Entropy, information rate, Coding to increase average information per bit, Shannon's theorem, Capacity of Gaussain Channel, Bandwidth-S/N tradeoff, Discrete Memoryless channel capacity, Error Correcting Codes, Parity Check, Block Codes, Cyclic Redundancy Check, Coding strength, Bit Error Rate Calculations.

EEL771 Random Processes in Control and Estimation
3 credits (3-0-0)


EEL772 Optimal Control Theory
3 credits (3-0-0)

Pre-requisites: EEL325

Electrical Engineering

EEP791 Power System Lab.I
2 credits (0-0-4)

EEL792 Power System Protection
3 credits (3-0-0)

EEL793 Power System Transients
3 credits (3-0-0)


Insulation Co-ordination : Overvoltage limiting devices, dielectric properties, breakdown of gaseous insulation, tracking and erosion of insulation, high current arcs, metallic contacts.

EEL794 High Voltage Direct Current Transmission
3 credits (3-0-0)

EEL796 Power System Control and Instrumentation
3 credits (3-0-0)

EEL797 Power System Dynamics
3 credits (3-0-0)

EEP798 Power System Lab. II
2 credits (0-0-4)

EEL799 Power System Reliability
3 credits (3-0-0)


EES800 Independent Study (Computer Technology)
3 credits (0-3-0)

EED801 Major Project Part-1 (Computer Technology)
6 credits (0-0-12)

EED802 Major Project Part-2 (Computer Technology)
12 credits (0-0-24)

EEL802 Testing and Fault Tolerance
3 credits (3-0-0)
Physical Faults and their Modelling; Stuck-at Faults, Bridging Faults; Fault Collapsing; Fault Simulation : Deductive, Parallel, and Concurrent Fault Simulation; Critical :Path Tracing; ATPG for Combinational Circuits : D-Algorithm, Boolean Differences, Podem; Random, Deterministic and Weighted Random Test Pattern Generation; Aliasing and its Effect on Fault Coverage; PLA Testing, Cross Point Fault Model and Test Generation; Memory Testing Permanent Intermittent and Pattern Sensitive Faults, Marching Tests; Delay Faults; ATPG for Sequential Circuits : Time Frame Expansion; Controllability and Observability Scan Design, BILBO, Boundary Scan for Board Level Testing; BIST and Totally Self checking Circuits; System level Diagnosis; Introduction; Concept of Redundancy, Spatial Redundancy, Time Redundancy, Error Correction Codes; Reconfiguration Techniques; Yield Modelling, Reliability and effective area utilization.

EEL804 Scientific Visualization
3 credits (3-0-0)
Pre-requisites: EEL754/EEL707

EEL806 Computer Vision
4 credits (3-0-2)
Pre-requisites: EEL205 & EC120
What is vision ; Overview of Applications; Camera: Physics of Image Formation, Projective Model of Camera, Camera Calibration; Multiple-view Geometry and Reconstruction; Shape from X ( defocus, shading, texture); Motion Analysis and Tracking; Object Recognition and Image Understanding.

EES810 Independent Study (Communications Engineering)
3 credits (0-3-0)

EEL811 Miscellaneous Underwater Systems
3 credits (3-0-0)

EEL812 Millimetre Wave Integrated Circuits
3 credits (3-0-0)
**EEL813 Selected Topics I**  
3 credits (3-0-0)

**EEL814 Selected Topics II**  
3 credits (3-0-0)

**EEL817 Access Networks**  
3 credits (3-0-0)  
Pre-requisites: EEL306 and EC 120  
The access loop, wired and wireless access, radio access, optical access networks, PONs, access standards, VS.x standards, service provisioning and inter-networking.

**EEL818 Telecommunication Technologies**  
3 credits (0-1-4)  
Data Networks, ISDN, SS7, Access-WLL/RLL, DECT, FITL, WAN-Frame Relay, ATM, Telecommunication Management network (TMN), Teletraffic Theory and Network analysis, Network planning and design.

**EED820 Minor Project (Control and Automation)**

**EEL823 Discrete Time Systems**  
3 credits (3-0-0)  
Introduction to discrete time systems. Time domain representation. Z-transformation. Analysis of discrete time systems; time domain approach and Z-domain approach. State variable representation, analytical design of discrete system, engineering characteristics of computer control systems, elements of hybrid computer, digital and hybrid simulation of sampled data systems.

**EEL824 Nonlinear Systems**  
3 credits (3-0-0)  

**EEL829 Selected Topics in Advanced Control & System Theory-I**  
3 credits (3-0-0)

**EED830 Minor Project (Integrated Electronics & Circuits)**  
3 credits (0-0-6)

**EEL831 Digital Signal Processing-II**  
3 credits (3-0-0)  
Pre-requisite: Digital Signal Processing I  

**EEV831 Special Module in Nano Electronics**  
1 credit (1-0-0)  
Pre-requisite: EEL732 and EEL784 or EEL218 and EEL329  
Special module that focuses on special topics. Development and Research problems of importance in the area of Nano Electronics.

**EEL832 Computer Aided VLSI Design**  
3 credits (3-0-0)  
Hardware description Languages; Verifying behaviour prior to system construction simulation and logic verification; Logic synthesis; PLA based synthesis and multilevel logic synthesis; Logic optimization; Logic Simulation; Compiled and Event Simulators; Relative Advantages and Disadvantages; Layout Algorithms Circuit partitioning, placement, and routing algorithms; Design rule verification; Circuit Compaction; Circuit extraction and post-layout simulation; Automatic Test Program Generation; Combinational testing: D Algorithm and PODEM algorithm; Scan-based testing of sequential circuits.

**EEV832 Special Module in Analog and Mixed Signal IC Design**  
1 credit (1-0-0)  
Pre-requisites: EEL732 and EEL786 or EEL219 and EEL329  
Special module that focuses on special topics. Development and Research problems of importance in the area of Analog and Mixed Signal IC Design.

**EEL833 Selected Topics in I.E.C.**  
3 credits (3-0-0)

**EEV833 Special Module in Low Power IC Design**  
1 credit (1-0-0)  
Pre-requisites: EEL734, EEL782 or EEL329  
Special module that focuses on special topics. Development and Research problems of importance in the area of Low Power IC Design.

**EEL834 VLSI Design**  
3 credits (3-0-0)  
Relationship between design of ICs, technology and device models. NMOS, CMOS, BiCMOS Process sequences and silicon foundry-concepts. Symbolic representations. Array and other design approaches. Topics in design-yield and redundancy, Low Power design. Testability and fault tolerance.

**Cell library formation. Design automation. Hardware description languages, Current Topics.**

**EEV834 Special Module in VLSI Testing**  
1 credit (1-0-0)  
Pre-requisites: EEL734, EEL782 or EEL329  
Special module that focuses on special topics. Development and Research problems of importance in the area of VLSI Testing.

**EEP835 I.E.C. Project Laboratory**  
3 credits (0-0-6)

**EEV835 Special Module in Machine Learning**  
1 credit (1-0-0)  
Special module that focuses on special topics. Development and Research problems of importance in the area of Machine Learning.

**EEV836 Special Module in Applied Mathematics**  
1 credit (1-0-0)  
Instructor or Supervisor’s Recommendation  
Special module that focuses on special topics. Development and Research problems of importance in Applied Mathematics.

**EEES837 Independent Study (Integrated Electronics & Circuits)**  
3 credits (0-3-0)

**EEL838 CMOS RF IC Design**  
3 credits (3-0-0)  
Pre-requisites: EEL734 and EEL782  
Historical Aspects - From Maxwell to current wireless standards: The Bridge between communication systems designer and RF IC Designer: a) Comm. System Characterization, b) RF System Characterization; Transceiver Architectures - Motivation for the individual Blocks: Lumped, passive RLC, RF properties of MOS, Turned Amplifiers; LNAs: Noise sources, Cascades and LNA Design; Mixers-passive and active mixers; Oscillators: Analysis Fundamentals, Inductors, LC Oscillators and VCOs; Frequency synthesizers: Principles, Ineger N vs Fractional PLL, Design Concepts.

**EEL839 Selected Topics in IEC II**  
3 credits (3-0-0)  
Pre-requisites: EEL734, EEL782  
Selected topics related or having a bearing on electronics, circuits, their analysis, design, or application.

**EED841 Minor Project**  
3 credits (0-0-6)

**EEL841 Solid State Controllers of Drives**  
3 credits (3-0-0)  
ROM based control of converters, such as rectifiers, choppers, inverters, cyclo-con-verters. Use of PLL for speed control. Basic
microprocessor system for speed control of drives. Field oriented control and programmable controllers. VSI and CSI converter with PWM technique for implementation of the field oriented control. Energy saving drive system, transfer function of converter controlled drive and analysis.

Switched Reluctance Motor Drive, Permanent Magnet Brushless Motor Drives, Synchronous Reluctance Motor Drives, Sensorless Control, Direct Torque Control, Direct and Indirect Vector Control, CLM Drives, Power Quality Improvements in Drives.

EEP841 Electrical Machines Laboratory
1.5 credits (0-0-3)

EES841 Independent Study (Power Electronics, Electrical Machines & Drives)
3 credits (0-3-0)

EET841 Industrial Training and Seminar
3 credits (3-0-0)

EED842 Major Project Part-1 (Power Electronics, Electrical Machines & Drives)
6 credits (0-0-12)

EEP842 Power Electronics Laboratory
1.5 credits (0-0-3)
Advanced experiments in electrical machines and power electronics

EED843 Major Project Part-2 (Power Electronics, Electrical Machines & Drives)
12 credits (0-0-24)

EEL843 Computer Aided Simulation & Design of Power Electronics Systems
3 credits (3-0-0)

EEP843 Electric Drives Laboratory
1.5 credits (0-0-3)
Advanced experiments on drive systems and their control, converter fed d.c. drives. Inverter fed a.c. drives. Computer control of drives.

EEL844 Advanced or Selected Topics in Power Electronics
3 credits (3-0-0)
Advanced topics in power electronics. Analysis and design of power electronic circuits.

EEP844 Microprocessor and Microcomputer Laboratories
1.5 credits (0-0-3)
Experiments in familiarization of microprocessors and microcomputers. Use of personal computers (PC) programming techniques. Software development on PC for typical drive problems. Machine interfacing with PC.

EEL846 Computer Aided Design of Electrical Machines
3 credits (3-0-0)

EEL847 Selected Topics in Machines & Drives
3 credits (3-0-0)

EED851 Major Project Part 1 (EI)
6 credits (0-0-12)

Pre-requisites: EC 165
This project spans also the course EED852. Topics should be from topics related to information and communication technology. The problem specification and the milestones to be achieved in solving the problem are to be clearly specified. Progress up to the end of the semester is to be presented for assessment and grade.

EEL851 Special Topics in Computers - I
3 credits (3-0-0)
Pre-requisites: CSL201 and EC 120
Topics of current interest related to computers; details will be provided by the instructor.

EED852 Major Project Part 2 (EI)
14 credits (0-0-28)
Pre-requisites: EED851
Continuation and completion of the work started in Project Part 1. Presentation at the end of the semester for award of grade.

EEL852 Special Topics in Computers - II
3 credits (3-0-0)
Pre-requisites: CSL201 and EC 120
Topics of current interest related to computers; details will be provided by the instructor.

EED853 Major Project Part 1 (EI)
4 credits (0-0-8)
Pre-requisites: EC 165
This course forms the first part of the two semester long major project. Work includes significant research and development in the area of information technology/communication technology under the guidance of faculty. Tasks include problem definition, preparation of work plan, literature review and initiation of work.

EEL853 Agent Technology
3 credits (3-0-0)
Pre-requisites: CSL201 and EC 120

EED854 Major Project Part 2 (EI)
16 credits (0-0-32)
Pre-requisites: EED853
This course is the second part of the two semester long major project. Work includes significant research and development in the area of information technology/communication technology under the guidance of faculty. Tasks include completion of planned work, report writing and presentation

EEL854 Protocol Engineering
4 credits (3-0-2)
Pre-requisites: EEL703
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.

EEL855 Internet Technologies
4 credits (3-0-2)
Pre-requisites: EEL703
Introduction to the Internet, comparison of Internet architectures, QoS issues, network applications, encryption, e-commerce, Web enabled systems, virtual reality, multimedia over the Internet.

EEL857 Network Security
4 credits (3-0-2)
Pre-requisites: EEL703
Practical topics in network security, mechanisms for secure networks,
policy, intrusion detection, cryptographic protocols, inter-networking security mechanisms, private and public key encryption, IPSEC-Internet Protocol security architecture.

EEL858 Mobile Computing
3 credits (3-0-0)
Pre-requisites: EEL703
Overview of mobile computing, introduction to SS7 and GSM, Wireless Networking Protocol: mobile IP; Adhoc Networks; Adhoc Routing, Wireless Protocols: Wireless TCP, Data Broadcasting, Mobile data management, Location Dependency/Awareness, Disconnected or Weak-connected operations, Adaptations, Mobile Applications and services, User Interface Issues, Security Issues.

EEB858 Telecom Networks Laboratory-II
3 credits (0-1-4)
Specification and implementation of the alternating-bit protocol in SDL ATM-Signalling Protocols Hand-over in GSM mobile network, Data transmission with GSM in the non-transparent mode, Protocol analysis of data transmission via Ethernet LAN, Development of voice based services for intelligent networks, Planning and evaluation of DECT systems.

EEL859 Network Management
4 credits (3-0-2)
Pre-requisites: EEL703
Network planning, network initialization and configuration management, fault management, usage accounting, and security. The course will also include discussion of some current network and management products. It will also cover the development of network management systems and discuss the role played by network management protocols and products.

EED860 Minor Project (Communications Engineering)
3 credits (0-0-6)

EEL860 Wireless Communications
3 credits (3-0-0)

EED861 Major Project Part-1 (Communications Engineering)
6 credits (0-0-12)

EEL861 Selected Topics in Communication Engineering - I
3 credits (3-0-0)
Pre-requisites: EEL306 and EC 120
Topics of current interest in communication engineering; details will be provided by the instructor.

EED862 Major Project Part-2 (Communications Engineering)
12 credits (0-0-24)

EEL862 Selected Topics in Communication Engineering - II
3 credits (3-0-0)
Pre-requisites: EEL306 and EC 120
Topics of current interest in communication engineering; details will be provided by the instructor.

EEL863 Selected Topics in Communication Engineering - III
3 credits (3-0-0)
Pre-requisites: EEL306 and EC 120
Topics of current interest in communication engineering; details will be provided by the instructor.

EEL864 Modern Antennas and Arrays
3 credits (3-0-0)

EEL865 Microwave Propagation and Systems
3 credits (3-0-0)

EEL866 Microwave Solid State Devices and Circuits
3 credits (3-0-0)

EEL867 Fading Channels
3 credits (3-0-0)

EEL869 Optical Data Processing
3 credits (3-0-0)
Review of Fourier optics, coherent and incoherent imaging transfer functions, equivalence of optical and electrical systems, spatial filtering, holographic data processing, optical memories, application to synthetic aperture radar and biological signal processing. Hybrid opto-digital signal processing.

EEV871 Selected Topics in Communication Engineering-IV
1 credits (1-0-0)
EEV872 Selected Topics in Communication Engineering-V
1 credits (1-0-0)

EEP874 Project Laboratory
4 credits (0-1-6)

EED875 Major Project Part-1 (Control & Automation)
6 credits (0-0-12)

EED876 Major Project Part-2 (Control & Automation)
12 credits (0-0-24)

EEL878 Artificial Intelligence in Control Applications
3 credits (3-0-0)
EEL879 Selected Topics in Advanced Control & Systems Theory-II
3 credits (3-0-0)

EEL881 Issues in Deep Submicro CMOS IC Design
3 credits (3-0-0)

EEP881 Network Software Laboratory
3 credits (0-1-4)
Network simulation tools, characterization of networks, test procedures for network software, real-time operating systems, object-oriented design for networks, optimization tools, visualization techniques.

EEL882 Introduction to Telecommunication Systems
3 credits (3-0-0)
Basics of data communication, telephone systems, modulation and demodulation, multiple channel communication, introduction to communication channels, introduction to data networks and their applications.

EEL885 EHV AC Transmission
3 credits (3-0-0)

EED888 Major Project Part-1 (Integrated Electronics & Circuits)
6 credits (0-0-12)

EED889 Major Project Part-2 (Integrated Electronics & Circuits)
12 credits (0-0-24)

EEL890 Photonic Switching and Networking
3 credits (3-0-0)
Photonic Switching: Switching architectures-single and multistage switching, space switching, time switching, combinations of space and time switching, interconnection networks; Networks: Introduction to computer data networks, ISO-OSI models, SDH, SONET; Fiber-optic LAN architectures and protocols-ring, star and bus architectures, DQDB, FDDI; High speed bus protocols- RATO-net, WDM networks- LAMBDAnet, coherent star, PASS-net, shuffle-net.

EED890 Major Project Part-1 (Power Systems)
6 credits (0-0-12)

EEL891 Selected Topics in Power System
3 credits (3-0-0)

EEL892 Power System Communication
3 credits (3-0-0)
Introduction. Communication links required for telemetry, telecontrol and teleprotection. Analog and Digital Communication-Speed and bandwidth requirements-Noise in power systems. Communication links PLC, microwave, telephone line, satellite, fibre optic. Requirements of various communication equipments used in power systems. Computer networking in power system.

EES893 Independent Study (Power Systems)
3 credits (0-3-0)

EEL894 Flexible A.C. Transmission Systems
3 credits (3-0-0)
The phenomenon of voltage collapse; the basic theory of line compensation. Static excitation systems; static VAR compensators; static phase shifters; thyristor controlled series capacitors.

EED895 Major Project (M.S. Research)
40 credits (0-0-80)

EEL895 Broadband Communication and Information Systems
3 credits (3-0-0)
Fundamentals of telecom systems, Principles of communication and signaling, Fundamentals of transmission; mathematical models for networks, Tele-traffic engineering: Telecom Management Networks, Protocols, Architectures for Broadband Networks, ATM, SDH/SONET; Access and Hybrid Networks; All optical networks.

EEL896 Power System Optimization
3 credits (3-0-0)
Economic load dispatch in thermal and hydro-thermal system; reactive power optimization; optimal power flow. Linear programming and non-linear programming techniques to optimal power flow problems. Security constrained optimization. Unit commitment and maintenance scheduling, Interchange evaluation, Minimum emission dispatch.

EEL897 Load Forecasting and Load Management
3 credits (3-0-0)

EED898 Major Project Part-2 (Power Systems)
12 credits (0-0-24)

EEL899 Distribution Automation
3 credits (3-0-0)
HUL701 Sociological Theory Development and Trends
3 credits (2-1-0)
Classical Theories: Positivism, Evolutionism, and Marxism. Structuralism and functionalism in sociology and social anthropology. Exchange theory. Symbolic interactionism, conflict theory, neo-Marxism; post-modernism. The purpose of the course is two-fold: first, to introduce the student to the field of social theories; and second, to present him with some perspectives whereby he may develop a better understanding of both his social environment and theoretical understanding.

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)
The concept of Behavioral Assessment: Uses and Varieties of Psychological Tests, Why Control the use of Psychological Tests? Test Administration, Examiner and Situational Variables and Effects of Training on Test Performance.

Other Techniques of Behavioral Assessment: Interview, Questionnaire and Schedule, Content Analysis, Observation as a tool of data collection, Rating Scales, Survey and Projective Techniques. Brief Review of some Selected Psychological Tests and Concluding Comments.


HUP722 Seminar (Case Material-based) Minor Project
3 credits (0-0-6)
(In lieu of any of the courses.)
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.


HUL761 Sociology of India
3 credits (2-1-0)
Approaches and Concepts: Institutions, Caste and Kinship; Religion; Marriage and Family. Agrarian social structure: Land reforms; Dimensions of social change; Sanskritisation and modernization. A profile of modern India.

HUL762 Industrial Economics
3 credits (2-1-0)

HUL766 Visual Methods in Social Research
3 credits (2-0-2)

HUL810 Communication Skills in Social Research
3 credits (3-0-0) (Audit)

HUL812 Grammar and Rhetoric
3 credits (3-0-0)
Two complementary aspects of studies in linguistics and literary theory are brought together in this course; grammatical paradigms for the study of sentential and supra-sentential structures, including those of narrative and argument; theories of rhetoric; persuasion, use and meaning; rhetorical functions such as those performed by tropes like metaphor, irony, simile, metonymy, etc. debates on the universal psychological as well empirical standing of such figurative language; its place in the lexicon etc. The course will be useful to those students of literature who require some knowledge of technicalities of grammar and to those students of linguistics who feel that the analysis of language extends beyond the study of sentence ‘structure’ to social ‘meaning’.

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.

HUL840 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.

HUL841 Philosophy of Science
3 credits (3-0-0)
The major issues to be discussed in this course include: (a) scientific explanation; (b) theories of confirmation of a scientific hypothesis; (c) theoretical-observational terms/distinction; (d) problem of induction; and (e) the problems of theory choice. A survey of the historical development of the twentieth-century philosophy of science will be provided. Some historical episodes in science will be employed to gain a better understanding of the issues to be discussed.

HUL843 The Philosophy of Language
3 credits (3-0-0)
The twentieth century is one which has been said to mark a ‘linguistic turn’ in philosophy. This course will examine the basic sense/reference, truth/false, denotative/ connotative, meaning/use, analytic/synthetic, argument/predicate, intension/extension dichotomies as they are explored in post-Fregean analytic philosophy. Five or six distinct strains of philosophical opinion are salient for this course. They are (A) the logical positivism associated, with Ayer et. al. (B) Wittgenstein’s ‘picture’ and ‘game’ theories of meaning; (C) the speech-act theory of Austin and Searle; (D) the Grocean maxims of conversational cooperation and non-natural meaning; (E) the ‘pragmatism’ of Quine on webs of meaning, Davidson on truth and interpretation and Rorty on philosophy as conversation and social conduct; (F) the writings of continental ‘non-analytic’ philosophers such as Derrida and Habermas who hold opposed positions on the nature of language. The views of Kripke, Dummett and Dennett among philosophers and Chomsky, Katz and Fodor among linguists will also be discussed.

The course may have a seminar format in which particular topics are considered in depth and short papers are prepared by students.

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: Ecofeminism. (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, Arneheim, 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.

HUL873 Sociology of Science
3 credits (3-0-0)
The relationship between the sub-culture of science and the wider
HUL881 Elements of the Narrative Art 3 credits (3-0-0)
It is a course more broad-based than the theory of fiction. The following topics will be studied: Narrative theory and types of narrative; point of view; plot; characterization; setting; time and place the language of narrative; figures of speech.

HUL882 The European Renaissance, Selfhood and Survival 3 credits (3-0-0)
This course will cover drama, prose, and poetry from one of the richest periods of European Literature: the Renaissance. It will relate the production of a work of art to Renaissance history and cultural politics. Texts by Pico, More, Machiavelli, Sidney, Spenser and Shakespeare and others will be examined from the point-of-view of selfhood and survival.

HUL883 Critical Theory: Plato to Derrida 3 credits (3-0-0)
This course will explore western critical theory from antiquity to the present and measure its efficacy when applied to a literary text. Ideas of nemeses, fiction truth, art and society, art and gender will be studied with regard to different "schools" of critical theory: Platonic, Aristotelian, Renaissance, Romantic, Formalist, Structuralist, Poststructuralist, Deconstructionist and Feminist. Since the material is vast, only three or four topics will be studied in a semester.

HUL884 Indian Writing in English 3 credits (3-0-0)
The course focuses on the dominant themes like India's struggle for freedom, partition and communal harmony/discord, Issues of pluralism and the related Problems as reflected in Indian Writing in English. It also aims at a close study of problems of modernization, diaspora and India's quest for identity, Rushdie and Post Rushdie. The students should be prepared to do intense study of the texts and wherever possible a comparative study of the literary representations with the visual and electronic media will also be undertaken. All the genres of literature will be made part of the study.

HUL885 American Fiction I 3 credits (3-0-0)
It is primarily a survey course covering American fiction before World War I. Its aim is to acquaint students with some of the major novelists of the period. Selected texts of some of the following will be studied: Hawthorne, Melville, Poe, Driesser, Edith Wharton, Willa Cather, Henry James, Ellen Glasgow.

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.

HUV886 Special Module in Cognitive Psychology 2 credits (1-0-2)
Prerequisites: HUL or SML 700/800 category courses
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.

HUV887 Special Module on Econometric Tools 1 credit (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.
Department of Management Studies

SML700 Fundamentals of Management of Technology
3 credits (3-0-0)
*Pre-requisites: SML305 and SML401


SML701 Strategic Technology Management
3 credits (2-0-2)
*Pre-requisites: SML305 and SML401
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 Leverag. 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.


SML702 Management of Innovation and R&D
3 credits (3-0-0)
*Pre-requisites: SML305 and SML401
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.

SML703 Management of Technology Transfer and Absorption
3 credits (2-0-2)
*Pre-requisites: SML305 and SML401
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.


SML704 Science and Technology Policy Systems
3 credits (3-0-0)
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.


SML710 Creative Problem Solving
3 credits (2-0-2)


SML713 Information Systems Management
3 credits (2-0-2)
*Pre-requisites: SML305
Module I: Survey of Information systems and technology. Concepts of information; Information as a resource. Types of information systems- management information systems, decision support systems,
transaction processing systems, on-line systems, executive support systems, real-time systems, expert systems.


Module III: Organizing for managing information resources; data administration and information management, Data center administration. The application development backlog, Outsourcing, Information system security. Managing technology-driven change. End-user computing. Training for IS users and managers.

SML714 Organisational Dynamics and Environment
3 credits (3-0-0)
*Pre-requisites: SML305 and SML401

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.

SML715 Quality and Environment Management Systems
3 credits (2-0-2)
*Pre-requisites: SML305 and SML401


SML716 Fundamentals of Management Systems
3 credits (2-0-2)
*Pre-requisites: SML305 and SML401


Module III: Methodologies for Development and Improvement.


SML717 Business Systems Analysis and Design
3 credits (2-0-2)
*Pre-requisites: SML305 and SML401

Module II: Requirements specification. Application prototyping, CASE methodologies and techniques; Systems design; Data-driven approaches (E-R Modelling). Process-driven approaches (Gane and Sarson and Youndon techniques). Traditional work flow methods.


SML720 Business Environment and Corporate Strategy
3 credits (2-0-2)
*Pre-requisites: SML305


SML723 Telecommunications System Management
3 credits (3-0-0)
*Pre-requisites: SML305 and SML401
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.

SML726 Telecom Systems Analysis, Planning, and Design
3 credits (3-0-0)
*Pre-requisites: SML305 and SML401
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.

**SML728 International Telecommunication Management**

3 credits (3-0-0)

*Pre-requisites: SML305 and SML401

**Module I:** Historical development and evolution of telecom, managerial issues, and future of industry; 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 telecommunications in socio-economic development; ICT & Social change, new technologies and services for international telecommunications; data services and business applications, Telecom prospects of WTO & other international bodies.

**Module III:** Current issues and organisational growth; telecom implications for the industry, value added services and market drives; regional prospectives on development of telecom; Human Resources Planning and Industrial relations in ITSM; skill formation for ITSM and learning renewal, future directions of growth.

**SML730 Organisation Management**

3 credits (3-0-0)

*Pre-requisite: SML401

**Module I:** Scope of organizations: Nature and function of organisations; individual organization environment interface; longitudinal thinking. Organisation Management: Theory, practice and major schools of thought, application potentials and possibility.


**Module III:** Integrating the elements: Organisational culture; coping strategies- individual & organisational; Impact of environmental and cultural variables on organizational structure and style; organisation design; mechanization, automation and computerisation; Organizational interdependence and organizational evaluation.

**SML731 Human Resources Management**

3 credits (3-0-0)

*Pre-requisites: SML401; Overlap with: SML305

**Module I:** Management of human resources: historical evolution of the field. Influences on the approach of management of human resources. Line and staff components of human resource management. Role of Human Resource management in a competitive business environment. Interpersonal dynamics.


**SML734 Management of Small & Medium Scale Industrial Enterprises**

3 credits (3-0-0)

*Pre-requisites: SML305 and SML401

**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.

**Module II:** Raising resources for new enterprises. Location, design, product and process. Choice of technique in small & medium businesses. Survey needs for growth of the enterprise. Monitoring to avoid sickness. Development and diversification.

**Module III:** Integration with LSEs and MNCs. Information network for new enterprises. Implication of WTO to SMEs. Globalisation & Competitiveness of SMEs. Entrepreneurship in the globalisation era.

**SML740 Quantitative Methods in Management**

3 credits (3-0-0)

**Module I:** Role of quantitative methods and operations research for managerial decision making and support. Role of mathematical models in problem formulation and solving. Structure of decisions, statistical decision theory; decision making under uncertainty, risk, certainty. Decision Trees; Fuzzy Decision Making. Game theoretic applications. Mathematical Programming models- formulation and applications. Linear Programming- graphical method, Simplex technique; transportation, assignment and transhipment problems. Mixed Integer Programming.

**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.

**SML745 Operations Management**

3 credits (3-0-0)

*Pre-requisites: SML305

**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.


**SML746 Business Statistics**

3 credits (3-0-0)

**SML760 Marketing Management**

3 credits (2-0-2)

*Pre-requisites: SML305

**Module I:** Introduction to Marketing function; genesis, the marketing concept. Marketing Management System: objectives, its interfaces with other functions in the organisation. Environment of Marketing-Political Environment Economic Environment, Market segmentation Consumer buying behaviour. Socio-cultural environment. Legal Environment. Ethical issues in marketing.

**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.

SML770 Managerial Accounting and Financial Management
3 credits (2-0-2)
Pre-requisites: SML305 Overlap with: SML401


SML780 Managerial Economics
3 credits (2-0-2)
Module I: Role of economic analysis in managerial decisions. Basic concepts; Objectives of business firms and profit policies. Theories of profit; Demand analysis and demand management w.r.t. domestic and world markets. Determinants, estimation and managerial uses of elasticities of demand; Demand forecasting; Supply function and market equilibrium analysis; Cost concepts; cost function; Break-even Analysis; Equilibrium analysis of firm in an open economy.

Module II: Pricing and output under different market situations; Recent advances in pricing theory and practices. Production analysis and Input Demand Functions; Project appraisal techniques. Social cost benefit analysis; Investment decisions under risk and uncertainty.

Module III: National Income concepts and their interrelationships. Inflation analysis; (Indian) Monetary System and banking structure. 

SMP783 Management Laboratory
3 credits (0-0-6)
Pre-requisites: SML305 and SML401
Module I: Introduction and overview of Management Laboratory-Interpretation of managerial process. Case development technology-Game development technology and simulation exercises- Data sources.

Module II: Research methodology in management and system sciences- Management systems instrument development technologies- Case analysis and report writing methodology.

Module III: Development of cases/games/simulation experiments. Seminars and group discussion.

SMP791 Computer Laboratory
1 credit (0-0-2)
Pre-requisites: SML305 and SML401

SMD792 Minor Project
3 credits (3-0-0)

SMV793 Statistics for Management
1 credit (1-0-0)
Pre-requisites: SML305 and SML401
Nature and role of statistics for management. Introduction to probability theory; Measures of central tendency and dispersion. Probability distributions; Sampling distributions. Estimation and hypothesis testing; t-tests; ANOVA; Chi-square tests; Non-parametric statistics; Correlation and regression analysis. Introduction to, and hands-on sessions on, packages for statistical modelling.

SMV794 Communication Skills
1.5 credits (1-0-1)
Pre-requisites: SML305 and SML401

SMV795 Systems Thinking
1 credit (1-0-0)
Pre-requisites: SML305 and SML401

SML801 Technology Forecasting and Assessment
3 credits (2-0-2)
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, Analog method, Organising for Technology Forecasting.


SML802 Management of Intellectual Property Rights
3 credits (3-0-0)
Module I: Nature of Intellectual Property; Patents, Industrial Design, Trademark and Copyright; Process of patenting and development; technological research, innovation, patenting, development; International cooperation on Intellectual Property;International treaties on IPRs; Patenting under PCT. Procedure for grants of patents.

Module II: Scope of Patent Rights; Licensing and transfer of technology; Patent information and databases; Geographical Indications.

Module III: Administration of Patent System. New developments in IPR; IPR of biological systems,plant varieties, computer softwares etc. Traditional knowledge; Case Studies; IPR and IITs.

SML803 Technical Entrepreneurship
3 credits (3-0-0)


Module III: Managing the new technological venture: Developing systems in new venture, Managing doing early operations, Growth and expansion, ending the venture. Legal issues, Franchising and
acquisition. Entrepreneurship, globalisation and Entrepreneurship.

SML811 Management Control Systems
3 credits (3-0-0)
Pre-requisites: SML713

SML812 Flexible Systems Management
3 credits (2-0-0)

SML813 Systems Methodology for Management
3 credits (2-0-0)
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.

SML815 Decision Support and Expert Systems
3 credits (2-0-0)
Pre-requisites: SML713
Module III: Integrating expert systems and DSSs. Strategies for implementing and maintaining management support systems. Case studies, and laboratory and filed projects.

SML816 Total Quality Management
3 credits (2-0-0)
Pre-requisites: SML745
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.

SML817 Management of System Waste
3 credits (2-0-0)
Pre-requisites: SML715 and SML720

SML818 Industrial Waste Management
3 credits (2-0-0)
Pre-requisites: SML715 and SML720
Module III: Waste management in Indian industries- present practices, potentials and perspectives. Management of waste in different industrial systems- steel, aluminium, power, automobile, transport and other service industries. Economic analysis and system models of industrial waste management systems. Analytical and Creative techniques to waste control.
SML819 Business Process Reengineering
3 credits (2-0-2)
Pre-requisites: SML720 and SML745
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.

SML820 Global Business Environment
3 credits (3-0-0)
Pre-requisites: SML720
Module I: Global Scene.
Historical and economic background, firms and International Business. The global scene and the challenges ahead, challenges to free International Trade Political Risk, Protection, Accounting, Taxation and Legal practices. The International debt risks.
Module II: Regional Issues.
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.

SML821 Strategic Management
3 credits (2-0-2)
Pre-requisites: SML720
Module II: Strategy Formulation.
Module III: Strategy Implementation.

SML822 International Business
3 credit (3-0-0)
Pre-requisites: SML720
Module I: Key Issues in International Business.
Competitive position of key Indian Industries. Entry strategies for Indian firms: Joint Ventures, strategic/technical alliances/collaboration. Strategies employed by Indian firms to develop and sustain international business.
Module III: Globalization Strategy.

SML823 Strategic Change and Flexibility
3 credit (2-0-2)
Pre-requisites: SML720
Module I: Patterns of Change and Flexibility.
Module II: Revising Strategies Postures.
Corporate restructuring, Alliances, joint ventures, acquisitions and mergers. Reorganising the firm, the impact of mergers and acquisitions on organizational performance. Management of continuity and change, Blue Ocean strategy.
Module III: Energising Strategies Change.

SML824 Policy Dynamics and Learning Organization
3 credit (2-0-2)
Pre-requisites: SML720
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 organisation, clarifying vision and opportunities for change in a learning organization.
Module II: Micro World and Policy Dynamics.
Systems-linked organization model. Micro world for policy learning. System Dynamics modeling applied to policy formulations, conceptual model. The language of systems thinking links and qualitative system dynamics, Flexibility Influence Diagram, Collaboration Diagram, Archetypes, leverage points, Integrative simulation models.
Module III: Frontiers.
Role playing games and case studies to develop principles for successful management of complex strategies in a dynamic world. Strategic Management game for policy planning, Interactive Planning. Strategic issues such as business cycles, market growth and stagnation. And diffusion of new technologies. Knowledge management in learning organizations.

SML825 Strategies in Functional Management
3 credit (3-0-0)
Pre-requisites: SML720

SML826 Business Ethics
3 credits (3-0-0)
Pre-requisites: SML720
Module I: Ethics in Business

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.

Module III: Ethics in Functions.

SML827 International Competitiveness
3 credits (3-0-0)
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 II: Evaluating & Planning for Competitiveness
Frameworks of Competitiveness & Strategy, Evaluating Competitiveness, Competitiveness Processes & Initiatives, Leadership Dimension, Cases.

Module III: Practitioner Perspectives
Business Models for Competitiveness, Functional (e.g. HR, Operational, Financial, Technological) Linkages, Partnerships/Cooperation for Competitiveness, Emerging Issues/Practices.

SML828 Global Strategic Management
3 credits (2-0-2)
Pre-requisites: SML720
Globalization of markets and competition, globalization and localization, Diagnosing Global Industry Potential, Designing a global strategy, Making Global strategies work, Global strategic alliances, M&A.

Module II: Regional Strategy and Entry Strategy.

Module III: Managing Globally and Future Challenges.

SML829 Current and Emerging Issues in Strategic Management
3 credits (3-0-0)
Pre-requisites: SML720
(Relevant current and Emerging Issues)

SML830 Organisational Structure and Processes
3 credits (3-0-0)
Pre-requisites: SML730 and SML731


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.

SML831 Management of Change
3 credits (2-0-2)
Pre-requisites: SML730 and SML731

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.


SML832 Managing Innovation for Organisational Effectiveness
3 credits (3-0-0)
Pre-requisites: SML730 and SML731

Module II: Managing social equity and organisation efficiency paradox, blocks to creativity, methods to overcome the blocks. Introducing creativity in organisation. Structure and creativity. Work culture and innovation.


SML833 Organisation Development
3 credits (3-0-0)
Pre-requisites: SML730 and SML731

Module II: Coping with environmental change. Socio-cultural dimensions of work and behaviour, Environmental analysis and impact. Diagnosis of the ongoing process from symptoms to causes. Organisation development and intervention strategies.


SML835 Labour Legislation and Industrial Relations
3 credits (2-0-2)
Pre-requisites: SML730 and SML731


SML839 Current and Emerging Issues in Organisation Management
3 credits (3-0-0)
Pre-requisites: SML730 and SML731
(Relevant current and Emerging Issues)

SML840 Manufacturing Strategy
3 credits (3-0-0)
Pre-requisites: SML745


Module II: Technology-manufacturing process interfaces with marketing, engineering, quality, purchasing, finance and accounting. Inter-relationship among manufacturing manager and their suppliers, customers, competitors, superiors and production workers.


SML843 Supply Chain Logistics Management
3 credits (3-0-0)
Pre-requisites: SML745

Module I: Perspective of Supply Chain Logistics Management. Logistics concept, role and scope; Logistics Environment- Integrating Logistics of Supply, Logistics of Production and Logistics of Distribution. Internal and external factors for logistics strategy, Operational Resources of logistics (personnel, warehouse means of transport, warehouse transport aids, organizational aids, material stocks, and area/space) Effective supply chain management, customer networking and manufacturing, Risk Pooling, Postponement, cross docking in supply chain, CPFR, IT-enabled supply chains value of Information, Coordination in SCM.

Module II: Logistics Activity Mix.
JIT and Logistics, Synchronised manufacturing. Purchasing and Materials Management. Distributional logistical systems and facilities—single stage or multistage, warehouse(s), their number, location and allocation, Automated Warehousing, Materials Handling and Packaging. Simulation aided planning of conveyor and warehousing systems.

Module III: Supply Chain Logistics Mix Management.
Logistical Connectivity: Transportation modes, rate structure, legal aspects; maintenance, spares and repairs; test and support equipment, Routing of freight flows. Management and Organization of the Logistics Systems; Organization, Information and cost control; Logistical information Systems, Computer aided logistics management. Case Studies.

SML844 Systems Reliability, Safety and Maintenance Management

SML845 Total Project Systems Management
3 credits (2-0-2)

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.

Module II: Network techniques for project management-PERT, CPM and GERT. Accounting 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.


SML846 Total Productivity Management
3 credits (3-0-0)
Pre-requisites: SML745

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.


SML847 Advanced Methods for Management Research
3 credits (2-0-2)
Management Studies

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.

SML849 Current and Emerging Issues in Manufacturing Management
3 credits (3-0-0)
Pre-requisites: SML745
(Relevant current and Emerging Issues)

SML850 Management of Information Technology
3 credits (3-0-0)
Pre-requisites: SML713
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.

SML851 Database Design and Data Management
3 credits (2-0-2)
Pre-requisites: SML713
Module I: Introduction to Database Systems.
Evaluation of database technology; Limitations of file systems; Database systems- hierarchical models (IMS architecture- DBD, PSB), network models (DBTG DDL and DBTG DML), and relational models normalization and relational calculus.
Module II: Database Design.
Database systems- hardware, software, data people; database systems and their organizational development; Database development lifecycle; Logical database design; implementation design.
Module III: Strategic Issues Related to IT Management.
Database implementation; Knowledge base systems and natural languages; Database administration and control; Distributed database systems. Data mining, data warehousing.

SML852 Network System: Applications and Management
3 credits (3-0-0)
Pre-requisites: SML713
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.
Module III: Managing networks.
Preparing for doing business on the internet; Choosing and costing networks and network services; network management requirements; network performance indicators; performance monitoring.

SML855 Electronic Commerce
3 credits (2-0-2)
Pre-requisites: SML713
Module I: Business Opportunities with or without Internet: Business revolution and e-commerce: issues of competitive advantage, physical distribution system and supply chain improvements, value chain analysis. Networks and commercial transactions, The Internet environment, on-line commerce solutions.
Types of e-commerce: web stores, auctions, discounting, advertising and promotions (case studies) etc., risks in internet commerce, jobs in cyberspace.
Module II: Technology of e-commerce Technology Basics: all the nets (internet, intranets & extranets), telecommunication infrastructure of internet, protocols & convergence.
Business technologies for WWW: database integration, web databases and software developments.
Security technologies: encryption, cryptography, public key solutions, key distribution and certification, Electronic payment methods: technologies (EDI, EFT, EFTPOS etc.), secure transaction models, Protocols for the public and private information (Secure sockets layer (SSL) and Secure electronic transaction (SET)).
Electronic Payment Systems: First virtual internet payment system, cyber cash.
Digital Currencies: Basics, eCash, Smart cards.
Re-intermediation at work, intelligent agents, datamining tools.
Module III: Setting up a e-business (Legal Commercial Framework).
Strategy for setting up a web site, creating commercial web site, shopping agents.

SML856 Business Intelligence
3 credits (3-0-0)
Pre-requisites: SML713
Module I: Data Warehousing.
Problems of modern databases & the nature of BI Warehousing, Multidimensional Modeling, Online Analytical Processing (OLAP) Systems Interface of BI with organization capability Paperless office & Virtual Organization.
Module II: Data Mining.
Knowledge Discovery, Data Mining tools, Market Basket Analysis, Management Applications Customer Relations Management (CRM) Data Visualization and Multidimensionality Geographical Information Systems (GIS) and Business applications.

Module III: Other Decision Supporting Technologies.

SML857 Database Management Information Systems
3 credits (3-0-0)
Pre-requisites: SML713
Module I: Introduction to database.
Role of information in an organization: Need for a data architecture, Need for Information Resource Management, Data concepts and data modeling, Entity- Relationship modeling, Relational Modeling including normalization, Maping Entity- Relationship Model to Relational Model.
Module II: Database Information Systems.
Structured Query Language, Data storage and file organization, Technology of DBMS, Concurrency control, Recovery management, Use of database and application development tools. Database security.
Module III: Emerging data management techniques.
Distributed database systems and object databases. Data warehousing and data mining; Executive information systems and decision support systems.

SML859 Current and Emerging Issues in Information Technology Management
3 credits (3-0-0)
Pre-requisites: SML713
(Relevant current and Emerging Issues)

SML861 Market Research
3 credits (2-0-2)
Pre-requisites: SML760; SML793
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.

SML862 Product Management
3 credits (3-0-0)
Pre-requisites: SML760
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.


SML863 Advertising and Sales Promotion Management
3 credits (3-0-0)
Pre-requisites: SML760
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.

SML865 Sales Management
3 credits (2-0-2)
Pre-requisites: SML760
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.
SML866 International Marketing
3 credits (3-0-0)
Pre-requisites: SML760

Module II: Strategic export planning. Handling an export transaction. Export marketing Checklist; Selection of Markets: Choosing Markets; Export pricing; Management of export logistics. Documentation for export; processing of an export trade. Sales forecasting in international trade; Identifying geographical territories for expansion. Cultural factors affecting business in global market.

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.

SML867 Industrial Marketing Management
3 credits (3-0-0)
Pre-requisites: SML760
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.


SML869 Current and Emerging Issues in Marketing
3 credits (3-0-0)
Pre-requisites: SML720 and SML760
(Relevant current and Emerging Issues)

SML870 Advanced Financial Management
3 credits (2-0-2)
Pre-requisites: SML770


SML871 Accounting for Decision Making
3 credits (2-0-2)
Pre-requisites: SML770

SML872 Working Capital Management
3 credits (3-0-0)
Pre-requisites: SML770


Module II: Current Assets Management.


Module III: Analysis aTools and New Development.


SML873 Security Analysis and Portfolio Management
3 credits (3-0-0)
Pre-requisites: SML770
Module I: Investment Environment.


Module II: Valuation of Securities.


SML874 Indian Financial System
3 credits (3-0-0)
Module I: Overview of Indian Financial System


Module II: Financial Markets.

Module III: Mutual Funds, Insurance and others.
Investment Policy and performance appraisal of Unit Trust of India, Insurance, IRDA. New Developments such as financial instruments, Private foreign investments, case studies and problems.

SML770 International Financial Management
3 credits (3-0-0)
Pre-requisites: SML770


SML780 Current and Emerging Issues in Finance
3 credits (3-0-0)
Pre-requisites: SML720
(Relevant current and Emerging Issues)

SML880 Selected Topics in Management Methodology
3 credit (2-0-2)

SML881 Management of Public Sector Enterprises in India
3 credits (3-0-0)
Pre-requisites: SML780


SML887 Business Laws
3 credits (2-0-2)
Pre-requisites: SML305


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.

SML889 Current and Emerging Issues in Public Sector Management
3 credits (3-0-0)
Pre-requisites: SML881
(Relevant current and Emerging Issues)

SMD890 Major Project
6 credit (0-0-12)

SMV895 Management Research Methodology
1 credit (1-0-0)
Pre-requisites: SML760
Problem conceptualization and definition. Hypothesis formulation. Selection of Research Methods, Flexible Systems Methodology for preparing research design, Scaling, sampling methods, Managing oral evidence, Questionnaire design, validation and pretesting. Interview design, Case study, Field experiments, Quasi experiments. Qualitative research methods. Statistical techniques and implementation of research plan using statistical packages.

SMV896 Human Values in Management
1 credit (1-0-0)
Pre-requisites: SML731

SML897 Consultancy Process and Skills
3 credits (3-0-0)
Pre-requisites: SML305 and SML401

Module II: The Consulting Process- Entry, Diagnosis, Action Planning, Implementation and Termination/Closing;


SML898 Consultancy Professional Practice
3 credits (3-0-0)
Pre-requisites: SML305 and SML401
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.

SML899 Current and Emerging Issues in Consultancy Management
3 credits (3-0-0)
Pre-requisites: SML305 and SML401

* Pre-requisite for PG courses is applicable for B.Tech. student.
MAL503 Linear Algebra
4 credits (3-1-0)
Overlaps with: MAL255

MAL509 Probability Theory
4 credits (3-1-0)
Overlaps with: MAL250
The objective of this course is to understand the theory of probability. And also, to give a concise account of the fundamental concepts of probability theory so as to probe into topics like random variables, distributions, characteristic functions and various modes of convergence. Probability as a set function, Borel-field and extension of probability measure. Random variables as Borel measurable functions. Distribution function. Multi-dimensional random variables. Conditional probability and statistical independence. Moments, correlation and regression. Characteristic function, uniqueness and inversion theorems. Convergence of sequence of random variables and various modes of convergence. Laws of large numbers. Central limit theorem, Liapunov’s and Lindeberg-Feller’s theorem, Law of iterated logarithm.

MAL513 Real Analysis
4 credits (3-1-0)

MAL514 Complex Analysis
4 credits (3-1-0)
Study of functions of a single Complex variable.

MAL516 Algebra
4 credits (3-1-0)

MAL517 Differential Equations
4 credits (3-1-0)
Overlaps with: MAL235
To use Calculus in solving differential equations and also to give a concise account of fundamental concepts of existence, uniqueness, stability and qualitative properties of solutions. Initial value problems, theorems on existence, uniqueness and continuous dependence of solutions on initial data, general theory of linear differential systems, Sturm’s theory on separation and comparison properties of solutions, Power series method, regular singular points, General existence and uniqueness theorems for nonlinear ODE, Boundary value problems, Green functions, Sturm-Liouville problems, autonomous systems and concepts of stability.

MAL518 Methods of Applied Mathematics
4 credits (3-1-0)
To use students knowledge in basic analysis, calculus and Linear algebra to solve some interesting problems in Applied sciences and mechanics. Expansion in eigenfunctions, Fourier series and Fourier integral, orthogonal expansions, mean square approximation, completeness, orthogonal polynomials, and their properties, integral transforms and their applications, linear functional, general variation of a functional, direct variational methods for solution of boundary value problems, integral equations of volterra and Fredholm type, seperable and symmetric kernels, Hilbert-Schmidt theory, singular integral equations, approximate methods of solving integral equations.

MAL519 Introduction to Computers and Programming
4 credits (3-0-2)
To teach the students basics of computer programming Introduction to Computers – CPU, ALU, I/O devices, Introduction to C Programming – data types, variables, statements, iterative statements, functions, procedures, passing arguments to procedures, pointer variables, file handling, concept of recursion. Introduction to C++.

MAL522 Statistical Inference
4 credits (3-1-0)

MAL524 Numerical Analysis
4 credits (3-0-2)

MAL526 Computer Oriented Operation Research
4 credits (3-0-2)
Pre-requisites: MAL513
Overlaps with: MAL245
To discuss the theory and algorithms for solving linear programming problems systematically and to study its various applications in other related areas like integer programming and networks Linear Programming, Transportation and Assignment Problems, Integer Programming, Sequencing Theory, Dynamic Programming, Theory of games, Network Analysis, Introduction to Nonlinear programming.

MAL601 Topology
4 credits (3-1-0)
Pre-requisites: MAL513
Overlaps with: MAL245

**MAL602 Functional Analysis**  
4 credits (3-1-0)  
Pre-requisites: MAL601, MAL514  
Overlaps with: MAL245  
Basic functional Analysis Link.  
Between Algebra Analysis. Same as listed in the courses of study.

**MAL607 Mathematical Logic**  
4 credits (3-1-0)  
To familiarize the student with modern algebraic techniques in logic and its applications to computing. Proposition calculus, truth proof, adequacy, decidability predicate calculus, soundness, deduction theorem, consistency completeness, models, Godel's completeness and incompleteness theorem Turing machines and undecidability of predicate calculus. Gentzen systems, Natural deduction, Applications to Computer Sciences.

**MAL609 Basic Computer Science**  
4 credits (3-0-2)  
To continue developing a disciplined approach to the design, coding and testing of programs written in a high-level language, to introduce basic data structures other than those normal provided as basic types in current programming languages; for example, linked lists, stacks, queues and trees to provide an understanding of the different implementations of these data structures, to introduce the analysis of algorithm and role of data structures in algorithm analysis. To introduce searching and sorting algorithms and their analysis. To introduce various algorithm design paradigms; for example, Greedy, Divide and Conquer, Dynamic Programming etc. Introduction to algorithm; Definition, Pseudo code; concepts of analysis of algorithms; Time complexity, space complexity, worst-case, average-case, big Oh and other notations; Recursion and recurrence relation; Introduction to basic data structures; Stack, Queue, Linked list, Trees, Binary trees. Sorting and searching algorithms; algorithm design techniques: Greedy, divide and conquer, Dynamic programming, Backtracking and branch and bound.

**MAL611 Principles of Fluid Mechanics**  
4 credits (3-1-0)  
To use students knowledge in geometry and differential equations to solve basic fluid mechanics problems and to give a concise account of basic concepts of Fluid Mechanics and some application in Engg.

**MAL614 Advanced Matrix Theory**  
4 credits (3-1-0)  
To provide in-depth knowledge about special topics in Matrix Theory that are very useful in applications of Science and Engineering. Review of Linear Algebra; Matrix calculus, Diagonalization, Canonical forms and invariant factors. Quadratic forms, Courant-Fischer minimax and related Theorems. Perron-Frobenius theory, Matrix stability, Inequalities g-inverses. Direct, iterative, projection and rotation methods for solving linear systems and eigenvalue problems. Applications.

**MAL617 Combinatorial Methods**  
4 credits (3-1-0)  
Introduction of combinatorial methods and techniques Basic combinatorial methods; Recurrence relations and generating functions; Latin squares and SDRs; Extremal set theory, Steiner Triple systems, Ramsey’s Theorem.

**MAL621 Computational Methods for Ordinary Differential Equations**  
4 credits (3-1-0)  
To bridge theory and practice providing sufficient theory to motivate the various methods and algorithms, yet devoting considerable attention to the practical capabilities of the method for Numerical Solution of Ordinary Differential Equations.


**MAL630 Partial Differential Equations**  
4 credits (3-1-0)  
To use students knowledge in Multivariable calculus in solving Partial differential equations and also to give a concise account of fundamental concepts of existence, uniqueness and qualitative properties of strong and weak solutions. Linear, quasi linear and general first order equations, Cauchy problem, Method of characteristics, Cauchy-Kowalevsky theorem, Second order equations: Elliptic, parabolic and hyperbolic equations, Duhamel's principle, method of spherical means, Maximum principles, Perron's method, Green's function, Definition and existence of weak solutions, Eigen value problems.

**MAL638 Applied Nonlinear Programming**  
4 credits (3-1-0)  
To give concise theory of non linear programming in elementary but rigorous manner and to develop skill in using this theory to solve non linear problems.

Review of simplex methods, Revised simplex method and decomposition principle for linear programming, Kuhn-Tucker conditions, methods for solving quadratic and convex programming problems, separable programming, fractional programming, Geometric programming, Multi objective programming, variations methods.

**MAL656 Graph Theory**  
4 credits (3-1-0)  
Graph is one of the important mathematical models in modeling several applications in computer science and engineering. The course aims at presenting a rigorous introduction to the theory of graphs. The course also emphasizes the role of graph theory in modeling applications in computer sciences and solving these applications using graph algorithms. Introduction to Graphs, Definition and basic concepts, Trees; characterizations of trees, minimum spanning tree; Paths and distance in Graphs: distance in graphs, center and median of a graph, activity diagram and critical path; Hamiltonian Graphs; sufficient conditions for Hamiltonian graphs, traveling salesman problem; Eulerian raphs; characterization of Eulerian graphs, The Chinese Postman problem; Planar Graphs: properties of planar graphs, a planarity testing algorithms, dual graph, 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, max-flow algorithm, connectivity and edge connectivity, Menger’s theorem; Graph representation; Graph searching: BFS,DFS Basic Graph Algorithms: MST, shortest paths, biconnectivity, Strong connectivity, etc.

**MAL658 Programming Languages**  
4 credits (3-1-0)  
To impart object oriented programming concepts in C++ and JAVA Concepts of object-oriented computing. Introduction to Object Oriented Systems Design and Analysis, Programming C++ and JAVA. Introduction to Web Programming.

**MAL701 Introduction to Programming and Data Structures**  
4 credits (3-0-2)  
Definition of a programme. Programming methodology. Concepts of structured programming. Definitions and operations on arrays, stacks,
MAL705 Discrete Mathematical Structures  
3 credits (3-0-0)  

MAP706 Scientific Software Laboratory  
3 credits (0-0-6)  
Implementation/development of scientific software.

MAP707 Programming Languages Laboratory  
2 credits (0-0-4)  
Development and implementation of programs using high level languages.

MAL708 Computer Organization and Operating Systems  
4 credits (3-0-2)  
Information representation and binary arithmetic; Basic combinational and sequential circuit design; RTL representation; subsystems of a computer; instructions and their formats; assembly programming; CPU organizations; micro-programming; memory organization; I/O structures; interrupt, DMA; Overview: functions of Operating systems, layered architecture; basic concept; interrupt architecture, system calls and notion of a process and threads; synchronization and protection issues; scheduling; memory management including virtual memory and paging techniques; i/o architecture and device management; file systems.

MAL710 Database Management Systems  
4 credits (3-0-2)  
Pre-requisites: CSL201  
Overlaps with: CSL332/CSL771  
Introduction to database concepts: data independence, consistency, security and integrity; Relational Algebra and Relational Calculus; Query languages; Database design: Functional dependencies, Normal forms, Decomposition of Relations; Indexing, Physical design, Transactions and concurrency control: Schedules and serializability, concurrency control techniques, locking mechanisms; Recovery and security: Types of failures and recovery manager; Transaction logging and checkpointing; Concepts of Object oriented data bases; Introduction to Distributed databases.

MAL711 Algorithmic Combinatorics  
3 credits (3-0-0)  

MAL712 Numerical Analysis of Differential Equations  
3 credits (3-0-0)  

MAL713 Matrix Computation  
3 credits (3-0-0)  
Direct solution of linear systems: Gauss elimination, triangular decomposition, effects of round-off errors norms, condition numbers,

MAL714 Finite Element Techniques and Computer Implementation 3 credits (3-0-0)

MAL715 Digital Image Processing 4 credits (3-0-2)
Pre-requisites: CSL201
Overlaps with: EEL715/CSL783/PHL756
Digital image fundamentals - representation, monochrome, and colour models, image sampling and quantization, Image transforms, Image representation by stochastic models, Image enhancement techniques, Image restoration, Image Analysis - edge detection, segmentation, Scene representation and description, Object recognition and image interpretation. Image compression.

MAL716 Theory of Automata and Formal Languages 3 credits (3-0-0)

MAL717 Fuzzy Sets and Applications 4 credits (3-1-0)
Pre-requisites: EC 90
Fuzzy sets as model for non-deterministic reasoning, logic and mathematical formalisms, fuzzy theory and algebraic theories, applications to: automata theory, decision theory, logic, dynamical systems, theory of computation, optimization.

MAL718 Computational Fluid Dynamics 3 credits (3-0-0)

MAL719 Statistical Computing 3 credits (3-0-0)
Fundamentals of sampling theory. Computer applications involving the sample size determination, statistical decision-making, computer packages for tabulating the various distributions of statistical decision-making. Correlation and regression. Experimental design: programs for analysis of variance in one way and two way design, multivariate data analysis.

MAL720 Neurocomputing and Applications
3 credits (3-0-0)
Pre-requisites: EC 90
Overlaps with: EEL781

MAL724 Cryptology
3 credits (3-0-0)
Mathematics of secure communications, secure communications and crypto-complexity, crypto-systems based on Knapsack problem, public key crypto-systems, algorithms for encryption and decryption, RSA systems, some applications of number theory and algebraic coding theory to cryptosystems. Recent advances in cryptography.

MAL725 Stochastic Processes and Applications
4 credits (3-1-0)
The objective of this course is to apply theory of stochastic processes to gain insight into the problems arise in queueing theory, reliability analysis and financial mathematics. Queueing theory and reliability analysis are introduced and studied; used for the analysis and evaluation of computer and communication systems. Stochastic processes arise in financial mathematics are also studied. Different solution methods (such as analytical and numerical) are used to evaluate these models and to gain insight into the behavior of the above stochastic systems. Stochastic processes, classifications, discrete and continuous time Markov chains, Poisson processes, renewal processes, Little’s formula, martingales, Brownian motion Erlangs loss system \((M/M/m/m-queue)\), finite source population, \(M/M/1/queue\); \(M/M/m\)-queue, multidimensional queues. \(M/G/1\)-queue, \(GI/M/1\)-queue, \(GI/G/1\)-queue, bulk queues, priority queues, solution techniques, steady state and transient analysis, performance measures.

MAL726 Principles of Optimization Theory
4 credits (3-1-0)
Elements of convex analysis, Karush-Kuhn-Tucker conditions, Convex optimization, Nonsmooth optimization, Conjugate functions and Fenchel duality, Fractional programming, Nonlinear Lagrangian and nonconvex duality, Monotone and generalized monotone maps.

MAL727 Applied Multivariate Data Analysis
4 credits (3-1-0)
To give a concise account of the multivariate statistical technique and use these for data analysis. Multivariate data and multivariate statistics, Principal component analysis, Cluster analysis, The generalized linear model, Regression and analysis of variance, Discrimination and classification, Factor analysis, Minor component analysis, Independent component analysis.

MAL728 Category Theory
4 credits (3-1-0)
To introduce the student to category theory which serves to unify the concepts distributed across various pure and applied branches of mathematical sciences. This will enable the student to access contemporary thinking in a number of subjects in mathematics and computer sciences.
i) Categories, functors, natural transformations, 2-categories.
ii) Adjoint functions, monads, Kleisli construction.
iii) Closed categories, and toposes.
iv) Allegories.
v) Applications to theoretical computer science.

MAL729 Computational Algebra and its Applications
4 credits (3-0-2)
To update knowledge and empower students with the advanced computations in modern algebraic structures and their applications in coding theory, cryptography apart from mathematics.

Applying the corresponding algorithms/programmes. (laboratory/design activities could also be included).


MAL730 Cryptography
4 credits (3-1-0)

MAL731 Introduction to Chaotic Dynamical Systems
4 credits (3-1-0)
The aim is to introduce students to current research in chaotic dynamical System.

We begin with an analysis of the dynamic of one-dimensional maps of both the interval and the circle. Topics to be covered include chaos, elementary bifurcations. Darkovski's theorem Schwarzian derivative symbolic dynamics and chaotic behaviour. Midway we discuss higher dimensional dynamics, including special examples like horse shoe and Henon attraction.

The latter part will be devoted to special topics like tent map, logistic functions, Cellular automaton.

MAL732 Financial Mathematics
4 credits (3-1-0)

MAL733 Stochastics of Finance
4 credits (3-1-0)
Stochastic Processes; Brownian and Geometric Brownian motion; Conditional Expectation and Martingales; Stochastic Integrals, Ito's formula; Stochastic Differential Equations; Girsanov Theorem and Feymann-Kac theorem; Applications of stochastic calculus in finance, Option pricing and Interest Rate Derivatives.

MAL734 Algebraic Geometry
4 credits (3-1-0)
To expose the students to the fundamentals of Algebraic Geometry which is currently one of the most important subject in Mathematics.


MAL735 Number Theory
4 credits (3-1-0)
To introduce students to the basic concepts in the Theory of Number, amalgamating classical results with modern techniques using algebraic and analytic concepts.

Congruences: Some elementary properties and theorems, linear and systems of linear congruences, Chinese Remainder Theorem, quadratic congruences, Quadratic Reciprocity Law, Primitive roots. Some elementary arithmetical functions and their average order, Mobius Inversion formula, Integer partitions, simple continued fractions, Definite and Indefinite Binary Quadratic Forms some Diophantine equations.

MAL736 Information Integrity
4 credits (3-1-0)
Pre-requisites: EC 90

Information Integrity, concepts and definitions; direct integrity and its mechanism; modeling information error; system's view of Information Integrity; open system view of business enterprise system; business process IS view as integral to close loop information and control system and as information origination process; information envelope, uncertainties therein, error Implications and loss of Information Integrity; inadequacy of existing integrity mechanisms; criticality of Information Integrity for efficient and economic processing of information in IS view; Usefulness- Usability - Integrity paradigm; cost benefit analysis of Information Integrity; mathematical equations for information value and for improvement of Information Integrity; design basis for Information Integrity analyzer and controller.

MAL737 Differential Geometry
4 credits (3-1-0)
Pre-requisites: EC 90

To introduce the students to geometry of hypersurfaces. Curves in plane and space, curvature, isoperimetric inequality, surfae in three dimensions, First fundamental form, curvature of surfaces, Geodesics, Gauss's Theorem.

MAL740 Queuing Networks for Computer of Communication Systems
4 credits (3-0-2)
Stochastic processes, classifications, discrete and continuous time Markov chains, Poisson processes, renewal processes, Little's formula. Erlangs loss system (M/M/m/m-queue), finite source population, M/M/1-queue; M/M/m-queue, multidimensional queues.
M/G/1-queue, GI/M/1-queue, GI/G/1-queue, bulk queues, priority queues.

Open (Jacksons) queueing networks; closed queueing networks, mean value analysis (MVA), time reversibility, Burke's theorem.

Solution techniques, steady state and transient analysis, Petri nets, discrete event simulation, performance measures.

Applications of above queueing systems in availability, reliability, computer systems, communication systems such as wired, wireless and mobile ad hoc networks.

**MAL741 Fractal Geometry**
4 Credits (3-1-0)
Pre-requisites: EC90

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, Diophantine approximation, chaos games, attractors, fractals, superfractals and multifractal measures, Mandelbrot and Julia sets, random fractals, fractals in Brownian motion.

**MAL745 Software Engineering**
4 credits (3-0-2)
Pre-requisites: CSL201
Overlaps with: CSL740

An introduction to software life cycle models; analysis, design, coding and testing methods, software size estimation; cost and schedule estimation; project management; risk management; formal technical reviews; configuration management and change control; and software reliability estimation. Emphasis on large development projects.

**MAL754 Principles of Computer Graphics**
4 credits (3-0-2)
Pre-requisites: CSL201
Overlaps with: EEL754/CSL781

Overview of Graphics Systems, Output primitives and their attributes, Geometric primitives in 2D, 2D transformations, 2D viewing, Clipping, Geometric primitives in 3D, 3D Object representations, 3D transformations, 3D viewing, GUI primitives, Computational geometry topics – Binary space partitioning trees, Triangulation, Polygon partitioning, Visible surface detection, Surface rendering, Illumination models, Basics of computer animation.

**MAL755 Algebraic Geometry**
4 credits (3-1-0)
Pre-requisites: MAL124 / MAL255


**MAL760 Advanced Algorithms**
4 credits (3-0-2)
Pre-requisites: MAL342
Overlaps with: CSL758


**MAL780 Special Topics in Computer Applications**
4 credits (3-0-2)
Pre-requisites: EC 90

Topic and course contents will be announced before registration by the concerned faculty.

**MAL782 Data Mining and Knowledge Discovery**
4 credits (3-0-2)
Pre-requisites: MAL342 & MAL372

Introduction to Data Mining, Data Cleaning and transformation, Data Warehousing architecture, Front end data warehousing operations, data cubes and other visualizations, data synchronization with operational databases, Classificatory knowledge Extraction and prediction, Decision Trees, Association Rule Mining, Error analysis, LIFT charts and ROC curves, Bagging and Boosting, Clustering, Sequence analysis, Design of parallel and distributed data mining systems, mining complex data. Laboratory assignments: Implementation of the above concepts.

**MAL785 Natural Language Processing**
4 credits (3-0-2)
Pre-requisites: MAL342 & MAL375 & MAL390

Linguistics Essentials: Parts of Speech and Morphology, Inflectional vs. Derivational Morphology, Phrase Structure Grammar (dependency, ambiguity), Syntax and Syntactic Theory, Semantics, Language variations, Pragmatics - language as a means of communication.

Study of Words: Frequency, Hypothesis testing, Collocation, n-gram models, Word-sense Disambiguation - supervised, unsupervised, dictionary-based.

Lexical Acquisition: Verb Categorization, Semantic Similarity.

Applications: Statistical Alignment techniques (length based, word-based, cognate-based), Machine Translation and its various approaches, Information retrieval (vector-based model, term distribution model), Text Categorization.

**MAL786 Cryptology**
4 credits (3-1-0)
Pre-requisites: EC 90

Private Key Cryptosystems: classical techniques, modern techniques, algorithms like DES, IDEA, RC5, Blowfish, etc, confidentiality using Conventional Encryption; Public Key Encryption and Hash Functions: principles of public key cryptosystems, Diffie-Hellman key exchange, RSA, introduction to elliptic curve cryptography; Introduction to Number Theory: modular arithmetic, Fermat's and Euler's theorem, primality testing, Chinese remainder theorem, discrete logarithms; Basics of Finite fields; Message Authentication and Hash function: MD5, SHA-1, HMAC etc.; Digital Signature and authentication protocols: Digital signature, DSS, Authentication protocols; Differential and Linear Cryptanalysis; existing cryptosystems and their security. Cryptanalysis of existing systems. Zero-knowledge protocols, One-way functions. Advanced protocols for different applications, e.g. e-cheque, e-cash etc. Network and System level security issues.

**MAL790 Special Topics in Computer Science**
4 credits (3-0-2)
Pre-requisites: EC 90

The course contents will be announced by concerned faculty member before registration.

**MAV791 Special Module in Dynamical Systems**
1 credits (1-0-0)
Pre-requisites: EC 90 for MT5 students
Basics - minimality, equicontinuity, recurrence, distality. Interplay of
dynamical properties. Ergodicity. Symbolic dynamics. Relations arising
from dynamical transformations and their Ellis semigroups. Entropy.
Structure theorems. Decomposition theorems.

MAL803 Pattern Recognition
3 credits (3-0-0)
Statistical and geometrical techniques of pattern recognition,
classification and cluster analysis, linear discrimination analysis and
feature extraction theory. Application of entropy principles and
mathematical programming techniques to pattern recognition. Fuzzy
theoretic approach to pattern recognition.

MAL805 Mathematical Modelling and Computer Simulation
3 credits (3-0-0)
Modelling of non-linear transport process in the context of urban air
pollution and dispersion of suspended matter in waterways; large-
scale motions in the atmosphere and oceans; humidity transport
equations; models in population ecology, predator-prey interactions
models of renewable resource harvesting; case studies and computer
simulation.

MAL807 Compiler Construction
3 credits (3-0-0)
Compilers and translators. Structure of a compiler. Lexical analysis and
syntax analysis. LL and LR parsing techniques and parser generators.
Symbol tables. Internal form of source programs. Semantic routines.
Error detection and recovery code generation. Code optimization.

MAL809 Numerical Software
3 credits (3-0-0)
Concept of a software library; design principles. Numerical library for
a large industrial organization : using the NAG library in industrial
research. Linear and non-linear algebra : singular-value
decomposition, software for sparse matrices, non-linear algebraic
equations in process engineering calculations, data fitting algorithms.
Differential and integral equations; solution of large systems, stiff
initial-value problems, efficiency of stiff integration routines, numerical
software for integral equations, problem of algorithm design for PDEs.
Optimization : mathematical programming systems.

MAL811 Mathematical Foundation of Artificial Intelligence
3 credits (3-0-0)
Knowledge Base as conventional and non-conventional logics, the
basic problems of incompleteness, inconsistency, non-monotonicity,
conservativity, uncertainty and imprecision in representation of a
knowledge-base. Deduction and computation : the inference systems,
arities, sorts and many-sorted algebras, polymorphisms. The
categorical formulation. Confluence and termination, Knuth-Benedix
method. The Church- Rosser property and sequential computation.
Logic programming, PROLOG and other logic programming languages.
Functional programming.

MAL819 Statistical Simulation on Computers
3 credits (3-0-0)
Random number generation tests for randomness, random variate
generation, rejection principle, compo-sition, variance reduction
techniques, simulation from multivariate distributions. Analysis of
simulation with general purpose languages. A minor application.

MAL823 Special Topics in Computer Applications
3 credits (3-0-0)
Review of elementary stochastic calculus and Black - Scholes - Merton
theory of option pricing. Corporate liabilities and contingent claims.
Risk structure of interest rates. Statistical techniques for analyzing
defaults. Credit scoring modeling using logistic regression, Discriminant
Analysis and support vector machines. Rating based term structure
models. Credit risk and interest rate swaps. Credit default swaps (CDS), collateralized debt obligations (CDO’s) and other related
products. The copula approach. Portfolio credit risk analysis using coherent risk measures.

MAD851 Major Project Part 1 (MT)
6 credits (0-0-12)
Pre-requisites: EC 165
Students will take up project under the guidance of a faculty member
in an area of the student’s choice. Projects are to be executed individually.

MAD852 Major Project Part 2 (MT)
14 credits (0-0-28)
Pre-requisites: MAD851
Students will continue with the projects taken up in the first part,
MAD851, under the guidance of the same faculty member.

MAL851 Applied Numerical Analysis
3 credits (3-0-0)
Error analysis and stability of algorithms. Nonlinear equations:
Newton Raphson method, Muller’s method, criterion for acceptance of
a root, system of non-linear equations. Roots of polynomial
equations. Linear system of algebraic equations : Gauss elimination
method, LU-decomposition method; matrix inversion, iterative
methods, ill- conditioned systems. Eigenvalue problems : Jacobi,
Givens’ and Householder’s methods for symmetric matrices.
Rutishauser method for general matrices, Power and inverse power
methods. Interpolation and approximation : Newton’s, Lagrange and
Hermite interpolating polynomials, cubic splines; least square
and minimax approximations.

Numerical differentiation and integration: Newton-Cotes and Gaussian
type quadrature methods.
Ordinary differential equations : Initial value problems: single step
and multistep methods, stability and their convergence. Boundary
value problems: Shooting and difference methods.
Partial Differential Equations : Difference methods for solution of parabolic and hyperbolic equations in one and two-space dimensions,
stability and their convergence, difference methods for elliptic
equations.

MAL853 Methods of Applied Mathematics
3 credits (3-0-0)
Classification of a system of PDEs. Riemann invariants and applications.
Group theoretic methods for the solution of non-linear differential
equations of physical and engineering systems.

MAL854 Interpolation and Approximation
3 credits (3-0-0)
Interpolation : general problem, representation theorems, remainder
theory, convergence of interpolatory processes. Approximation :
best, uniform and least-squares, degree of approximation.
Approximation of linear functionals: Optimal approximations in Hilbert
spaces, roots and extremals : Convergence of Newton’s method in
Banach spaces, minimizing functionals on normed linear spaces,
applications to integral equations and control theory.
Splines : applications to computer-aided design.
Filters : linear, least-squares and Chebyshev.
Applications to signal processing.

MAL855 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
proceduresBayes, minimax and admissibilities properties, subset

MAL856 Lie Algebras
3 credits (3-0-0)

MAL860 Linear Algebra
3 credits (3-0-0)

MAL863 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.

MAL874 Analysis
3 credits (3-0-0)
MEP601 Introduction to Computers and Programming (Non-credit Audit) 2 credits (0-0-4)

MEL626 Mechanical Equipment in Power Plants 3 credits (3-0-0)

MEL661 Materials Management 3 credits (2-0-2)

MEL667 Long Range Planning 3 credits (3-0-0)

MEL671 Value Engineering 3 credits (2-0-2)

MEL674 Principles of Management 3 credits (3-0-0)

MEP691 Basic Mechanical Laboratory 1 credit (0-0-2)
Basic experiments related to thermodynamics, fluid mechanics and heat transfer.

MED700 Design Project 4 credits (0-1-6)
Formulation of project team - students from different programs (maximum 2) and one or more faculty facilitators (to be done in the preceding semester). Selection of a product/machine/device from engineering industry for study–the life cycle should encompass aspects of thermal and mechanical design, and manufacturing. Setting objectives, making project schedule, and record management process. Some examples of products: centrifugal pump, heat exchanger, turbine blade, control system, cooling tower, burner, instrument. Development of conceptual alternatives and selecting one for detailed working; conceptual design; detailed design using knowledge of PG core and elective courses, and design and production engineering courses; use of codes and standards; preparation of engineering drawings; process planning, manufacturing, assembly, testing, and as possible; testing to failure, and failure analysis; documentation.

MEL703 Advanced Thermodynamics 3 credits (3-0-0)

MEL705 Experimental Methods in Thermal Engineering 4 credits (2-0-4)
Statistics: Distributions, estimators, confidence levels, sample size, test of hypothesis, Goodness-of-fit test Chauvenet’s criteria; Regression analysis, co-relations. Uncertainty analysis. Design of experiments.
Instruments: Specifications. Static and dynamic characteristics. Instruments for measuring distance, profile, pressure, temperature,
velocity, flow rate, level, speed, force, torque, noise, chemical analyses. Estimation of systematic errors. Sig
nal conditioning, data acquisition and analysis. Transducers, A-D & D-A converters, interfacing with computers and PLCs.


Laboratory: Calibration. Experiments related to heat transfer, fluid mechanics, thermodynamics and gas dynamics. Project on experiment design including drawings, wiring diagrams, selection of instruments and computer interfacing. Use of various controllers and actuators. Data management and presentation.

**MEL707 Applied Mathematics for Mechanical Engineers**

3 credits (2-0-2)

In relation to mechanical engineering applications, such as, heat transfer, fluid mechanics, vibrations, dynamics and others, the following topics will be covered:

- Partial differential equations - characteristics and classification of 2nd order PDEs. separation of variables, special functions, eigenfunction expansions, Fourier integrals and transforms, Laplace transforms, methods of characteristics, self-similarity.

**MEL708 Combustion Generated Pollution and Control**

4 credits (3-0-2)


**MEL709 Heat Exchangers**

4 credits (3-0-2)


**MED710 Mini Project**

3 credits (0-3-0)

Identification of faculty supervisor(s), topic, objectives, deliverables and work plan (in the preceding semester prior to registration); regular work during the semester with weekly coordination meetings (about 1 hour) with the faculty supervisor; and an end-semester demonstration to all faculty and students. Grade to be decided on the basis of a midterm and an end-semester presentation following the open demonstration vis-a-vis the approved work plan. The topic should be of advanced standing requiring use of knowledge from program core courses and be preferably hardware oriented. The mini-project would be available aerosols; codes and standards. Only in the 2nd and 3rd semesters and should be carried out individually. In the 3rd semester, the topic will have to be different from the major project.

**MEL710 Air-conditioning**

4 credits (3-0-2)


**MEL711 Refrigeration and Air-conditioning Technologies**

4 credits (3-0-2)


**MEL712 Advanced Power Plant Cycles**

4 credits (2-0-4)


**MEL713 Design of I.C. Engine Components and Sub-systems**

4 credits (3-0-2)


**MEL714 Thermal and Nuclear Steam Power Plants**

4 credits (3-0-2)


**MEL715 Gas Dynamics**

4 credits (3-0-2)

Recapitulation of fundamentals, introduction to numerical analysis of compressible flow. Oblique shocks, compression and expansion waves,

**MEL716 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 thermal conductivity models, specific heat, thin films, convection in microtubes and channels, boiling and condensation, nanoparticles and nanofluids - preparation and transport properties, microscale radiative heat transfer - modelling, properties, measurements at microscale, Engg. applications-flow in microchannels, micro heat pipes, microelectronics, superconducting films, radiation etc.

**MEP720 Advanced Mechanical Laboratory**  
3 credits (0-1-4)  
Basic and advanced measurements and their use in fluid mechanics, heat transfer, emission and vibration applications. Introduction to computers and their use for preparing engineering drawings. Introduction to mathematical packages. Use of computers and microprocessors for data acquisition. Introduction to advanced computational packages for fluid flow, heat transfer, combustion, stress analysis and dynamics calculations.

**MEL725 Power Plant Steam Generators**  
3 credits (3-0-0)  
Recapitulation of basics, design methodology, fuel preparation and combustion system design. Burners - coal, oil and gas, steam-water system design, circulation beat exchange components, fouling and corrosion, draft system (air and flue gas) design, boiler controls. Mechanical design of pressure parts, heat recovery boiler-design, water quality and its control, case studies.

**MEL727 Power Plant Turbo-machinery**  
3 credits (3-0-0)  
Recapitulation of basic fluid mechanics and thermodynamics. Introduction to turbo-machine flow phenomena, dimensional analysis, design and performance parameters, flow through nozzle and diffuser cascades, wind tunnel tests, loss correlations. Stages, velocity triangles, degree of reaction, impulse and reaction, work and efficiency expressions. Losses, 3-D flow. Axial and centrifugal compressors and fans. Surge, stall. Hydraulic turbines and pumps.

**MEL730 Hydroelectric Power Plants**  
3 credits (3-0-0)  

**MEL731 Analytical Dynamics**  
3 credits (3-0-0)  
Review of Newtonian Dynamics, Degrees of Freedom, Generalized Coordinates, Systems with Constraints, Holonomic and non-holonomic constraints; Principle of Virtual Work, D’Alembert’s principle; Lagrange Equations of motion; Hamilton’s equations; Coordinate transformation, Rotating coordinate systems; Kinematics of a rigid body, Euler angles; Euler’s equations of motion (rotation); Behavior of Dynamics Systems—Geometric theory, Stability of dynamic systems, Lyapunov direct method; Introduction to flexible body dynamics.

**MEL732 Advanced Mechanical Design**  
4 credits (3-0-2)  
Review of machine element design based on strength and distortion criterion; review of choice of materials and their treatment; Effect of lubrication in mechanical design.

**MEL733 Vibration and Noise Engineering**  
4 credits (3-0-2)  

**MEL734 Instrumentation and Automatic Control Systems**  
4 credits (3-0-2)  
Practicals: Static and dynamic Behaviour of some important transducers, calibration procedure, Development of Computer aided experimentation systems. Experimental studies on Hydraulic, Pnumatic, Electrical controller.

**MEL735 CAD and Finite Element Analysis**  
4 credits (3-0-2)  
Introduction and overview. Need and Scope of Computer Aided Machine Design. Role of Geometric Modelling, FE and Optimization; 2D and 3D Geometric transformations, Obtaining 2D views from 3D representations: Orthographic and Perspective Projections. Windowing and view-porting; Geometric modeling; Modelling of curves, cubics, splines, beziers and b-splines; Modeling of surfaces; Modeling of solids—b-rep, CSG, octree, feature based modelin; 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 Dynamic and Non linear analysis; Limitations of FEM.
ME736 Automotive Design
4 credits (3-0-2)
Design requirement of Automobile (power-speed curves); Engine as a system and its subsystems, Lubrication system, Fuel injection systems, Cooling System; Design requirements of the automobile transmission. Automatic transmissions; Dynamic considerations in designing of suspension system; Modern systems of suspensions; Kinematic requirements of a steering mechanism; Need for Power Steering; Braking requirements of an automobile. Brake materials; Modeling and simulation of different subsystems, e.g., suspension system, etc.; Instrumentation and Control—Gauges (Speedometer, Oil, temperature indicators, etc.); Microprocessor controlled units; Safety and comfort aspects in the automotive component designs.

Practicals: Illustrative designs of subsystems, e.g., manual transmission, suspension system, steering mechanism, and others. In these exercises, the use of available software packages, like ADAMS, MATLAB, will be undertaken; System integration—Steps and methodologies to put the designed subsystems together, Wheel alignment and balancing; Suspension and steering adjustments; Issues related to safety; Crash modelling of vehicles.

ME737 Machine Tool Design
4 credits (3-0-2)
Design requirements of machine tools. A design approach for machine tools. Identification and quantification of objectives and constraints in machine tool design. Estimation of power requirements and selection of motor for metal cutting machine tool spindles. Design of gearbox, spindle and guideways. Principles of design of structural components, namely, head stock, tail stock, carriage, table, knee, column and overarms to achieve desired static & fatigue strength, stiffness, dynamic characteristics and other requirements. Exercises on the design of machine tools using existing CAD software packages.

Introduction to computer integrated manufacturing systems and CNC machine tools. Design/selection of linear motion systems, ball, screws, CNC feedback devices, controllers, feed drives and servomotors for CNC machine tools. Recent developments in CNC and other machine tools.

ME738 Dynamics of Multibody Systems
4 credits (3-0-2)
Overview of kinematic descriptions, Serial, tree, and closed-loop chains; Degrees of freedom. Kinematic constraints of rigid and flexible systems; Lagrange, Newton-Euler, Kane's equations, and orthogonal complement approaches of deriving a dynamic model for tree and closed-loop systems consisting of rigid and/or flexible bodies; Dynamics analyses using classical approximation, FEM, and other computer software, e.g. ADAMS.

ME739 Mechanics of Robots
4 credits (3-0-2)
Types and components of robots; Classification of closed- and open-loop kinematic systems, Definition of mechanisms and manipulators, Kinematic constraints, Degree of freedom (DOF) and Mobility; DH parameters, Coordinate transformations, Matrix methods; Forward kinematics of robot manipulators with examples; Inverse kinematics; Jacobian and singularity; Graphical and Algebraic inverse kinematic solution; Dynamic considerations, Rigid body dynamics, Newton-Euler formulation, Equations of motion; Methodologies for inverse and forward dynamics; Parallel robots; Inverse and forward kinematics and Singularity.

ME740 Advanced Lubrication Theory
4 credits (3-0-2)
Lubrication - Thin Film, Mixed Boundary and Solid; Bearings - Hydrodynamic, Hydrostatic, Elastohydrodynamic; Basic Equations - Navier Stokes, Continuity, Reynolds; Thick Film Lubrication - Externally Pressurized Bearings, Hydrodynamic Journal and Thrust Bearings; Dynamic Properties of Lubricant Films - Linear and Nonlinear Theory; Turbulence - Constantinescu Model, Ng-Pan- erlod Model; Elastohydrodynamic Lubrication - Theory, Contact Mechanics, Deformation, Rolling Contact Bearings; Thermal Effects - Effective Viscosity, Energy Equation, Themoshydro-
dynamic Theory, Journal Bearings, Thrust Bearings, Rolling Bearings; Non-Newtonian Lubrication; Gas Lubrication.

ME741 Blade and Disc Dynamics
4 credits (3-0-2)

ME742 Optimum Design of Mechanical Systems
4 credits (3-0-2)

Optimum selection of material & processes in mechanical design using material selection database, charts and optimisation methods. Optimising product design functionality, aesthetics and economics by employing industrial design principles and by suitable selection of material & processing including use of polymers, composites and other non metallic materials and relevant processes.

ME743 Plant Equipment Design
4 credits (3-0-2)
Introduction to various kinds of plant equipment. Technological considerations in plant equipment design. Special consi-derations for typical industries such as food processing, chemical industry. Rolling mills, mass production industries and power plants.


Material Handling Equipment, Types and use. Design considerations for hoisting equipment, Surface and Overhead equipment Stackers and elevators. Design consideration in rotating machinery, modelling and analysis of rotor bearing system, bearing characteristics and selection, placement of critical speeds, optimum dynamic response, check for stability, effect of seals, foundation effects. Materials and manufacturing considerations in design of rotating machinery. In the exercises the use of available software packages should be undertaken.

ME744 Design for Manufacture and Assembly
4 credits (3-0-2)
MEL745 Advanced Robotics
4 credits (3-0-2)
Review of serial robotic manipulators. Classification of parallel robots (Stewart platform, wheeled mobile robots, walking machines, etc.). Algorithms for inverse and forward kinematic/dynamic analyses of parallel robots. Kinematic design of serial and parallel robots based on singularity, workspace, manipulability, dexterity, etc. Mechanical design of robot links and joints. Introduction to control of robotic systems.

Practicals: Experiments with existing robots

MEL746 Design of Noise, Vibration and Harshness
4 credits (3-0-2)


MEL748 Tribological Systems Design
4 credits (3-0-2)
Lubrication, Friction and Wear aspects in Design; Tribological Surfaces - Roughness and Mechanisms of Lubrication, Friction & Wear; Regimes of Lubrication; Viscosity - its representation and Measurement; Apparent Viscosity; Selection of Bearings - Rubbing, Fluid Film, Rolling Element; Lubricants - Types and Selection; Bearing Design - Rubbing, Fluid Film Journal and Thrust, Dynamically Loaded, Rolling Element; Lubrication Systems - Selection and Design Considerations; Maintenance of Bearings; Seals; Design of Clutches and Brakes; Linear Bearing Design; Slideways; Material Considerations for Various Applications.

MEL749 Mechatronic Product Design
4 credits (3-0-2)

Interfacing. DA and AD converters, software and hardware principles and 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.

MEL751 Industrial Engineering and Systems
4 credits (3-0-2)

MEL752 Quality Assurance
4 credits (3-0-2)
Introduction to quality assurance and quality control, Various elements in Quality Assurance program, On-line and Off-line quality control, Statistical concepts in quality, probability distributions, Central limit theorem, Chance and assignable causes of quality variation, Process control charts for variables, Control chart parameters, Target process setting / Centering, Control limits and specification limits. Process capability studies, Capability indices, Quality remedial / Corrective actions, Special purpose control charts, Reject limits, Variables inspection and attributes Inspection, Control charts for attributes, Narrow limit gauging, Quality rating, Defects classification, Average run length, Sensitivity of control charts.

Sampling inspection for product acceptance, Single, double, multiple & sequential sampling schemes, OC, AOQ, ASN, and ATI curves, Design of sampling plans, Standard sampling systems, Economics of product inspection, Quality costs, ISO 9000 quality system, Product quality and reliability, Failure data analysis and life testing. Problems and illustrations in Quality Assurance.

MEL754 Operations Planning and Control
4 credits (3-0-2)
Generalised model of a production system, the national economy as a Leontief's input-output system, decisions in the life cycle of a production system, evaluation of investments in new product and services, risk analysis using decision trees, product mix decisions, deterministic and stochastic models, different kinds of production systems, mass, batch job and cellular production, location decisions: multi-criteria approach, mathematical models for facility location and layout, use of iso-cost lines in location decisions, demand forecasting using qualitative and quantitative methods, aggregate production planning, hierarchical production planning, materials requirements planning versus conventional inventory control.

MEL756 Supply Chain Management
4 credits (3-0-2)
Historical evolution of SCM, Supply Chain components: Inbound logistics, Operations, Outbound logistics, Forecasting, Inventory strategy, Transportation Strategy, Warehouse management, Information Strategy for SCM, Role of Information Technology in SCM, Performance measurement, Organization design and structure for effective supply chain.

MEL760 Project Management
3 credits (2-0-2)
Project as a goal fulfillment venture, projects versus routine production, life cycle of a project, generation of new project ideas, brainstorming, screening of ideas, project appraisal on various fronts: market and demand, technical feasibility, financial evaluation, ecological appraisal, multi-criteria evaluation of projects, work breakdown structure, project network development, project shedding using PERT and CPM, floats and their interpretation, project simulation, project crashing and resource aggregation, leveling and allocation, project monitoring and control using earned value and the concept of critical chain, human factors in project management.

MEV760 Special Topics in Industrial Engineering
2 credits (2-0-0)
The contents for this course will vary from time to time based on the emergent industrial scenario. Concepts such as BPR, ERP, SCM and the practitioners view on the same will be presented through case studies and experience sharing sessions. There will be case studies,
software demonstrations and experience sharing sessions from faculty (total 14 sessions each of 2 hour duration).

**MEL761 Statistics for Decision Making**
4 credits (3-0-2)
Fundamentals of probability theory and statistical inference used in engineering and applied science, descriptive statistics, Probability models, random variables, expectations, moment generating functions and its properties, conditional probability, useful discrete and continuous distributions, their properties and applications in QM, reliability, quality control and simulation, law of large numbers, central limit theorem and its applications, case studies, statistical inference, confidence interval estimation, point estimation, case studies, concept of null hypothesis, testing of hypothesis, goodness of fit tests, linear regression, non-parametric test procedures, industrial applications, curve fitting and other techniques of estimation, introduction to software in statistics.

**MEL762 Facility Planning and Plant Engineering**
3 credits (2-0-2)

**MEL763 Methods Engineering and Ergonomics**
3 credits (2-0-2)

**MEL764 Human Factors Engineering**
3 credits (2-0-2)

**MEL765 Operations Research-I**
4 credits (3-0-2)
Introduction to operations research, its historical development, introduction to mathematical programming models and computational techniques, linear programming and simplex method, sensitivity analysis, transportation problem, dynamic programming , Integer programming, goal programming, network analysis, some of the main stochastic models used in engineering and operations research applications: Poisson process, birth and death processes with applications in queuing models, inventory models.

**MEL768 Quality Management: A Systems Perspective**
3 credits (2-0-2)

**MEL769 Metal Forming Analysis**
4 credits (3-0-2)

**MEL770 Introduction to Stochastic Modeling and Simulation**
4 credits (3-0-2)
Quick review : basic probability, random variables; Introduction to Discrete Time Markov Chains - definition and characterization, Transient Distributions, Limiting Behaviour, Cost models, First passage times, Applications/Case studies; Poisson Processes, Continuous Time Markov Chains - Introduction, Transient and limiting behaviour, Cost models, Applications/Case studies; Simulation - basics, discrete event simulation, Monte Carlo Simulation, Variance Reduction Techniques, Applications to queuing, Finance Lab Activity : Problem solving, applications/case studies for the Markovian Theory component; Simulation software for simulation component.

**MEL772 Metal Forming Technology**
3 credits (3-0-0)
Technological advances in metal forming processes- forging, rolling, extrusion, wire drawing and sheet metal forming, Design of roll pass and rolling schedules, Description of typical cold rolling and hot rolling mill plants, Computer aided die design for forging, extrusion and wire drawing, Automation in metal forming processes, Recent developments in forming equipment (high speed presses etc.), Advances in sheet metal forming, Sheet metal die design, Formability evaluation, Unconventional forming processes like Hydrostatic extrusion, High energy rate forming processes, Hydro-forming of sheets and tubes, Powder forming, Finite Element Simulation of forming processes.

**MEL775 IT in Manufacturing Enterprises**
3 credits (3-0-0)

**MEL778 Design and Metallurgy of Welded Joints**
4 credits (3-0-2)
Introduction to importance of welding in fabrication, Problems & difficulties in welded structures, How to obtain a sound welded structures and analysis, Properties for selection of materials, Characteristic
properties and behaviour of commonly used materials, Effect of alloying materials, Heat flow in metals, Heating and cooling cycles in welding, Effect on HAZ, Hot cracking, Development of phases, Microstructure etc, Causes and cures for various discontinuities & defects in weldments, Weldability, Weldability of commonly used materials, Mechanical testing of weldments, Service and fabrication weldability tests and their importance, Thermal stresses and distortion, Brittle fracture and fatigue in welded joints, NDT of welds, Introduction to engineering physical metallurgy, Welding metallurgy and microstructures, Joint preparation, weld symbols, Weld joint designs for strength and quality, Automation in welding, Cost analysis.

**MELE780 Metrology**

**Credit Points:** 4 points (3-0-2)

- Ferrous and Non-ferrous materials and their properties, Metal Matrix Composites and their properties and suitability as casting materials, Selection of materials for casting, melting of metals, Solidification of castings, casting design considerations, mould designs for sand and die castings, gating system design, riser design, casting defects: their causes and their removal, cleaning of castings, heat treatment of castings, inspection, repair and salvage of castings, quality control in foundries, special casting processes, Specific considerations to Grey CI, stainless and non-ferrous foundry practices, Foundry Mechnazition Pollution control in Foundries.

**MELE81 Machining Processes and Analysis**

**Credit Points:** 4 points (3-0-2)

- Survey of various methods of metal removal, Mechanics of orthogonal cutting, nature of contact between chip and tool, stress distribution at chip-tool interface, controlled contact tools, Mechanics of oblique cutting, Thermal aspects of metal cutting. Cutting fluids, method of selection of fluids, Dry cutting, Tool wear, Wear theories, experimental methods, Tool life, Machinability, machining economics, Dynamometer, Abrasive Machining Processes, mechanics of grinding process, grinding wheel wear, High Speed Machining, Ultra-precision Machining and hard turning, Non-Traditional Machining Processes such as EDM, ECM, USM, EDM, AJM, IBM, WJM and LBM.

**MELE83 Automation in Manufacturing**

**Credit Points:** 4 points (3-0-2)

- Modern developments in automation in manufacturing and its effect on global competitiveness, Need and implications of automation in manufacturing, different types of production systems and automation, hard/fixed automation including process automation, Rapid prototyping and tooling, Hydraulic and pneumatic actuators, their design and control devices, sequence operation of hydraulic/pneumatic actuators, designing of complete systems with hydraulic, electro-hydraulic and digital control devices, applications in manufacturing, material handling systems, feeders, orienting and escapement devices, their analysis and design, Automatic assembly machines, designing for automatic assembly.

**MELE84 CNC Technology and Programming**

**Credit Points:** 4 points (3-0-2)


**MELE86 Metrology**

**Credit Points:** 3 points (2-0-2)

- Introduction to dimensional metrology, limits, fits and tolerances, application of tolerances, limit gauging, design of gauges, measuring instruments and their design considerations, angular measurements, auto collimators and interferometers, applications of dimensional inspection, measurement of screw threads, thread gauges for internal and external threads, gear inspection, inspection of surface quality, parameters for assessing surface finish and experimental methods of surface finish measurements, feature inspection, straightness, flatness, parallelism, squareness, circularity and roundness, automated dimensional measurements, automatic gauging, automatic measuring machines for inspecting multiple workpiece dimensions, measurement with coordinate measuring machines.

**MELE87 Welding and Allied Processes**

**Credit Points:** 4 points (3-0-2)

- Introduction to joining technology, General survey and classification of welding processes, Safety and hazards in welding, Physics of the welding arc and arc characteristics, Metal transfer & its importance in arc welding, Various forces acting on a molten droplet and melting rates, Power sources for arc welding, Welding consumables: fluxes, gases and filler materials, SMAW, SAW, GTAW and related processes, GMAW and variants, PAW, Gas welding, Soldering, Brazing and diffusion bonding, Thermal cutting of metals, Surfacing and spraying of metals, Resistance welding processes: spot, seam, butt, flash, projection, percussion etc, Thermo welding, Electro-slag and electro-gas welding, Solid-state and radiuant energy welding processes such as EBW; LBW; ESU, Explosive welding; Friction welding etc, Welding of plastics, Advances, challenges and bottlenecks in welding.

**MEPE790 Project Engineering**

**Credit Points:** 4 points (2-0-4)

- Process engineering functions, Degrees of freedom and datum surfaces, Errors in manufacturing, factors affecting manufacturing accuracy, Preliminary analysis of processing alternatives, dimensional and tolerance analysis, Dimensional and Geometrical tolerances, detailed planning of process of manufacture, Process-planning records, Production techniques for typical components and tools Jigs and fixture design and manufacture, Group technology & CAPP.

**MELE791 Composite Materials and Processing**

**Credit Points:** 4 points (3-0-2)

- FRP Composites, fiber types, fiber forms and properties, matrices type and properties, lamina, laminate, composites–macro and micro-mechanical analysis & properties, failure theories, primary and secondary manufacturing - Lay-up, Filament winding, Pultrusion, Compression moulding, RTM, RIM, SRIM, machining - drilling, routing etc., application Metal Matrix Composites–powder metallurgy, sintering, squeeze casting, applications Ceramic Matrix Composites–clays, whiskers, fibers, mixing, mass processing techniques, applications.

**MELE792 Injection Molding and Mold Design**

**Credit Points:** 3 points (2-0-2)

- Nature of engineering plastics, visco-elasticity, design methods & grade selection Principles of Injection Molding, Injection molding machine and types, capacity & clamping tonnage, mold size, plasticating extruder concepts, molding properties and control parameters, molding cycle, Injection Molds for thermoplastics, cavity and core- integer & insert type, product consideration, material consideration, shrinkage, flow length, mold temperature, molding stresses, parting line, feeding system design - sprue, runner, gate, weld line strength, ejection system design, mold cooling systems, runnerless molding, gas assisted and thermosts molding.

**MELE794 CAD/CAM**

**Credit Points:** 4 points (3-0-2)

- Introduction to CAD/CAM, representation of curves, surfaces and solids for CAD/CAM applications, computational geometry for manufacturing, product design for manufacture and assembly, computer aided process planning, computer aided assembly planning, computer aided inspection & reverse engineering, manufacturing process simulation, virtual & distributed manufacturing, computer integrated manufacturing.

**MELE796 Rapid Prototyping and Tooling**

**Credit Points:** 4 points (3-0-2)

- Review of solid modeling techniques with comparison advantages and disadvantages. Basic Principal of RP processes, Classification of RP Processes, Various Industrial RP Systems like Sterolithography, Fused Deposition Modeling, Selective Laser Sintering, Laminated Object Manufacturing, 3D Printing, Ballistic particle modeling etc., Role of Rapid Prototyping and Rapid Tooling in Product Development and Simultaneous Engineering, Process planning for rapid prototyping,
STL file generation Defects in STL files and repairing algorithms, Slicing and various slicing procedures, Accuracy issues in Rapid Prototyping, Strength of RP Parts, Surface roughness problem in Rapid Prototyping, Part deposition orientation and issues like accuracy, surface finish, build time, support structure, cost etc., Rapid tooling techniques such as laminated metallic tooling, direct metal laser sintering, vacuum casting. Introduction to reverse engineering Integration of reverse engineering and rapid prototyping.

**MEL801 Fire Dynamics and Engineering**
4 credits (2-0-4)

**MEL802 Convection Heat and Mass Transfer**
3 credits (3-0-0)

**MEL804 Radiation and Conduction Heat Transfer**
3 credits (3-0-0)


**MEL806 Thermal Systems Simulation and Design**
3 credits (2-0-2)

**MEL807 Computational Heat Transfer**
4 credits (2-0-4)

**MEL808 Refrigeration Systems and Components Design**
4 credits (2-0-4)

**MEL809 Heat Transfer Applications**
3 credits (1-0-4)
Design, including experimental and numerical analysis, of heat transfer devices/systems related to a wide variety of applications, such as, energy conversion, food processing, manufacturing, solar energy, electronic and electrical equipment cooling, microscale heat transfer, heat sinks, heat exchangers, heat pipes, biomedical applications, measurements and instrumentation, amongst others. The tasks will involve fabrication and experimental measurements.

**MES810 Independent Study (Thermal Engineering)**
3 credits (0-3-0)
Identification of faculty supervisor(s), topic, objectives, deliverables and work plan (in the preceding semester prior to registration); regular work during the semester with weekly coordination meetings (about 1 hour) with the faculty supervisor. Grade to be decided on the basis of the two assessments. The independent study would be available only in the 2nd and 3rd semesters and should be carried out individually or in groups of two students. In the 3rd semester, the topic will have to be different from the major project.

**MED811 Major Project Part–1**
6 credits (0-0-12)
Formation of project team (one student and one or more faculty supervisor(s)), evaluation committee and selection of topic in the 2nd semester. The topic should be of advanced standing requiring use of knowledge from program core courses. The independent study would be available only in the 2nd and 3rd semesters and should be carried out individually or in groups of two students. In the 3rd semester, the topic will have to be different from the major project.

**MEL811 Steam and Gas Turbines**
4 credits (3-0-2)

**MED812 Major Project Part–2**
12 credits (0-0-24)
The student will continue working full-time as per the approved work plan of Part–1 during the winter after the 3rd semester and during the 4th
semester. The progress will be monitored at weekly coordination meetings with the supervisor(s). During the semester, the student will give a departmental seminar that will serve as the mid-term evaluation also. At the end of the semester, the student will make a presentation to the committee for evaluation. The grade to be decided on the basis of the two assessments. The project will also be displayed at an open house.

**MEL812 Combustion**  
4 credits (3-0-2)  

**MEL813 Cascade Theory**  
4 credits (3-0-2)  
Introduction to cascades, meridional and cascade planes, flow and geometrical influencing parameters. Instrumentation and observation techniques in cascade testing, evaluation of prediction accuracy. Cascade design, fabrication, instrumentation and assembly. Low speed cascade testing of rectilinear turbine and compressor cascades. 3-D flows, radial and annular cascades. High speed turbine and compressor cascade testing. Boundary layer development. Experimental and CFD techniques. Stalled and separated flow in compressors, flutter and vibrations. Unsteady flow simulation and measurement. Applications: boundary layer and circulation control, turbine blade cooling, new blade designs. Design application for cascades information, future trends.

**MEL814 Turbocompressors**  
4 credits (3-0-2)  

**MEL815 Applied Combustion**  
4 credits (2-0-4)  

**MEL816 Analysis of I.C. Engine Processes**  
4 credits (3-0-2)  

**MEL818 Multiphase Flows**  
4 credits (2-0-4)  
Industrial applications of multiphase flows; general equations and two-phase flow modeling; particle-fluid interaction; Lagrangian and Eulerian approaches; gas-liquid systems–sprays, dispersion, heat and mass transfer; bubble-liquid systems; gas-solid systems–dusty flows, entrainment, dispersion, aerosol dynamics; pneumatic conveying; fluidization–regimes, hydrodynamics, heat transfer and combustion; separation–gas-solid and liquid-solid; design and performance of filters and scrubbers; numerical techniques; measurements in multi-phase flows and aerosols; Codes and standards.

**MES830 Independent Study (Design of Mechanical Equipment)**  
4 credits (0-4-0)


Parametric excitation and instabilities. Instability due to fluid film forces and hysteresis, Effect of support non-linearities, Rigid Rotor Balancing, Influence coefficient and modal balancing techniques for flexible rotors.

**MEL839 Precision Engineering**

4 credits (3-0-2)

Introduction to precision machine design, Principles of accuracy, repeatability and precision. Errors due to geometry, Kinematics, thermal expansion, dynamic forces and instrumentation etc. System design considerations in precision engineering. Rolling and sliding contact bearings. Hydrostatic and magnetic bearings. Precision gears, positioning mechanisms and drives. Electro-magnetic piezoelectric and fluid actuators.

Microelectro-mechanical systems. Precision measurement and control devices. Three dimensional co-ordinate measuring machines. Surface finish measurement. Precision machining and finishing operations. Assembly and tolerancing.

Micromachining systems. Tribological vibrations and noise considerations in high speed mechanical units. Case studies from some of the applications like computer drives, printers, sewing machines, video and audio recorders, optical devices etc.

**MEL840 Experimental Modal Analysis and Dynamic Design**

4 credits (3-0-2)


Dynamic design of mechanical equipment structures via model testing, structural dynamic modification and model updating.

**MEL841 Advanced Structural Dynamics**

4 credits (3-0-2)


**MEL842 Advanced Concurrent Engineering**

4 credits (3-0-2)

Product life cycle, quality products, evapo-rative markets, globalization and Concurrent engineering. Review of concurrent engineering techniques like DFM (design for manufacture), DFA (design for assembly), QFD (quality function deployment), RP (rapid prototyping), TD (total design) for integrating these technologies. Product information systems and their architecture. Information environment for suppliers, management, testing & inspection design engineering, purchasing, process control, manufacturing, support plans, operators, quality control, servicing and maintenance. Product infor-mation modeling. Integration of information models and end users applications. Computer aided simultaneous engineering systems. Integrated concurrent design and product development. Constraint networks.

**MEL844 Designing With New Materials**

4 credits (3-0-2)


**MEL850 Network Models and Applications**

3 credits (2-1-0)


**MEL851 Industrial Engineering Challenges in E-Business**

3 credits (3-0-0)


**MEL852 Computer Integrated Manufacturing Systems**

3 credits (2-0-2)


**MES860 Independent Study (Industrial Engineering)**

3 credits (0-3-0)

**MED861 Major Project Part–1 (Industrial Engineering)**

6 credits (0-0-12)
MEL861 Industrial Application of Simulation
3 credits (3-0-0)

MEL862 Major Project Part -2 (Industrial Engineering)
12 credits (0-0-24)

MEL865 Systems Dynamics Modeling and Industrial Applications
3 credits (2-0-2)

Application in planning and policy design for Production System. Dynamics created by interactions with companies, suppliers, customers, and competitors. Planning and policy models to evaluate financial performance of organizations. Dynamics created by capacity expansion and professional resource expansion.

Case studies. DYNAMO, STELLA and SD based management games.

MEL886 Maintenance Management
3 credits (3-0-0)

Overhaul and Repair Decisions: Optimal overhaul/repair/replace maintenance policies for equipment subject to breakdown finite and infinite time horizon. Optimal repair effort of a maintenance work force to meet fluctuating taking into subcontracting opportunities.

Spares Provisioning: Spares provisioning for single and multiechelon systems under budgetary constraints.

Maintenance Organisation: Computer application in maintenance management, MIS for maintenance.

MEL887 Financial Engineering
3 credits (2-1-0)

MEL871 Financial Engineering
3 credits (2-1-0)
The concept of firm, the basic theory of interest, impact of inflation, opportunity cost of capital. Deterministic cash flows, project net present value, other projects evaluation criteria, concept of depreciation, before and after tax cash flows, single period random cash flows, mean variance portfolio theory, portfolio analysis and management, determining betas, single index models, capital asset pricing model, options and futures, using options in project valuations.

MEL875 Operations Research III
3 credits (3-0-0)

MEL876 Advanced Quality Engineering
4 credits (3-0-2)
Pre-requisites: MEL761/MEL752/MEL744/TTL773/TTL751/TTL711

MES880 Independent Study (Production Engineering)
3 credits (0-3-0)

MED881 Major Project Part –1 (Production Engineering)
6 credits (0-0-12)

MED882 Major Project Part-2 (Production Engineering)
12 credits (0-0-24)

MED885 Major Project (M.S. Research)
40 credits (0-0-80)
PHL551 Classical Mechanics  
4 credits (3-1-0)  

PHL552 Electrodynamics  
4 credits (3-1-0)  
Review of electrostatics and magnetostatics boundary value problems using Laplace's equation, Maxwell's equations for time varying fields, polarization and conductivity, plane waves in dielectrics and conductors, wave propagation in plasmas, reflection/refraction, critical reflection, surface waves and medium frequency communication, wave-guides, transmission lines, dipole antenna, antenna array, Rayleigh scattering, Postulates of special relativity, Lorentz transformations, 4-vectors, interval, 4-momentum, mass-energy equivalence, relativistic covariance of Maxwell’s equations, Lienard-Wiechert potentials, radiation from accelerated charges, applications to communication and radar.

PHL553 Mathematical Physics  
4 credits (3-1-0)  
Matrices, Eigenvalues and eigenvectors, Vector spaces, Group theory and its applications; Fourier transform, Discrete Fourier transform, Fast Fourier transform; Sturm-Liouville problem; Review of wave, heat and Laplace partial differential equations; Integral equations; Fredholm and Volterra equations; Green’s functions, applications of Green’s function in Quantum Mechanics and Solid State Physics; Conformal mapping and its applications; Cartesian tensors with applications in Physics.

PHL554 Concepts of Solids  
4 credits (3-1-0)  
Summary of crystal lattices, Reciprocal lattice, Bonding & packing in crystals, Point and space groups, Defects in crystals, Classical & quantum theory of harmonic crystal, Thermal expansion, Phonon collisions, Lattice thermal conductivity, Origin of bands, E-k diagrams; Band structure of semiconductors, Impurity levels in thermal equilibrium, Non-degenerate semiconductors, p-n junction, Drift and diffusion currents.

PHL555 Quantum Mechanics  
4 credits (3-1-0)  

PHL556 Statistical Mechanics  
4 credits (3-1-0)  
Introduction to statistical methods, random walk and the binomial distribution, statistical properties of the random walk, relation to Gaussian and Poisson distributions, central limit theorem; statistical description of systems of particles—basic postulates and statistical ensembles, macrocanonical, canonical and grand canonical ensembles; method of calculation using the ensemble approach and its applications to classical systems; density matrix formalism; quantum statistical mechanics and its applications to bosons and fermions; thermodynamics of phase transition in a Van der Waal system, statistical mechanics of magnetic phase transitions.

PHL557 Electronics  
4 credits (3-1-0)  
Thevenin and Norton’s theorem, Hybrid- & r- parameters, Biasing, current mirror, Small signal Amplifiers, Feedback amplifiers, power amplifiers, JFET and MOSFET circuits, Operational amplifiers DC coupled pairs, Differential amplifiers, its parameter; basic applications, Sinusoidal oscillators, Multi vibrators, Schmitt trigger, 555 IC timer, Clipping and clamping circuit, Sample and hold circuit, Active RC filter, Butterworth and Chebyshev filter, Power supplies and regulators, Power electronic circuits, Basic logic gates, Boolean algebra, combinational logic gates, digital comparators, Flip flops, shift registers, counters, Analog to digital converters.

PHL558 Applied Optics  
4 credits (3-1-0)  

PHP561 Laboratory I  
6 credits (0-0-12)  
Experiments from the areas of Optics, Electrodynamics and Electronics will form the practical contents of this course.

PHP562 Laboratory II  
6 credits (0-0-12)  
Experiments from the areas of Solid State Physics, Spectroscopy and Nuclear Physics will form the practical contents of this course.

PHP563 Advanced Laboratory-II  
4 credits (0-0-8)  
Experiments from the areas of Thin Films, Solid State Devices, Holography, Fiber Optics and Analytical Methods will form the practical contents of this course.

PHP565 Cooperative Phenomena in Solids  
4 credits (3-1-0)  

PHP567 Atomic and Molecular Spectroscopy  
4 credits (3-1-0)  
Spectra of alkali metals, doublet fine structure, two electron atom,
Zeeman and Paschen-Back effect, X-ray spectra, general factors influencing spectral line width and line intensities, Molecular symmetry, irreducible representation, Rotational and vibrational spectra of diatomic molecules, FTIR and Laser Raman spectroscopy, Electronic spectra, Franck-Condon principle, bond dissociation energies, Molecular orbitals and models, Fluorescence and phosphorescence.

**PHL569 Nuclear Physics**
4 credits (3-1-0)
Basic observations of nuclear physics: Nuclear radii and charge distributions, Nuclear binding energy, Electric and magnetic moments, Semi-empirical mass formula, Nuclear force and two nucleon system, Nuclear models, Gamow’s theory of alpha-decay, Fermi’s theory of beta-decay, Electromagnetic transitions in nuclei multipole radiation, Nuclear fission. Nuclear reactions, particle accelerators and detectors, Sub-nuclear degrees of freedom: Symmetries of elementary particle physics, Quark model, Bag model, Introduction to QCD and Quark-gluon plasma (Qualitative).

**PHD651 Project I**
3 credits (0-0-6)

**PHD652 Project II**
6 credits (0-0-12)

**PHL653 Semiconductor Electronics**
3 credits (3-0-0)
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 quadratic models; equivalent circuit; Threshold voltage calculation; Substrate biasing effect; LED, Laser, Photodiode and solar cells, Tunnel, IMPATT & Gunn diodes and comparison of microwave devices.

**PHL654 Experimental Methods**
3 credits (3-0-0)
Optical Microscopy; Scanning Electron Microscopy; Scanning Tunneling Microscopy; Atomic Force Microscopy; X-ray diffraction; Transmission Electron Microscopy; Low Energy Electron Diffraction; Reflection of High Energy Electron Diffraction; Neutron diffraction; Electron Spectroscopy for chemical analysis; Auger Electron Microscopy; Secondary ion mass spectroscopy; Electron Energy Loss Spectroscopy; X-ray Fluorescence; Rutherford back scattering; UV-VIS-NIR spectrophotometer & Ellipsometry; Deep Level Transient Spectroscopy; Thermally Simulated Current; C-V and Admittance Spectroscopy; Hall effect and Time of Flight methods for charge carriers, Differential scanning colorimeter; Differential Thermal Analyzer.

**PHL655 Laser Physics**
3 credits (3-0-0)

**PHL656 Microwaves**
3 credits (3-0-0)
Maxwell’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.

**PHL657 Plasma Physics**
3 credits (3-0-0)

**PHL658 Mini Project**
3 credits (0-0-6)
To provide an opportunity to interested students to gain practical experience of a kind different than that of his major project, i.e. if the major Project is experimental than Mini Project should be theoretical or simulation OR vice versa. It will be available in 3rd semester only.

**PHL660 Selected Topics**
3 credits (3-0-0)

**PHL661 Special Topics**
3 credits (3-0-0)

**PHL701 Electronic Properties of Materials**
3 credits (3-0-0)

**PHL702 Science & Technology of Thin Films**
3 credits (3-0-0)
Physical Vapor Deposition - Hertz Knudsen equation; mass evaporation rate; Knudsen cell, Directional distribution of evaporating species Evaporation of elements, compounds, alloys, Raoultt’s law; e-beam, pulsed laser and ion beam evaporation, 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 thermody-namics of CVD; Thermal CVD, Laser & plasma enhanced CVD, Chemical Techniques - Spray Pyrolysis, Electrodeposition, Sol-Gel and LB Techniques, Nucleation & Growth: capillarity theory, atomistic and kinetic models of nucleation, basic modes of thin film growth, stages of film growth & mechanisms, amorphous thin films, Epitaxy–homo, hetero and coherent eplayers, lattice misfit and imperfections, epitaxy of compound semiconductors, scope of devices and applications.

**PHL703 Materials Technology**
3 credits (3-0-0)
Phase diagrams: allotropic transformations, Vegard law, binary and ternary phase diagrams and non-equilibrium phase transformations, Purification of materials: theory for effective distribution coefficients and its determination, zone refining, Diffusion: Laws and mechanisms for surface, grain boundary and volume diffusion, Phase transformations:

PHL704 Semiconductor Device Technology
3 credits (3-0-0)
Silicon wafer fabrication and oxidation techniques, Growth kinetics, Oxide growth measurements techniques, Defects in silicon, silicon dioxide, Interface defects, Point defect based model for oxidation, Polysilicon, Si3N4, and Silicide formation. UV, Electron, plasma and x-ray lithography techniques, Wet etching and plasma etching techniques. Diffusion and ion implantation, Diffusion in polycrystalline materials, Ion implantation techniques, Modeling and measurement of dopant profiles, Overview of process flow for IC technology.

PHL705 Physics of Semiconductor Devices
3 credits (3-0-0)

PHL707 Characterization of Materials
3 credits (3-0-0)

PHP711 Solid State Materials Laboratory I
4.5 credits (0-0-9)
The experiments will be primarily on the preparation of Single crystals from melt, polycrystalline bulk by conventional sintering, and thin films by spray pyrolysis & spinning, and characterization of (i) Hall measurements, and optical properties of thin films by spectrophotometric and ellipsometric measurement, (ii) Thermal properties of alloys, (iii) Dielectric properties, dielectric dispersion and voltage dependent resistivity of certain electronic ceramics, (iv) structural determination of crystals, and (v) Estimation of dislocation density by chemical etching.

PHP712 Solid State Materials Laboratory II
4.5 credits (0-0-9)
The experiments will be primarily on the preparation of thin film by thermal evaporation and sputtering techniques, growth of SiO2 on Si by oxidation, synthesis of polycrystalline samples of ferrites, high temperature superconductors and electronic ceramics, and characterization of (i) electronic and optical properties of thin films, (ii) magnetic, thermo-resistive and superconducting properties of electronic ceramics.

PHL721 Electronic Ceramics
3 credits (3-0-0)
Bonding in ceramics and their structure including defects and nonstoichiometry; Development of microstructure in equilibrium and nonequilibrium phases, calculations, grain growth and solid liquid phase sintering; Ceramic coatings and their deposition; Properties of valence controlled, photonic, electro-optic, magnetic and superconducting ceramics, nonlinear dielectrics and ferrites; Applications of electronic ceramics in various devices including sensors for gases, temperature, pressure and voltage, and in optical communication, magnetic and oxide electronics, and electric power and energy storage devices.

PHL722 Analytical Techniques
3 credits (3-0-0)
Mass Spectrometry, Thermal Characterization, Ultrasonic Nondestructive Methods, Spectrophotometry & Ellipsometry, Spectroscopic Techniques: Molecular spectroscopies including Microwave, FTIR, Raman and surface enhanced Raman Spectroscopy; Resonance Spectroscopies, Mossbauer Spectroscopy, Magnetic & Dielectric Analysis.

PHL723 Vacuum Science and Cryogenics
3 credits (3-0-0)

PHL724 Magnetism and Superconductivity
3 credits (3-0-0)

PHL725 Physics of Amorphous Materials
3 credits (3-0-0)
Types of amorphous solids, aspects of glass transition, structure, rcp and crn structures, EXAFS and Synchrotron radiation, Molecular solids and Network dimensionality, network solids, 8-N rule, topological defects and valence alteration, Electronic structure of amorphous solids, localized and extended states, mobility edges, CFO model, Density of states and their determination, transport in extended and localized states, Optical properties of amorphous semiconductors, absorption edge and absorption tail, high absorption region, sum rules, Some case studies and applications of important amorphous materials, hydrogenated amorphous silicon, chalcogenide glass, metallic glasses.

PHL726 Nanostructured Materials
3 credits (3-0-0)
Physics of low-dimensional materials, 1D, 2D and 3D confinement, Density of states, Excitons, Coulomb blockade, Surface plasmon, Size and surface dependence of physical, electronic, optical, luminescence, thermo-dynamical, magnetic, catalysis, gas sensing and mechanical properties. Physical and chemical techniques for nanomaterial synthesis, Assembling and self organization of nanostructures, Nanoscale manipulation, Nanotube and wire formation, Importance of size distribution control, size measurement and size selection.

PHL727 Quantum Heterostructures
3 credits (3-0-0)
Bandstructure modification by alloying and strain, Modulation doping, Lattice matched and lattice mismatched materials, Strained heterostructures. Quantum confinement in 2D, Excitons, lattice vibrations and electron transport in quantum structures, Optical behavior and inter band transitions, Electro optic and quantum Hall effects. Motivation for using heterostructures for devices, Schottky barrier and p-i-n photodetector,
Charge coupled devices, Edge emitting, Surface emitting and Quantum well LED's and lasers. Nanostructure FET, Velocity modulation and quantum interference transistor, Hetrostructure bipolar transistor and Resonant tunneling devices.

PHL731 Independent Study
3 credits (0-3-0)
The contents would include specific advanced topics of current interest in Materials Synthesis, New Materials and their behavior and New Device structures and concepts. The contents would be announced every time the course is offered as a self study course

PHL741 Quantum Electrodynamics and Particle Physics
3 credits (3-0-0)
Dirac equation, plane wave solutions, Foldy-Wouthusen transformations, S-matrix, Classical fields, equations of motion, conserved quantities, Quantization of complex scalar, electromagnetic and spinor fields, The interaction Hamiltonian, normal and chronological products, Wick's theorem, Feynman's rules and diagrams: electron scattering by an external em field, electron-photon scattering, pair creation, current form factors, Cross-sections, traces, scattering of electrons and p- mesons of a nuleon, decay processes, Renormalization, one-loop correction, electron self-energy, vacuum polarization, Parity, Charge conjugation, Time reversal invariance, CP violation and CPT theorem, SU(2) of Isospin, SU(3) of color, Quark model of hadrons: SU(3) of flavor, Isospin and strangeness, baryon octet, meson octet, magnetic moments of baryons, electron-proton scattering – proton form factors, Inelastic e-p scattering – structure functions, partons and Bjorken scaling.

PHL742 General Relativity and Introductory Astrophysics
3 credits (3-0-0)

PHL743 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.

PHL744 Advanced Topics in Quantum Mechanics
3 credits (3-0-0)
Klein-Gordon equation, Dirac equation, Negative energy states, hole theory, angular momentum and spin, Coupling to an electromagnetic field, Non-relativistic limit, Hydrogen atom spectrum in Dirac theory, Non-relativistic propagator, Propagator in positron theory, Scattering of electrons and positrons in a Coulomb field, Strong interaction, Nucleon-Nucleon and meson-nucleon scattering. Second quantization of the electromagnetic, the mesonic and the fermionic fields, Microscopic theory of superfluidity. Interaction of electrons with phonons in a metal, pairing, Cooper pairs, BCS theory of superconductivity, Bose-Einstein condensation.

PHL751 Optical Sources, Detectors and Photometry
3 credits (3-0-0)
Eye and Vision: Visual system, accommodation, adaptation, sensitivity, acuity; Radiometry & Photometry: Radiometric quantities and their measurement, color and brightness temperature; photometric quantities, radiation from a surface; Brightness and luminous intensity distribution; Integrating sphere; Illumination from line, surface and volume sources; Illumination in images; Colorimetry: Fundamentals, trichromatic specifications, colorimeters, CIE system; Conventional light sources: Point and extended sources; Incandescent, fluorescent, arc and gas discharge lamps; LEDs; Illumination engineering: Lighting fundamentals, day lighting, examples of design, lighting of factories and streets; Optical Detectors: Photographic emulsion, thermal and photon detectors; Detector characteristics and figures of merit, noise considerations; Photoconductors and characteristics; Photomultiplier tubes, photodiodes; calibration of detectors; detector arrays, CCD.

PHL752 Laser Systems and Applications
3 credits (3-0-0)

PHL753 Optical System Design
3 credits (3-0-0)
Gaussian theory of optical system; Aberrations: Transverse ray and wave aberrations, chromatic aberration and third order aberrations; Ray tracing: paraxial, finite and oblique rays; Image evaluation; Geometric OTF: its computation and measurement; Strehl ratio; Variance of wave aberration function, RMS wave aberration function, spot diagram;Optimisation techniques in lens design, definition of merit function, commonly used optimisation methods, damped least square method, orthonormalization, and global search method; Tolerance analysis; Achromatic doublets, apochromats and aplanats; Cooke Triplet and its derivatives; Double Gauss lens, Introduction to zoom.

Lenses and aspherics; Examples of modern optical systems such as optical systems using aspherics, zoom lens, GRIN optics.

PHL754 Optical Instruments and Metrology
3 credits (3-0-0)
Spectroscopic instrumentation; Fabry-Perot interferometer, diffraction gratings, Fourier transform spectroscopy; Interferometric instrumentation for testing; Shearing, scatter fringe, three-beam and polarization interferometers; Scanning microscopy: Imaging modes, depth discrimination, super resolution, practical aspects, measurements on semiconductor devices, near-field techniques; Displays : television optics, liquid crystal displays, video projectors; Adaptive optics : Wavefront sensing and correction, adaptive systems, reconstruction and controls; Opto-medical Instruments: Keratometers, ophthalmoscopes, optometers, optical coherence tomography; Infrared instrumentation: I.R. telescopes, focal plane arrays, cryo-cooling systems, scanning and stabilization mechanisms, smart weapon seekers, forward look infrared, space-based sensors; Space optics: Satellite cameras,high-resolution radiometers, space telescopes; Optical metrology: Surface inspection, optical gauging and profiling, techniques for nondestructive testing, Moire self imaging and speckle metrology, sensing elements, instrumentation and applications in material science and biology.
PHL755 Statistical and Quantum Optics
3 credits (3-0-0)
Probability theory, generating function, characteristic function; Stochastic processes, spectral properties, correlation and convolution; Analytic signal and spatial frequency analysis; Temporal, spatial and partial coherence; Propagation of coherence, Van Cittert and Zernike theorem; Higher order correlations; Differential photo detection probability; joint probability of multiple photodetection, Mandel's formula; Intensity interferometry; Quantum theory of light, density operators and Wigner function; Coherent states and squeezed states; Photon statistics; nonclassical states and EPR paradox; Laser Doppler velocimetry, light beating and photon correlation spectroscopy; Doppler free spectroscopy, saturation spectroscopy; Laser speckle statistics.

PHL756 Fourier Optics and Optical Information Processing
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: vanderLugt filter; joint-transform correlator; character recognition, invariant pattern recognition, image restoration; Data processing from synthetic aperture radar (SAR), acousto-optic signal processing, discrete analog processors.

PHL757 Optical Materials and Thin Films
3 credits (3-0-0)
Refractive index and dispersion; Transmission, reflection and absorption of light; Glass and amorphous materials; Optical material for UV and IR; Laser crystals: Spectroscopy of laser crystals, laser crystals for high gain, crystal growth and characterization; Optics of anisotropic crystals: biaxial, uniaxial crystals, double refraction, index ellipsoid, optical activity; Non-linear optical crystals; Liquid crystals; Photorefractive materials, theory of photorefractivity, application of photorefractive; Semiconductors : band gap modification by alloying optical properties of quantum well, quantum wire, quantum dot structures; Photonic band gap (PBG) materials, growth of PBG materials, light transmission in PBG materials, application of PBG materials; Optics of thin films: reflection, transmission and absorption in thin films; antireflection (AR) Coating : single layer AR coating, double layer AR coatings, multilayer and inhomogeneous AR coatings; Reflection coatings : metal reflectors, all dielectric reflectors; Interference filters : edge filters, band pass filters, Fabry-Perot filters, multi-cavity filters; Thin film polarizers; Beam splitters; Thin film integrated optical structures and devices.

PHL758 Theory and Applications of Holography
3 credits (3-0-0)
Basics of holography, in-line and off-axis holography; Reflection, white light, rainbow and wave guide holograms; Theory of plane holograms, magnification, aberrations, effects of non-linearity, band-width and source size; Volume holograms: coupled wave theory, wavelength and angular selectivity, diffraction efficiency; Recording medium for holograms: silver halides, dichromatic gelatin, photosist, phoconductor, photorefractive crystals, etc.; Applications : microscopy; interferometry, NDT of engineering objects, particle sizing; holographic particle image velocimetry; imaging through abated media, phase amplification by holography; optical testing; HOEs: multifunction, polarization, diffusers, interferometers, couplers, scanners; Optical data processing, holographic solar concentrators; antireflection coatings; holo-photoelasticity; Colour holography: recording with multiple wavelength; white light colour holograms; Electron holography, acoustic and microwave holography and some typical applications, computer holography, digital holography.

PHL759 Selected Topics in Applied Optics
3 credits (3-0-0)
The course would cover topics of current interest, not covered in other courses.

PHP761 Optics Laboratory-I
3 credits (0-0-6)
Experiments involving testing and measurements with the following instruments : Strain viewer, higher precision spectroscope, micro-optic autocollimator, knife edge and star test apparatus, Fizeau interferometer, Twyman Green interferometer, multiple beam interferometer, schlieren photography, Abbe refractometer, vacuum coating unit, various types of microscopes.

PHP762 Optics Laboratory-II
3 credits (0-0-6)
This course is designed to make the students familiar with modern measurement techniques. Typical experiments are in the following areas: Spatial filtering, Holography, Speckles, Fourier optics, Contrast enhancement, Displacement measurement, vision testing, O.T.F. measurements etc.

PHP763 Optical Workshop
3 credits (0-0-6)
Introduction to various types of glass, cutting, edging, grinding, smoothing and polishing. Polishing machines. Making of tools and test plates. Fabrication of optical components like flats, prisms, concave mirrors and lenses etc.

PHP764 Mechanical Workshop and Engineering Drawing
3 credits (0-0-6)
This course is so designed as to (i) give the student adequate practice of preparing drawings of simple instruments and their mountings, (ii) make the student familiar with the techniques employed in a mechanical workshop and some practice in fabrication of simple attachments for optical instruments.

PHL790 Integrated Optics
3 credits (3-0-0)
Planar waveguides :Step-index and graded-index waveguides, guided and radiation modes. Strip and channel waveguides, anisotropic waveguides, segmented waveguide; electro-optic and acousto-optic waveguide devices. Directional couplers, optical switch; phase and amplitude modulators, filters, etc. Y-junction, power splitters, Arrayed waveguide devices, fiber pigtailage, Fabrication of integrated optical waveguides and devices. Waveguide characterisation, end-fire and prism coupling; grating and tapered couplers, nonlinear effects in integrated optical waveguides.

PHL791 Fiber Optics
3 credits (3-0-0)
Fiber numerical aperture, Sources of signal attenuation and dispersion, Step and graded index multimode fibers, including plastic fibers LP modes in optical fibers: Single-mode fibers, mode cutoff and mode field diameter, Pulse dispersion in single-mode fibers: dispersion-tailored and dispersion-compensating fibers. Birefringent fibers and polarization mode dispersion. Fiber bandwidth and dispersion management, Erbium-doped fiber amplifiers and lasers; Isolators, Fiber fabrication techniques. Fiber characterization techniques including OTDR, Connectors, splices and fiber cable.

PHL792 Optical Electronics
3 credits (3-0-0)
Nonlinear effects in optical fibers: SPM, XPM and FWM, solitons, SRS & SBS.

PHL793 Semiconductor Optoelectronics
3 credits (3-0-0)
Review of semiconductor physics: energy bands, density of states, Fermi level, p-n junctions. Homo-and hetero-junctions, quantum wells, Semiconductor materials; Semiconductor optical amplifiers, LEDs and LDs: Device structure and Characteristics, DFB, DBR, and quantum well lasers, VCSELS & Laser diode arrays, Electroabsorption modulators and SEEDs, Semiconductor photodetectors; PINs and APDs, CCDs and OEICs.

PHL795 Optics and Lasers
3 credits (3-0-0)

PHL797 Selected Topics-I
3 credits (3-0-0)

PHL798 Selected Topics-II
3 credits (3-0-0)

PHL800 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.

PHD801 Major Project Part I
6 credits (0-0-12)
PHD802 Major Project Part II
12 credits (0-0-24)
This major project is for two semesters, but its allotted in the month of April, so that the students can use the summer vacation period for literature survey and preliminary studies. The projects end in May/June at the end of fourth semester. The evaluation of the Part-I and Part-II would be done independently at the end of third and fourth semesters, respectively. The project can be on any topic covered under applied optics and related subject.

PHP853 Advanced Optical Workshop II
3 credits (0-0-6)
Fabrication of precision optical components/instruments.

PHS855 Independent Study
3 credits (0-3-0)
Student, in consultation with the course coordinator, would select a topic for the self-study and prepare seminars on the topic. In addition, experts may also be invited to give lectures on advanced topics, which would also form part of the curriculum of this course.

PHL891 Guided Wave Optical Components and Devices
Review of optical fiber properties: multimode, single mode, birefringent, photonic crystal and holey fiber: Directional couplers: Analysis, fabrication and characterization: application in power dividers, wavelength division multiplexing, interleavers and loop mirrors: Fiber Bragg gratings: Analysis, fabrication and characterization: application in add-drop multiplexing, gain flattening, dispersion compensation and wavelength locking: fiber half-block devices and application in polarizers, modulators and wavelength filters, Fiber polarization components: polarization controllers and associated micro-optic components like isolators and circulators; Optical fiber sensors: Intensity, phase and polarization based sensors, applications in various disciplines.
TTV700 Special Module in Selected Topics
1 credit (1-0-0)

TTV702 Management of Textile Business
1 credit (1-0-0)
Pre-requisites: 90 credits for B.Tech.
The Textile Industry of India: Past & its evolution to the present day.
The structure of the Indian Textile Industry: Cotton textile sector, Jute textile sector, Silk textile sector, Man-made textile sector, Wool Textile sector, Statistics of Indian textile business (Domestic & Export) and World textile trade, Textile policy, World trade practices, norms, barriers, etc. Various pertinent prevailing issue impacting textile industry and trade, corporate social responsibility, other compliances, ISO accreditation, etc., Retailing in textiles vis-a-vis consumer trends and behaviour and the challenges, Future of the Indian textile industry and trade.

TTL711 Polymer and Fibre Chemistry
3 credits (3-0-0)
Introduction to natural and synthetic polymers; Terms and fundamental concepts; Step-growth polymerization, Carother’s equation, Functionality, Crosslinking; PET manufacturing; Chain growth polymerization, Free radical polymerization, Kinetics of free-radical initiation, termination, chain transfer, Mayo’s equation, cage effect, auto-acceleration, inhibition and retardation; Polypropylene manufacturing; Acrylic polymerization; Atom transfer radical polymerization, ionic polymerization, ring opening polymerization; Nylon-6 manufacturing; Co-polymerization and its importance. Copolymer equation, reactivity ratio, tailor making of copolymer properties; Techniques of chain polymerization; Bulk, solution, emulsion, microemulsion and suspension polymerization; Chemical Modification of fibres; Polymer solution, Flory’s theory; Interaction parameter; Molecular weight and its distribution by: End group analysis, osmometry, light scattering, ultra centrifugation, gel permeation chromatography, intrinsic viscosity; Spectroscopic methods of polymer characterization such as, FTIR, UV. NMR.

TTP711 Polymer and Fibre Chemistry Laboratory
1.5 credits (0-0-3)
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; Molecular weight measurement; Intrinsic viscosity and end group analysis; Analysis of chemical structure by FTIR, UV spectroscopy.

TTL712 Polymer and Fibre Physics
3 credits (3-0-0)
Molecular architecture in polymers, Configuration and conformation; Nature of molecular interaction in polymers, Cumulative interaction, Entanglement, Random chain model and rms end-to-end distance; Glass transition temperature (Tg), Factors affecting Tg; WLF equation; Rubber Elasticity; Melting and Crystallization; Models describing fibre structure, Fringed fibrillar and fringed micellar model, One phase model; Requirement of fibre forming polymers; Crystallinity and orientation; X-ray diffraction measurement of crystallinity, orientation, crystal size, small angle X-ray scattering; Measurement of density of fibres, Density crystallinity, Infrared spectroscopy for determination of orientation, crystallinity etc; Optical microscopy for measurement of birefringence; Internal and surface structure by electron microscopy; Thermal methods DSC TGA and TMA for structural investigation; Morphological structure of Cotton, Wool, Silk, Regenerated Cellulose, Polyester, Nylon, Polypropylene, Polyacrylonitrile.

TTP712 Polymer and Fibre Physics Lab
1.5 credits (0-0-3)
Characterization of fibres by Infrared spectroscopy, Density measurements; Thermal analysis such as 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 Microscopy (SEM) of fibres.

TTT713 Technology of Melt Spun Fibres
4 credits (3-1-0)
Transport Phenomena in Fibre Manufacturing; Polymer rheology-Newtonian and non-Newtonian fluids, shear flow, elongational flow; Heat transfer operations, Mass transfer operations, diffusion in polymers; Necessary conditions of fibre forming polymer, Melt instabilities, Necking and stress induced crystallization in high speed melt spinning, Effect of process parameters on fibre spinning and structure of polymeride 6 and 66, polyethylene terephthalate and polypropylene fibers/filament. Force balance in a spinning line, Simulation of melt spinning process, Drawing Process and its necessity, Neck or flow deformational drawing, Natural draw ratio, Drawing machines, Effect of parameters on structure development in nylon, polyester and PP, Types of heat setting, Effect of setting parameters on structure and properties of polyester, nylon, polypropylene fibres, Zone drawing and annealing, Concept of bulking, Process of false twist, air-jet and stuffer box texturing processes and machines.

TTL714 Physical Properties of Fibres
3 credits (3-0-0)
Introduction to fibre structure and requirements of fibre forming polymers; Moisture Relations: Moisture sorption and desorption in fibres Sorption isotherms, Heats of sorption, Swelling and theories of moisture sorption; Mechanical properties: Mechanism of deformation in fibres; Principles of elasticity and viscoelasticity; Creep and stress relaxation; Boltzmann superposition principle; Dynamic mechanical properties; Model theory of viscoelasticity; Time- temperature superposition principle; Stress-strain relations, Yield and fracture; Fibre friction: its nature, theory, application and measurement; Optical properties: Polarizability and refractive index. Birefringence and its measurement; Thermal Properties: Thermal expansion, Thermal conductivity; Electrical Properties: Dielectric properties, effect of frequency and temperature on dielectric constant, Electrical resistance and its measurement, Static electricity and measurement of static charge in fibres.

TTL715 Technology of Solution Spun Fibres
3 credits (3-0-0)
PAN properties; Solution rheology and its dependence on parameters. Effect of parameters on entanglement density, fibre spinning and subsequent drawing; Various solvent systems; Dope preparation; Wet and dry spinning processes; Effect of 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 of PAN and its advantages; Gel spinning; Melt spinning of PAN; Bicomponent and bulk acrylic fibres. Acrylic fibre line, crimping and annealing, tow to top conversion systems; Viscose rayon process, wet spinning, zinc sulfate spinning; Polynosics and high performance fibre; Lyocell process, structure and properties; Gel spinning of PE, introduction to high performance fibres and their spinning systems such as rigid rod polymer, liquid crystalline polymers, polyactic acid and spandex fibre manufacturing.

TTP716 Fibre Production and Post-spinning Operations Laboratory
2 credits (0-0-4)
Experiments related to fibre 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.

TTL717 Advances in Manufactured Fibres
3 credits (3-0-0)
Profile fibres, hollow & porous fibres, spandex fibres; Biodegradable fibres, polyglycolic acid fibres, polyactic acid fibres, chitosan fibres, their preparation properties and applications; Bicomponent fibres, blended fibres; Fibres in medicine and biotechnology; Aesthetic fibres, bio-mimicking fibres; Membranes; Smart fibres; Comfort fibres; Fibres for Ballistic protection; Micronodier fibre; Spun Bonded and Melt blown nonwovens; Photochromatic fibres; Plasma processing of textiles; Processes for manufacturing of tapes and films.

**TTL718 High Performance Fibres and Composites**
3 credits (3-0-0)
Production and properties of aromatic polyamides & polyesters, Rigid rod and ladder polymers such as Kevlar, Nomex, BBL, PBZT, PBO, PBI, Manufacturing of carbon fibres from PAN precursors, viscose and pitch fibres, Liquid crystal fibres, High performance polyethylene fibres, Ceramic fibres, Definition of composites, Resins for composites, Fibre architecture- short and long, Interfaces, Composite theory, Fabrication of composite materials, Case studies on composites.

**TTL721 Theory of Yarn Structure**
3 credits (2-1-0)

**TTL722 Mechanics of Spinning Processes**
3 credits (3-0-0)

**TTL723 Selected Topics in Yarn Manufacture**
3 credits (2-1-0)

**TTL724 Textured Yarn Technology**
3 credits (3-0-0)
Pre-requisites: EC 90
Principles of twisting 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.

Air jet texturing - Principle, mechanisms, development of jets and machinery, process optimization and characterization, air jet texturing of spun yarns.

Air interlacement - Principle and mechanism, jet development and characterization.

Bulked continuous filament yarns - Need, principle, technology development.

Hi-bulk yarns - Acrylic Hi-bulk yarn production, mechanism and machines involved, other such products.

Solvent and chemical texturing - Need, texturing of synthetic and natural fibres.

**TTL731 Theory of Fabric Structure**
3 credits (2-1-0)


Structure and properties of knitted and nonwoven fabrics.

**TTL732 Computer Aided Fabric Manufacturing**
3 credits (2-0-2)
Electronic Dobby: Working principle, constructional variants, design of the electronic dobby, drive arrangement, systems for pattern data transfer.

Electronic Jacquard: Working principle, constructional variants, various electronic Jacquard systems, selection system, pattern data transfer and management.

CAD for dobby, jacquard, label weaving and carpet: Development of Jacquard designs, process of drafting and sketch design, development of figures, composition of design, geometric ornamentation, arrangement of figures, weave simulation.

Laboratory: Working on electronic dobby and electronic Jacquard, working an CAD, development of various designs on CAD and development of design samples.

**TTL733 Selected Topics in Fabric Manufacture**
3 credits (2-1-0)
Development trends in winding, warping and sizing machines for improving quality of preparation and cost, reduction with specific reference to shuttleless weaving machines. Tension control and automation in sizing.


Nonwovens: Fibre/filament arrangement in web and its effect on mechanical properties of nonwoven fabrics. Failure mechanism in different nonwoven fabrics. Effects of machine, fibre and process variables on properties of nonwoven fabrics. Production of spun bonded and melt blown fabrics.

**TTL740: Science and Applications of Nanotechnology in Textiles**
3 credits (3-0-0)
Pre-requisites: EC 90
Introduction to Nanoscience and Nanotechnology; Synthesis of Nanomaterials used in Textiles; Carbon nanotubes, carbon nanofibers, fullerenes, metal and metal oxide nanoparticles, such as nano silver, nano silica, nano titania, nano zinc oxide, nano magnesium oxide; Size and surface dependence of their physical and chemical properties such as mechanical, thermo-dynamical, electronic, catalysis; Surface functionalization and Dispersions of Nanomaterials; Nanotoxicity concerns; Nanomaterial applications in textiles and polymers; Nanocomposites: definition and types, synthesis routes, characterization techniques; nanocomposite fibers, coatings, their application e.g., gas barrier, antimicrobial, conducting; Nanofibers: preparation, properties and applications such as filtration, tissue engineering, Nanofinishing: water and oil-repellent, self-cleaning, antimicrobial, UV protective, Nanocoating methods on textile substrates: Plasma Polymerization, Layer-by-layer Self Assembly, Sol-Gel coating.

**TTL741 Coloration of Textiles**
3 credits (3-0-0)

Developments in dyes and dyeing processes for the dyeing of various textile substrates with various dye classes; Dyeing of blends; Mass coloration of man-made fibres; Development in printing methods and machines; Direct, resist and discharge styles of printing; Printing of blends; Transfer printing; Physicochemical theories of the application of dyes and auxiliaries to substrates, including the thermodynamics and kinetic principles involved; Dye-polymer interactions; Role of fibre structure in dyeing.

**TTL742 Theory and Practice of Textile Finishing**
3 credits (2-0-2)

General overview of the recent technological developments in the area of textile finishing; Special emphasis will be on formaldehyde free finishes for wash-and-wear and durable press applications; Fire retardant finishes for apparel and industrial textiles; silicon and amino silicon softeners; fluorochemicals for water repellency and soil release functions; water proof breathable principles and technology involved in their production; surface modifications of textiles and their impact on various functional properties; antistats for synthetic fibres / fabrics; micro-encapsulation and its relevance in textile finishing application; new finishes for different functional and aesthetic requirements.

**TTL743 Principles of Colour Measurement and Communication**
3 credits (2-0-2)

Physical, physiological and psychophysical aspects of colour, colour perception, colour specification, colour measurement and control colour, Basis of modern techniques for colour specification, measurement, control and communication, Applications of colour science to textiles, colour reproduction, computer-based imaging and display systems, Basic concepts of computer colour graphics.

**TTL744 Environment Management in Textile and Allied Industries**
3 credits (3-0-0)

Pre-requisites: EC 90
Importance of ecological balance and environmental protection; Definition of waste and pollutant; Pollutant categories and types; International and Indian legislation and enforcing agencies in pollution control; Waste management approaches; Environmental Management Systems – ISO 14000; Environmental impact along the textile chain from fibre production to disposal; Toxicity of intermediates, dyes and other auxiliaries etc.; Pollution load from different wet processing operations; Their relevance and effluents and their characterisation; Technology and principles of effluent treatment; Advanced colour removal technologies, Recovery and reuse of water and chemicals; Air and noise pollution and its control; Eco labelling schemes; Industrial hygiene and safe working practices; Analytical testing of eco and environmental parameters; Eco friendly textile processing; waste minimisation, standardisation and optimisation, process modification; safe and ecofriendly dyes and auxiliaries; Industrial hygiene and safe working practices; Solid waste (fibre and polymer) recycling; Fibre waste modification; Environmental management systems: ISO 14000; Certification and criteria; case studies.

**TTL746: Medical Textiles**
3 credits (3-0-0)

Pre-requisites: EC 90

**TTL750: Science of Clothing Comfort**
3 credits (3-0-0)

Pre-requisites: EC 90

**TTL751 Apparel Engineering and Quality Control**
3 credits (2-0-2)

Mechanics of sewing operation: Feeding mechanism, mechanism of generation of needle thread tension, feed dog setting mechanism, stresses and heat generated during sewing, interaction of feed and pressure, sewing dynamics. Measurement and controls in sewing operation: Pressure, sewing speed, thread tension, needle temperature, needle penetration force. Automation in sewing operation.

Fabric quality assessment for clothing industry: Fabric quality requirement for high quality garments, low stress fabric mechanical properties and their effect on sewing operation. Use of FAST and KES system. Fabric mechanical properties and sewing operation interaction: Tailorability and formability. Lindberg theory, optimization of sewing parameters by using fabric mechanical property, optimization of finishing parameters such as steam, pressure, vacuum, for getting desired effect. Fabric defect analysis for clothing industry: Defect identification, bow and skewness, correlating defect with back process, valueless.

Quality control in apparel manufacturing: Determination of sewability, seam pucker, seam slippage and needle cutting index, evaluation of cutting defect, fusing defect, sewing defect, inspection of dimension, appearence, drape, change in color, shape and spots.

Measurement and selection of sewing thread properties for different fabrics: Optimization of sewing parameters such as ticket number, needle number, yarn tension, stitch density and stitch type for desired sewability.


Packaging of finished garment, final random inspection of finished garments, packaging method, safety norms.
Accessories: Buttons, hook and eye, jips, velcro.

**TTL752: Functional Textile Envelopes**  
3 credits: (2-0-2)  
Pre-requisites: EC 90

Introduction to and classification of functional clothing envelopes: definition and terminology, Principles of Ergonomics and Human factors engineering: their application in design of functional clothing envelopes, Principles and practice of Anthropometrics, Biomechanical considerations in design of envelopes for specific applications, Comfort in 3D assemblies, Principles of optimal design approach and application to Functional envelope design. Techniques and tools for testing and performance evaluation: trials on thermal manikins and humans for effect on physiological parameters and performance efficiency. CAD/CAM for design of design templates, 2D and 3D visualization, simulation and modeling on human bodies, Case studies, testing and analysis of existing functional envelopes with a view to study specific design and manufacturing considerations.

**TTL761 Costing, Project Formulation and Appraisal**  
3 credits (2-1-0)  

Project Cycle: Phases of project cycle identification, preparation evaluation, documentation & Supervision. Various functions in project cycle - Technical, commercial, financial, economic, managerial.  
Project formulation and Appraisal: Appraisal concept, Need for appraisal, Methodology, Various aspects - market, management, technical, financial and economic, Key financial indicators in appraisal, Investment decision from appraisal report, Post-project appraisal.  
Evaluation of Technological Content of Textile Projects: The choice of Technology and their assessment, operating constraint, appropriateness of technology, factors influencing selection, various aspects of technology transfer.  
Project Utilities and Environmental Aspects for Textile projects: Power, Steam, Fuel, Water, Compressed air, Air conditioning, Pollution (air, water, ground noise).  
Special Appraisals: For Modernisation projects, balancing equipment, expansion and diversification projects (including backward & forward integration).

**TTP761 Evaluation of Textile Material – I**  
1 credit (0-0-2)  
Characterization of Fibre : Birefrigence, sonic modulus, density measurements, thermal analysis, X-rays (orientation and crystallinity); Yarn Testing : Tensile properties, hairiness, cross-sectional studies and yarn preparation.

**TTL762 Management of Textile Production**  
3 credits (3-0-0)  
Pre-requisites: EC 90


**TTP762 Evaluation of Textile Material – II**  
1 credit (0-0-2)  

**TTL763 Technical Textiles**  
3 credits (2-1-0)  


Automotive Textiles: Application of textiles in automobiles. Requirement and design for pneumatic tyres, airbags and belts. Methods of production and properties of textiles used in these applications.

Sewing threads, cords and ropes: Types, method of production and applications. Functional requirements, structure and properties.

Miscellaneous: Functional requirements and types of textiles used for paper making, agricultural, architectural, packaging and footwear.

**TTL764 Process Control in Spinning & Weaving**  
3 credits (3-0-0)  
Role of ambient temperature and humidity. Life of accessories. Workload.  
Principles for control of productivity in different sections, Contribution of control in yarn, winding, warping, sizing & weaving to the cost of production in fabric manufacture.  
Splicing, machine allocation and load distribution, Control of migration in sizing, size droppings, sizing materials.  
Controls in the winding for processing yarns for dyeing & knitting, Controlling sloughing off during winding, warping & weaving. on-line data system and its use in controls.

**TTL765 Product Development**  
3 credits (2-1-0)  
Pre-requisites: EC 90

specifications for new products. Case studies from the point of view of developing textile products for selected end use applications.

**TTL771 Electronics and Controls for Textile Industry**
4 credits (3-0-2)


**TTL772 Computer Programming and its Applications**
3 credits (2-0-2)

**TTL773 Design of Experiments and Statistical Techniques**
3 credits (3-0-0)
Pre-requisites: EC 90

**TTL782: Nonwoven Science and Engineering**
3 credits (3-0-0)
Pre-requisites: EC 90

**TTL830: Modeling and Simulation in Fibrous Assemblies**
3 credits (2-0-2)

**TTL866 Functional and High Performance Textiles**
3 credits (2-1-0)
Protective clothing: Clothing requirements for thermal protection, ballistic protection, UV-protection, protection from electro-magnetic radiation and static hazards, protection against micro-organisms, chemicals and pesticides. Design principles and evaluation of protective clothing; Medical Textiles: Textiles in various medical applications, Application oriented designing of typical medical textiles, Materials used and design procedures for protecting wounds; cardiovascular application, sutures etc; Sportswear: Clothing requirements for different sports. Development of highly functional fibres, yarns and fabrics for temperature control and moisture management; Stretch, bulky and light weight fabrics; Composites: Two and three dimensional fabrics and triaxially braided materials for composites; Production and properties of preforms and composites; Properties and uses of rigid composites; Stimuli sensitive intelligent textiles - their production, properties and applications; Smart textile incorporating functional devices; Miscellaneous: Glass, ceramic and metallic fibres and their textile products.

**TTS890 Independent Study (Fibre Science & Technology)**
3 credits (0-3-0)
Student should undertake a research oriented activity including software development, machine design and development, instrumentation, product and process development or indepth study of a subject of outside the regular courses offered in the programme. 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 persued by the student. The student must submit a detailed plan of work for the programme coordinator before approval of registration for the course.

**TTS891 Independent Study (Textile Engineering)**
3 credits (0-3-0)
Student should undertake a research oriented activity including software development, machine design and development,
instrumentation, product and process development or indepth study of a subject of outside the regular courses offered in the programme. 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 must submit a detailed plan of work for the programme coordinator before approval of registration for the courses.

TTD891 Major Project Part-I (Fibre Science & Technology) 6 credits (0-0-12)

TTD892 Major Project Part-II (Fibre Science & Technology) 12 credits (0-0-24)

TTD893 Major Project Part-I (Textile Engineering) 6 credits (0-0-12)

TTD894 Major Project Part-II (Textile Engineering) 12 credits (0-0-24)
CRL702 Architectures and Algorithms for DSP Systems
4 credits (2-0-4)
Introduction to Digital Signal Processing System (DSP tasks; DSP processors and embodiments; Numerics Represntation and Arithmetic Operation Format (Fixed point and floating point representations; Extended precision; Floating point emulation; Q notation; Fixed point and floating point arithmetic operations). Architecture of Programmable Digital Signal Processors (Central processing unit: Data and program memory features; Peripheral interfacing/Execution control). Digital signal Processor specific Assembly language programming (Instruction types; Addressing modes. Assembly language programming for specific fixed / floating points DSP processor; Pipelining). DSP Algorithms (Convolution and FFT; Methods for generation of elementary functions; Pseudo-random number generation.) Software Design for Low power (Sources of power consumption in a programmable DSP;Software power estimation; Software optimization techniques for low power).

Practicals: Familiarization with assembly language programming tools of chosen DSP Processor; Number representation formats and arithmetic operations. Basic DSP operations: Filtering, FFT, Random Number and other function generation algorithms, Laboratory Project.

CRL704 Sensor Array Signal Processing
3 credits (3-0-0)
Representation of Space- Time Signals (Coordinate systems; propagating waves; wave number-frequency space; random fields; noise assumptions). Signal Modeling and Optimal Filters (Auto-regressive (AR), Moving average (MA), ARMA models; Autocorrelation and power spectral density (PSD) of random processes; linear minimum mean square and linear least squares error estimator; solution of normal equations; optimum filter; matched filters.) Adaptive Filter Theory (Motivation and applications; method of steepest descent; least mean squares adaptive filters; recursive least squares adaptive filters; Convergence issues and performance analysis.) Power Spectrum Estimation (Nonparametric methods; Estimation of autocorrelation function and PSD using periodogram; Blackman-Tukey and Welch- Bartlett methods; Parametric methods; Model order selection; PSD estimation using rational spectral models; MUSIC ESPRIT). Signal Shaping for Transmission (Representation of band pass signals; band pass sampling theorem; Complex Envelope; Ambiguity function and its properties; Considerations in signal shaping.) Array Processing (Array signal modeling; sensor array/ geometries; spatial/sampling; beam forming- spatial and space-time filtering; array aperture; delay and sum beam forming; frequency domain beam forming; optimum beam forming: MVDR beam former, Generalized side-lobe canceller; Adaptive beam forming).

CRL705 Advanced Sensor Array signal Processing
3 credits (3-0-0)
Introduction: Motivating examples, history of array signal processig, wave propagation, mathematical model, basic notations, assumptions, and problem formulation. DOA Estimation Problem: Basic estimation methods, beamforming techniques, subspace techniques, ML techniques (Deterministic and stochastic), some special techniques for ULAs, coherent, wideband, nearfield, spread etc, sources, Beamforming: Classical methods, subspace techniques, space time beamforming. Special techniques for ULA, wideband etc. sources. Detection of number of signals, Classical methods, subspace methods, Array design techniques.

CRL707 Human and Machine Speech Communication
3 credits (3-0-0)
Introduction; (Human-machine speech communications aspects; speech chain, digital representations of speech; intensity level of sound). Speech production (anatomy and physiology of speech organs; articulatory phonetics; acoustic phonetics; phonetics transcription; universal speech production model). Speech signal analysis (Time-domain methods; Frequency domain methods; Pitch estimation spectrogram analysis; Cepstrum analysis;). Linear prediction coding (Least squares autocorrelation and covariance methods; Line spectral frequencies). Psychoacoustics and auditory perception (Hearing; critical bands; phenomena of masking; Hel scale; perceptually important features of speech; prosodic features). Speech signal coding (Speech coder attributes; Coding rates; PCM; ADPCM; CELP;Harmonic coding of speech; Coding standards). Evaluation of speech quality (Dependencies of quality; Objective and subjective quality evaluation measures; Objective evaluation of subjective quality). Speech synthesis (Limited and unrestricted text to speech synthesis; Articulatory synthesis; Concatenative synthesis; Incorporation of prosody). Automatic Speech recognition (Pattern recognition approach; Dynamic time warping; Feature extraction; HMM; Language models). Speaker recognition (Verification vs. recognition, recognition techniques; features that distinguishing speakers).

CRL711 CAD of RF and Microwave Circuits
4 credits (3-0-2)

Practicals : Design and fabrication of band pass filter using SERENADE. Design and fabrication of wilkinson power divider using SERENADE. Design and fabrication of ring coupler using SERENADE. Design and fabrication of NRD guide band pass filter using HFSS.

CRL712 RF and Microwave Active Circuits
3 credits (3-0-0)
Small signal amplifiers- low noise, maximum gain, stability, Broad band amplifiers- matching circuits, travelling wave amplifiers. Power amplifiers- Efficiency, CAD, device modeling, measurement. Mixers-Single ended, balanced, double balanced, different configurations for microstrip, waveguide etc., noise properties, simulation using harmonic balance, Oscillators- various configurations depending on active device, stability and noise, resonators, VCO, transient analysis using SPICE, harmonic balance analysis, frequency synthesis using DDS, PLL.

CRL713 Fundamentals of RF Electronics
3 credits (2-0-2)
Mathematical foundation in understanding of signal, microwave circuits, and devices: Phase diagrams, duality, superposition, miller, Thevenin and Norton Theorems, instantaneous, average, complex power their representation nomenclature, Fourier series, Laplace, Fourier and Z transforms, convolution, correlation and basic properties of Fourier transforms, transmission line theory, T and IT equivalent circuit, behavior of transmission line at radio frequency. Physics and operation of bipolar, and MOS structures. DC and Low Frequency Circuit Concepts: BJT Biasing, mode of operation small signal AC analysis. FET circuits at DC, AC analysis, first and second order AC models of FETs, high frequency models of BJT and FETs, single pole approximation, differential amplifiers, and frequency response. Circuit Representation of Two Port RF/ Microwave Networks. : Impedance, Admittance, Hybrid, Transmission Matrix, Generalized S parameters, Reciprocal Networks, Loss less Networks, Signal Flow graphs and its Applications, Gain Consideration in Amplifiers, Impedance Matching and network selection: power gain concept, mismatch factor; return loss, input/output VSWR, maximum gain, constant gain design, figure of merit, matching network, Double sideband suppressed carrier, Asymmetric sideband sigals, phase/ frequency modulation, narrowband angle modulation wideband frequency modulation. Band pass Digital Signaling: (OOK, BPSK, DPSK), multilevel signaling (QPSK, MPSK, QAM), minimum-shift keying (MSK) and comparison of band pass digital signaling systems, band pass sampling, filtering and linear distortion.
**CRL715 Radiating System for RF Communication**
3 credits (3-0-0)
Antennas: radiation concepts, dipoles, monopoles, antenna parameters (gain, efficiency, etc.) theory, comparison with simulators, and measured data for simple antennas. Analysis and synthesis of simple linear arrays. Optimizers. Equivalence theorems and application to horns and reflectors, comparison with simulations. Active and passive electronic scanning antennas. Microstrip and other printed antennas, analysis using equivalent circuit, numerical techniques. Broad band printed antennas, and other broad-band antennas for ESM. Scattering by wedge GTD, and application to short-range communications.

**CRL720 Surface Acoustic Wave Devices and Applications**
3 credits (3-0-0)

**CRL721 Analog/RF IC Modeling and Design**
3 credits (2-0-2)
Amplifier fundamentals in CMOS, Bipolar and BiCMOS technologies. SiGe: Heterojunction Bipolar Transistors for RF applications and their noise performance, Trans-receiver building blocks for CMOS, Bipolar and BiCMOS. Low voltage, Low noise, Low power techniques in RF CMOS sub micron design receive Archer, RF/ Base band filtering and compensation. LNAs and VCOs at RF-Design and Limitations, Direct conversion, Image rejection, sub sampling mobile and cellular communication. Multimode, multi-band communication 3G communication.

**Practicals:** Design and characterization of a high gain (20,000) differential Amplifier, Design and Simulation of high gain high frequency SiGe Double Hetero Structures Transistors, Characterization and simulation of a communication link, coding schemes, self correcting codes and auto-correlation process. Design and characterization of an integrated transmit/ receive module, Sampling, sub sampling, band pass sampling and spectrum characterization.

**CRL722 RF and Microwave Solid State Devices # 3**
3 credits (3-0-0)
Review of basic concepts in semiconductor device operation; energy-band diagram, drift and diffusion current, generation recombination excess carriers, and p-n junction theory. Schottky barrier diode: formation of metal-semiconductor barrier, Schottky-Mott theory and modification, metal-semiconductor interface, silicides-Si interface, effect of interface states, current flow through barrier, forward and reverse bias I-V, C-V characteristics, measurement of barrier height. Schottky diode device structures and technology Omic contact formation. Varactor diode, equivalent circuit, C-V characteristics for linearly graded, abrupt, and hyper abrupt p-n junction, cut-off frequency. P-N diode general considerations, I-V and C-V characteristics. IMPATT diode, principle of operation, small signal impedance, power conversion efficiency, diode structure and fabrication. Transferred electron devices, differential negative resistance effect, Gunn diode. GaAs MESFETs, basic device structure, theory of operation equivalent circuit and analysis. Silicon MOSFETs: brief review of MOSFET theory, Passive design and operation, high frequency structures SOI based MOSFETs. Passive components in RF technology (inductors, capacitors), MMICs.

**CRL723 Fabrication Techniques for RF & Microwave Devices**
3 credits (1-0-4)
Concept of process flow in IC fabrication, representative process flow for diode/MOSFET. High temperature processes; oxidation, diffusion, and annealing. Use of "masks" in IC fabrication, mask design and fabrication, Photolithography process. Chemical etching processes: dry and wet etching. Vacuum and vacuum systems. Thin films in IC processing, resistive evaporation, e-beam, RF and DC sputtering processes. Concept of test chip design and process parameter extraction.

**Practicals:** Vacuum system, Thermal evaporation, DC/RF sputtering, Mask making techniques: Coordinatograph/Photo-plotter first Reduction Camera, Step and Repeat process, Photolithography process, Etching techniques, Oxidation/ diffusion processes, Diode fabrication, Band Pass filter fabrication, Measurement equipment calibration.

**CRL724 RF and Microwave Measurement System Techniques**
3 credits (3-0-0)
Review of measurement and instrumentation basics. Principles and applications of various sensors used in characterization of RF materials, devices, circuits and system: acoustic, ultrasonic, magnetic, electrical, thermal, optical, radiation and smart sensors, Mechanical and thermal engineering issues for RF modules/ instruments. Instrumentation concepts and measurement techniques in: Oscilloscopes, Spectrum analyzers, Network analyzer, Lock-in-amplifiers, Waveform generators, Bit-error rate measurement, S/N measurement Talemtry, Data recording and display, Recent advances in RF and Microwave measurement Techniques.

**CRL725 Technology of RF and Microwave Solid state Devices**
3 credits (3-0-0)
Review of semiconductor device processing technologies: process sequence development for a representative MOS technology, overview of oxidation, diffusion, mask making, pattern transfer, etching, metallization etc., process integration. Techniques of metallization: Introduction to vacuum systems. Sputtering (DC, RF and magnetron), e-beam evaporation for ohmic and Schottky. Contact formation, silicides for gate and interconnect. Fine line lithography process: optical lithography, x-ray and e-beam lithography, lift-off techniques. Wet and plasma assisted etching techniques, RIE, RIBE. Introduction to
Ion Implantation, Molecular Beam Epitaxy. Chemical Vapour Deposition (epitaxial growth, polycrystalline, silicon, dielectric films, flow pressure and plasma chemical deposition). GaAs MESFET technology. Introduction to MEMES technology.

CRL726 RF MEMS Design and Technology
3 credits (3-0-0)
Introduction and origin of MEMS, driving force for MEMS development, fabrication process. MEMS fabrication technologies: Conventional IC fabrication processes, bulk micro machining, surface micro machining, LIGA process, anodic and fusion bonding, packaging techniques for MEMS. Sensors, Classification and terminology of sensors, sensor characterization basic concept of acoustic, mechanical, magnetic, radiation, thermal sensors and intergrated sensors. Actuation in MEMS devices, electrostatic actuation, parallel plate capacitor-cantilever beam based movement, comb-drive structures. The MEM switch; Cantilever based MEM switch, Membrane based switch design microwave material and mechanical considerations. The MEMS switch; cantilever based MEMS switch, membrane based switch design, microwave, material and mechanical considerations. Microwave transmission lines, membrane supported micro-strip line, coplanar waveguide, micro-machined waveguide, inductors, capacitors and tunable capacitors. MEMS based RF and microwave circuits: phase shifter, resonators, filters, oscillators.

CRL728 RF and Electronic System Design Techniques
3 credits (3-0-0)

CRL731 Selected Topics in RFDT- I
3 credits (3-0-0)
Lecture course for covering special topics in the area of relevance to a group of students attending the RFDT programme.

CRL732 Selected Topics in RFDT- II
3 credits (3-0-0)
Lecture course for covering special topics in the areas of relevance to a group of students attending the RFDT programme.

CRL733 Selected Topics in RFDT- III
3 credits (3-0-0)
Lecture course for covering special topics in the areas of relevance to a group of students attending the RFDT programme.

CRS735 Independent Study
3 credits (0-3-0)
Interactive course offered by faculty to specific students for carrying out in-depth study in certain areas of technology.

CRL737 Selected Topics in Radars and Sonars
3 credits (3-0-0)

CRV741 Acoustic Classification using Passive Sonar
1 credits (1-0-0)
Prerequisite: EEL205 (Signals and Systems) or equivalent.
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.

CRD802 Minor Project
3 credits (0-0-6)
Interactive course offered by faculty to specific students for carrying out in-depth study in certain areas of technology.

CRD811 Major Project-I
6 credits (0-0-12)
Laboratory-based project to demonstrate and develop advanced skills for technology development in a specified area.

CRD812 Major Project-II
12 credits (0-0-24)
Laboratory-based project to carry out original research and advanced design/development in a specific technology area.
The following two courses are offered by the Centre for postgraduate students.

**VEL700 Human Values and Technology**  
*3 credits (2-1-0)*  

**VEL710 Traditional Knowledge and Values**  
*3 credits (2-1-0)*  
Some of the values inherent in these TKS are 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, decentralized, aesthetically pleasing, wealth distributive etc. It would be emphasized that these values are inherently present in the framework of 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.

**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.
Amar Nath and Shashi Khosla
School of Information Technology

SIL765 Network & Systems Security
4 credits (3-0-2)
Pre-requisites: CSL374 / CSL672 or equivalent, CSL373 / CSL633 or equivalent
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, and defenses against them. The course will involve reading research papers on relevant topics, programming assignments, and projects.

SIL769 Internet Traffic – Measurement, Modelling & Analysis
4 credits (3-0-2)
Pre-requisites: CSL374 / CSL672 or equivalent

SIL801 Special Topics in Multimedia Systems
3 credits (3-0-0)
Pre-requisites: Course Co-ordinator’s permission
Objective of the course is to expose students to the advanced concepts in Multimedia Systems. 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)
Pre-requisites: Course Co-ordinator’s permission
Objective of the course is to expose students to the advanced concepts in Web Based Computing. 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 Medicine
1 credit (1-0-0) Pre-requisites: None
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 Communication Technologies for Development
1 credit (1-0-0) Pre-requisites: None
ICT for development is an emerging area of research that combines high-tech CS/IT skills, and put them to uses to solve social development problems. Some of the topics we will explore include the design of low-cost communication technologies for rural areas, agriculture consultancy systems, techniques for surveys and data collection to maintain health records, artificial intelligence to guide farmers on cropping patterns, and security schemes for financial inclusion and branchless banking.

SIV864 Special Module on Media Processing and Communication
1 credit (1-0-0) Pre-requisites: None
Communication today has rich multimedia contents. Under the varying bandwidth attention is required for appropriate processing of the media contests 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.

SID880 Minor Project in Information Technology
3 credits (0-0-6) Pre-requisites: Course Co-ordinator’s permission
Objective of the course is to provide an opportunity to the students to work on development/research project in his/her area of specialization as part of M.S. degree.

SIV886 Special Module in Computer Human Interaction
1 credit (1-0-0) Pre-requisites: 120 credits for UG students
The goal of this course is to expose students to cutting edge research problems in the area of designing human-computer interaction systems. The topic may include interfaces such as touch, voice, design of icons, typography, gestures, etc. for a variety of devices.

SID900 Major Project for M.S. (Research)
40 credits (0-0-80) Pre-requisites: Course Co-ordinator’s permission
Objective of the course is to provide an opportunity to the students to work on development/research project in his/her area of specialization as part of M.S. degree.

SIV895 Special Module on Intelligent Information Processing
1 credit (1-0-0) Pre-requisites: None
This course will focus on presenting conclave of methods which are being practiced for intelligent computing-learning techniques, classification methods, embedding intelligence, neural network, soft computing and evolutionary methods. Emphasis will also be given on the variety of multidisciplinary applications of such techniques.
School of Biological Sciences

SBL701 Biometry
3 credits (3-0-0) Pre-requisites: EC 90
Probability and Set theory: Application to biological data, Random variables: Individuals vs. populations in biological systems, Classification of data: "Discreteness or Continuity" in biological evolution, Distributions, Descriptive statistics, Inferential statistics, Analysis of variance (ANOVA), ANOVA-advanced concepts, Power analysis of variance, Regression and Correlation, Count/Frequency data. MATLAB based assignment activities will be designed for data simulation and analysis corresponding to the covered lecture material.

SBL702 Systems 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.

SBL703 Advanced Cell Biology
3 credits (3-0-0) Pre-requisites: EC 90
Chemistry of biological structure, function and information flow, Cellular compartmentalization and molecular organization of organelles, Properties and growth of HelA, Jurkat, SP9 etc.; De-novo synthesis of organelles versus templated replication, Microtubule, microfilament and intermediate filaments; Transport of biomolecules; Nuclear structure, chromatin packing and transport; Microtubule, actin and filament based motile systems, cell-cell recognition and adhesion; Fluorescence, phase contrast, confocal and AFM; Molecular basis of cancer, oncogenes and tumor suppressor genes; cell growth and differentiation.

SBL704 Human Virology
3 credits (3-0-0) Pre-requisites: EC 90
Introduction, overview and history of medical Virology; Virus structure, classification and replication – symmetry, 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 immunoprophylaxis, 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
Over-view 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), oblongonucleotides, peptide, PNA mediated therapeutics, drug delivery systems (lipids, cell penetrating peptides), vaccine, monoclonal antibodies produced by and in the living organisms, nanobiopharmaceutes, 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 Phytopharmacines, 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, GMFs, legislations, Safety Regulations associated with biologics in biopharmaceuticals.

SBL707 Bacterial Pathogenesis
3 credits (3-0-0) Pre-requisites: EC 90 and BEL110 or CYL110 or CYL120 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: EC90 and BEL110 or CYL120 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: EC90 and BEL110 or CYL110 or CYL120 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, sulphorylation, 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.

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 materials, biomimeralisation, Biomimetic ahesives and attachment devices in nature, prosthectics function and design, bioinspired robotics, biomimetic pattern formation, colour and camouflage, photocells, role in agriculture and human health, future prospects in the industry.

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.

SBV801 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, recursion, 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.

SBV802 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, cryomicrotography, software packages for data collection and processing, generating a model, refinement and validation, time resolved cryoEM.

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, Bioconjugate 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 posttranslational 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.
Centre for Atmospheric Sciences

**ASL701 Dynamics of Atmosphere and Ocean**
3 credits (3-0-0)
Overlaps with: ASL710, ASL840
Basic hydrodynamic equations in a rotating frame of reference, geostrophic balance; basic laws of conservation, hydrostatic balance, gradient and thermal winds, dimensional analysis, simplified equations for ocean and atmosphere in motion; shallow water equations, potential vorticity conservation; barotropic and baroclinic instabilities; acoustic, gravity, Rossby and Kelvin waves; horizontal and transverse waves, vertically propagating waves; large-scale atmospheric circulations, available potential energy; equatorial dynamics, heat-induced tropical circulations, Gill's solution; mid-latitude circulations; planetary waves and stratosphere.

Ocean Dynamics: thermohaline and wind-driven ocean circulations; Ekman layers, Sverdrup transport, western boundary currents; ocean circulation variability; oceanic mixed layer; response of ocean to a moving storm or hurricane.

**ASL703 Physics of Atmosphere and Ocean**
3 credits (3-0-0)
Overlaps with: ASL710, ASL830
Thermodynamics of dry and moist air: atmospheric stability and dry adiabatic lapse rate, Clausius-Clapeyron (C-C) equation, moist processes in the atmosphere, saturated and unsaturated accent, moist adiabatic and saturated adiabatic processes in the atmosphere, saturated adiabatic lapse rate, pseudo adiabatic processes and equivalent potential temperature, conditional instability of second kind, thermodynamic diagrams; moist convection, condensation processes, formation of cloud droplets, precipitation.

Ocean physics: thermodynamics of seawater, observed temperature, salinity, and density in the ocean; density stratification, water mass distribution, coastal currents and upwelling; thermohaline circulation, The Gulf Stream and its rings; ocean currents, The Great Ocean Conveyor Belt, coupling of surface and deep ocean waters; basic foundation of turbulence, turbulent flows, turbulent vorticity, turbulent pressure, eddy diffusivity, and coherent structures; surface fluxes, air-sea interaction, mixing processes in the ocean.

Radiative transfer in atmosphere and ocean: Sun and climate. Planck function, black-body radiance, local thermodynamic equilibrium, radiometric quantities, absorption and emission, Schwarzschild's equation, radiative equilibrium in a grey atmosphere, balance between incoming solar and outgoing thermal radiation; More complex radiative transfer: integration over frequency, single lines, average transmission over a spectral interval, absorption by atmospheric gases, Heating rates, net radiative heating; a simple model of scattering in the atmosphere; Radiative transfer in atmosphere-ocean system.

**ASL705 Boundary Layer Meteorology and Air Pollution**
3 credits (3-0-0)
Overlap with: ASL831
Boundary layer processes, atmospheric boundary layers, bulk and gradient Richardson numbers, shear and buoyant production of turbulence, organized large eddies, boundary layer wind and thermodynamic profiles, convective and stably stratified boundary layers; surface layer; similarity theory, conservation equations for covariances, Reynolds stresses; turbulent fluxes; equations of atmospheric turbulence and closure assumption, TKE budget equation, observational techniques; Ekman boundary theory, oceanic boundary layers; parameterization and models of turbulent transport. Air pollution meteorology: sources of air pollution, Gaussian plume models, diffusion from point, line and area sources; urban air pollution.

**ASL706 Parameterization of Physical Processes**
3 credits (3-0-0)
Parameterization of subgrid-scale processes; one-dimensional PBL model; parameterization of subgrid orographic processes, gravity-wave (GW) drag; parameterization of dry adiabatic and moist convective processes, cloudiness parameterization in numerical models; cloud microphysics in numerical models; radiative transfer; band and emissivity models, multi-level longwave and shortwave radiation computations; surface and atmosphere interaction, land surface parameterizations, surface hydrology modelling, energy balance at the surface, surface albedo and vegetation cover.

**ASL707 Mathematical & Statistical Methods in Atmospheric Sciences**
3 credits (3-0-0)
Initial and boundary value problems, ordinary differential equations, orthogonal functions; partial differential equations: solving them through variational and numerical methods. Review of probability, discrete and continuous distributions, multivariate probability distributions, assessing goodness of fit, hypothesis testing, regression, time-series analysis, principal component/empirical orthogonal function analysis.

**ASL710 Atmospheric Physics**
3 credits (3-0-0)
Overlap with: ASL701

**ASL712 Air Sea Interaction**
3 credits (3-0-0)
Ocean-atmosphere system, transfer properties between atmosphere and ocean, oceanic absorption of solar energy, fluxes in the surface boundary layer over the sea, marine boundary layer, ENSO, variability of the ocean parameters in relation to Indian monsoon, physical parameterizations of the air-sea interaction, coupled ocean-atmosphere modeling.

**ASL715 Science of Climate Change**
4 credits (3-0-2)
Description of the climate system, natural greenhouse effect and the effect of trace gases and aerosols, feedbacks in the climate system, climate change in the past, ice ages, proxy records, abrupt climate change, Instrumental record of climate, climate variability on various time-scales, simple models of climate, General Circulation Models, natural and anthropogenic climate change: detection and attribution, impacts and mitigation of climate change.

**ASL718 Tropical Meteorology**
3 credits (3-0-0)

**ASL720 Satellite Meteorology and Remote Sensing**
3 credits (3-0-0)
Satellite Meteorology, satellite observing system; retrieval of clouds, winds, temperature, humidity, trace gases and aerosols, rain; Image interpretation and analysis with ERDAS, ocean colours, SST, scatterometer studies, energy budget, Microwave soundings from satellites. Remote sensing of oil slicks, vegetation, Radar equation, Doppler and other polarization techniques, measurement of albedo and vegetation cover.
ASL722 Biological Oceanography  
3 credits (3-0-0)  
Oceanic life and ecosystems, biological productivity of ocean, biological exploitation of ocean, uses and problems of ocean, theories of population in marine ecological communities, mathematical models, ecological fluxes, scale analysis, effects of marine pollution on living resources. Physico-biological models, estuarine biological modelling, coastal ecosystem modelling.

ASL724 Atmospheric Diffusion and Air Pollution  
3 Credits (3-0-0)  
Various sources and types of pollutants in the atmospheric environment, Reynolds averaging, closure problem, atmospheric diffusion, types of boundary conditions for modelling dispersion. Solution of diffusion equation for instantaneous and continuous sources; dispersion from ground and elevated sources; long and short range dispersion, removal mechanism; dry and wet deposition, chemical removal, atmospheric surface boundary layer, similarity theory. Wind rose, dispersion parameters and plume rise. Gaussian and box models, optical stack height; case studies for the dispersion of pollutants.

ASLP751 Simulation Lab I: Weather Analysis and Forecasting  
2 credits (0-0-4)  
*Note: This Course is not open to Undergraduate Students.*
Programming languages, Unix & shell programming, data formats: ASCI, GRIB, NetCDF. Introduction to Fortran 95, programming in Fortran 95; Examples for converting and reading ASCI, GRIB, NetCDF data files; graphical display of meteorological fields. Visits to observation facilities of IMD: meteorological instruments workshop; radiosonde and radar installations; forecasting for aviation and air pollution, meteorological parameters, GTS, weather codes and decoding of weather observations; visits to IMD for map discussion participation; thermodynamic diagrams, tropical weather systems, tropical cyclones; synoptic features during different seasons, western disturbances, monsoon circulation and its climatology at surface, 850 hPa and 200 hPa; sea-level pressure distribution on the globe; θ and ψ fields. Mass and wind field balance, synoptic forecasting from analysis of weather maps; satellite image interpretation, cloud classifications ERDAS software, Introduction to numerical methods used in weather prediction, quasi-geostrophic and balance models, omega equation.

ASLP752 Simulation Lab II: Objective Analysis & Data Assimilation  
3 credits (0-0-6)  
Observed meteorological / oceanographic parameters and their interpretation; Numerical mathematics of weather prediction: space discretizations, Arakawa’s staggered and non-staggered schemes, Arakawa Jacobians; time integration schemes. Objective analysis: interpolating polynomials and function fitting for a triangular, rectangular and polygonal geometry; preparation of initial conditions from observations using method of successive correction and spline interpolations; Initialization: mass and wind field balance, Rossby adjustment theory, introductory dynamic and normal-mode initialization; initial model grid data preparation and forecast / hindcast experiments with a limited area model. Variational data assimilation: variational methods, variational assimilation basics; Examples of 3D/4D-VAR with shallow water model and its adjoint; Experience with meteorological / satellite data assimilation; Simple oceanographic data assimilation at mesoscale and assimilation of altimetry data and ARGO data.

ASLP801 Simulation Lab III: Ocean-Atmosphere Forecast Methodology  
3 credits (0-1-4)  
Design of horizontal and time differencing schemes, discrete analogues of basic governing equations, discrete formulations of horizontal and vertical mixing; preparation of model initial and boundary conditions from meteorological analyses and climatological data; Limited-area modelling, short-range forecast experiments with limited area model; medium and long range weather prediction experiments with a GCM; experience with different convection schemes in thunderstorm/cyclone modelling with a fine resolution hydrostatic/ non-hydrostatic model. Image analysis of simulated fields with ERDAS.

Data studies: Madden-Julian oscillation, El niño and Southern Oscillation, Gill’s barotropic model, computation of heat-induced tropical circulations; ocean analysis from ARGO data; ocean circulation models, computation of air-sea fluxes using meteorological and oceanographic data.

ASLP803 Advanced Ocean Dynamics  
3 credits (3-0-0)  
Western boundary intensification, barotropic currents, baroclinic transport over topography. Mesoscale eddies and variability. Indian Ocean dipole circulation, linear waves, wave spectra, wave propagation. 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 and rip currents, littoral drift, sediment transport, coastal ocean response to wind forcing, storm surges, coastal upwelling and fronts, Kelvin, Yanai, Rossby, inertia-gravity waves.

ASLP804 Air Quality Monitoring and Health Risk Assessment  
3 credits (2-0-2)  
Short and long range transport and diffusion; Model Evaluation and Uncertainty analysis; Dispersion of toxic substances, Nomograms for safe distance estimation, Risk assessment techniques; Case studies, air pollution measurement techniques: High, low volume sampling, aerosol samplers, Ozone and CO analyzers, indoor air monitoring, Wind rose, air quality and associated health effects, Spirometer measurements, dose response relationships for health risk assessment.

ASLP808 Atmospheric Chemistry and Aerosols  
3 credits (3-0-0)  
General characteristics of atmospheric composition, ozone layer, stratospheric and tropospheric chemistry; principles of chemical kinetics; gas-phase and aqueous-phase reactions in the atmosphere; chemistry and physics of the polluted atmospheres, photochemical reactions and smog; monitoring techniques, organic pollutants in the atmosphere; atmospheric aerosols, impact of aerosols and clouds on climate; Montreal and Kyoto protocols, major fire emissions, greenhouse effect, climate change and green chemistry.

ASLP813 Climate Variability  
3 credits (3-0-0)  
Global distributions of temperature, precipitation, etc.; Koppen’s classification of climates, climate variability as estimated from observations and paleoclimatic proxy data; natural (internal) and externally forced climate variability; modeling climate and its variability using simple energy balance climate models, atmospheric and oceanic general circulation models, and coupled ocean-atmosphere models. Global efforts in understanding and predicting climate change, Impacts of climate change.

ASLP814 Modelling of Dynamic Processes of Oceans and Atmosphere  
3 credits (3-0-0)  
Overlap with: ASLP50  
Finite difference approximations, Discrete analogues of differential equations in meteorology, relaxation methods, advection equations, Time differencing schemes, stability analysis, shallow-water models and filtering, Integral invariants, energy and entropy conserving schemes, Matsuno, leap-frog schemes, geostrophic adjustment, spectral methods, semi-implicit formulation, Non-linear instability, vertical coordinates, vertical discretization, Limited area models, Ocean mixing and ocean wave modelling.

ASLP815 Marine Pollution and Costal Zone Management  
3 credits (3-0-0)  
Hydrodynamics of coastal zone, wave dynamics, coastal engineering, offshore backwater system, alongshore and waste water transport, sediment suspensions, offshore ocean dumping, impact of coastal ocean
on living resources, petrochemical exploitation, wave power extraction, tidal energy, offshore thermal energy conversion, impact of saltwater intrusion, sea level rise and impact on coastal zone; management of estuaries, sustainable development of the coastal zone, health related problems of coastal zone.

ASL816 Advanced Dynamic Meteorology
3 credits (3-0-0)
Quasi-geostrophic analysis, circulation and vorticity theorems, Ertel-Rossby invariants, Ertel's PV conservation theorem, Thomson's and Bjerkness baroclinic circulation theorem, barotropic and baroclinic instabilities, symmetric instabilities; quasi-geostrophic motion in equatorial area, heat induced tropical circulations; Rossby waves, internal gravity waves, vertically propagating waves, Rossby adjustment theory; middle atmospheric dynamics, sudden stratospheric warming, QBO; general circulation of the atmosphere.

Turbulence in the atmosphere: ensemble-averaged equations, space-averaged equations, conservation equations for covariances, large-eddy simulations, atmospheric surface layer, convective boundary layer, stable atmospheric boundary, statistical representation of turbulence, quasi-geostrophic turbulence.

ASL817 Mesoscale Meteorology
3 credits (3-0-0)
Circulation systems related to orography, valley winds, energy budgets, cloudiness, precipitation, evaporation, fog, lightening, snow avalanches and valley air pollution; general properties of mountain perturbations, adiabatic mesoscale perturbations in a straight atmospheric flow, adiabatic synoptic scale perturbations, dissipation of mechanical energy, mountain drag, modelling aspects of mountain waves, mountain generated momentum fluxes, theory of linear gravity waves, orographic gravity-wave drag, its parameterization and influence in general circulation models.

ASL819 High Performance Computing in Atmospheric Science
3 credits (2-0-2)
Basic ideas on multitasking and massively parallel processing, different architectures, application of HPC in global and regional models, parallelism in weather and climate models, domain decomposition method, 1D, 2D and 3D parallelization of GCMs, MPI, PVM, SHMEM, message passing libraries, high performance compilers, load balancing, inter-processor communication, network communication, graphical user interface, data formats, local and wide area networking, data flow and data mining.

ASL830 General Meteorology
3 credits (3-0-0)
Overlap with: ASL703
Basic concepts, thermodynamics of dry and moist air, thermodynamic diagrams, hydrostatic equilibrium, hydrostatic stability and convection, cloud structure and precipitation; Physics of radiation: solar and terrestrial radiation, mean annual heat balance.

ASL831 Introduction to Micrometeorology
3 credits (3-0-0)
Overlap with: ASL705
Effects and sources of air pollutants, air quality standards; solar radiation, wind system, stability conditions, mixing height, heat Island effect, land-sea breeze, puffs and plumes; atmospheric surface boundary layer; momentum and heat exchanges with homogeneous surfaces; building wakes and other topographical effect; drag and heat transfer coefficients; sampling and standardization techniques, dispersion of air pollutants. Eddy diffusion models, Gaussian models, evaluation of dispersion parameters, optimal stack height by using Nomograms; short- and long-term dispersion models; dry and wet deposition, precipitation chemistry; Monin-Obukhov similarity theory; Statistical analysis of meteorological and air quality data; Modern automatic air sampling and monitoring techniques; site location criteria for meteorological instruments and tracer techniques for air pollution impact studies.

ASL832 An Advanced Course in Micrometeorology and Risk Assessment Techniques
3 credits (3-0-0)
Planetary boundary layer modelling, observed characteristics of the atmospheric boundary layer, upper air measurements, theoretical treatments of the diffusion of material, dispersion during calm winds, numerical models for dispersion of pollutants, complex terrain modelling, long range transport and diffusion; risk assessment techniques for accidental release of toxic and inflammable materials, hazard analysis, potential risk, conceivable release mechanisms and release rates, dense gas dispersion, merits and demerits of various models, nomograms for determination of safe storage quantities and safe distances, estimation of vulnerable zones, model evaluation and uncertainty.

ASL840 Dynamic Meteorology
3 credits (3-0-0) 
Overlap with: ASL701
Fundamental forces, equations of motion in rotating and non rotating coordinate frames, scale analysis, basic conservation laws, spherical coordinates, thermodynamic equation, geostrophic approximation, hydrostatic balance, static stability, circulation and vorticity, conservation of potential vorticity; Rossby adjustment theory, atmospheric waves, quasi-geostrophic equations, omega equation, hydrodynamic instability, available potential energy.

ASL850 Numerical Modelling of the Atmospheric Processes
3 credits (3-0-0)
Overlap with: ASL814
Equations governing the atmospheric motion, equations in different coordinate systems, atmospheric waves, scale analysis, hierarchy of balanced models, primitive equation models, numerical solution of atmospheric model equations, finite difference and spectral methods, various time integration schemes, conservation properties, some examples of numerical solutions, Numerical weather predictions with limited area and global models. Cloud-radiation interaction, convective adjustment processes, cumulus convection and large scale atmospheric variables, land surface processes and surface fluxes, parameterization of physical processes, design of optimal parameterization schemes, interaction of sub-grid scale processes with environment.

ASL860 Synoptic Meteorology
3.5 credits (3-0-1)

ASC 861 Atmospheric Science Colloquium
1 credit (0-1-0)
Students give weekly seminar on the topics in ocean and atmospheric sciences given by the teacher and also attend all seminars held in the Centre. The students present their understanding of the topic covered under the weekly seminars.

ASL870 Physical Oceanography
3 credits (3-0-0)
Ocean in perspective, early exploration and a brief history of physical oceanography; Physical and chemical properties of ocean water: composition of sea water, salinity, density, thermal expansion of sea water, viscosity, surface tension, heat conduction, adiabatic temperature changes, optical properties, osmotic pressure, electrical conductivity, suspended and dissolved substances. Temperature- salinity (T-S) relationship, formation of characteristics water masses; salinity and temperature of the surface layers. Circulation and stratification of the Ocean: General surface circulation, deep-water movement, and major ocean currents. Thermohaline circulation and ‘core’ analysis, temperature and salinity inversion in the ocean, the role of bottom topography in determining temperature and salinity distribution. Regional Oceanography: Criteria for a regional classification, regions of equatorial currents, regions of monsoon currents, Oceanography of Indian Ocean: Exploration, major current systems-Somali current, equatorial and monsoonal gyres, water masses and water types, climate, pressure field and wind systems, cloud cover and precipitation.

ASL871 Special Topics in Storm Surges
3 credits (3-0-0)
To be given by the interested faculty
ASV872 Special Module in Storm Surges
1 credit (1-0-0)
To be given by the interested faculty

ASV873 Special Module in Indian Ocean Studies and its Relevance to the Monsoons
1 credit (1-0-0)

ASV874 Special Module and Disaster Management
1 credit (1-0-0)

ASV875 Quantifying Uncertainty
1 credit (1-0-0)
The fundamental motivation for this course stems from the observation that progress is solving difficult inference problems in the oceans, atmosphere and climate can be improved by exposing the students to certain recent methodological advances in engineering and applied mathematics. For example, Markov Chain Monte Carlo methods are largely unfamiliar to the audience, though their popularity in other fields is high and an interest in adopting them in earth science is rapidly rising. There are several such promising methods, of course, which this course brings together for Quantifying Uncertainty, an increasingly important topic in the earth science with particular importance to climate studies. It will focus on methods to represent, propagate and reduce uncertainty organized modularly. These modules offer a comprehensive introduction to the atmospheric scientist, planetary scientist, geophysicist or oceanographer, and have the potential to inform many other disciplines. Simultaneously, they help strengthen the bridge between Engineering and Science.

Representation requires the study of probability density functions, parametric and non-parametric, and the methods by which they can be estimated from data and model outputs. Including a primer on density estimation, modules two and three cover parametric and non-parametric density estimation using the EM algorithm and illustrated with paleoclimatic and tropical cyclone problems.

In order to propagate uncertainties represented as probability density or mass function, we often need to invoke Monte-Carlo methods because explicit propagation is difficult in the face of dimensionality problems that models of governing geophysical fluid equations typically pose. With a primer on sampling, we teach MCMC in modules four and five.

Propagation of uncertainties using estimated or sampled densities is the next step. Typically, however, this process is also plagued by the curse of dimensionality underlying the numerical model of geophysical fluid governing equations. One aspect of propagating uncertainty involves reducing the model complexity. Module six, seven and eight provide a comprehensive review. Starting with a tutorial on principal components and moving to polynomial chaos expansions. They will illustrated with applications in atmospheric chemistry.

Module 9-12 is concerned with both propagating and reducing uncertainties and presents a unified framework for spatial, temporal inference using Graphical Models, which accurately synthesize the Kalman and Particle Filters among others. With a primer on Ensemble filters and smoothers, we will illustrate application of Graphical Models in data assimilation. This will lead to the last module, where we study particle filtering with Geosciences application.

ASL875 Special Topics in Air Pollution
3 credits (3-0-0)
To be given by the interested faculty

ASV876 Special Module in Air Pollution
1 credit (1-0-0)
To be given by the interested faculty

ASV877 Special Topics in marine and Water Pollution
3 credits (3-0-0)
To be given by the interested faculty.

ASV 878 Special Module in marine and Water pollution
1 credit (1-0-0)
To be given by the interested faculty

ASS 800 Independent Study
3 credits (0-3-0)
To be given by the interested faculty

ASD891 Major Project –I
6 credits (0-0-12)

ASD892 Major Project–II
12 credits (0-0-24)
Centre for Biomedical Engineering

**BML700 Introduction to Basic Medical Sciences for Engineers**
3 credits (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.

**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.

**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.

**BML810 Tissue Engineering**
3 credits (2-0-2)
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.

**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.

**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

**ESP700 Energy Laboratories**
3 credits (0-0-6)

**ESN704 Basic Thermal Engineering**
0 credit (1-0-0)
First and second law of thermodynamics, Thermal fluid systems, Standard cycles, Mixtures of gases, Heat transfer, Fluid mechanics, Practical examples, Use of steam tables.

**ESL710 Energy, Ecology and Environment**
3 credits (3-0-0)
Interrelationship between energy, ecology and environment, Sun as a source of energy, nature of its radiation, Biological processes, Photosynthesis, Autecology and synecology, Population, Community, Ecosystems (wetland, terrestrial, marine), Food chains, Ecosystem theories, Sources of energy, Classification of energy sources, Environmental issues related to harnessing of 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 & 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 green house 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, Interconversion 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.

**ESN712 Basic Electrical Engineering**
0 credit (1-0-0)
Power circuits and electrical machinery, AC circuit analysis, Three phase circuits, Power circuits components and energy conservation devices, Variable speed drives, Demand controls.

**ESP713 Energy Laboratories**
3 credits (0-0-6)

**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 (coal based, RDF based), 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 generation and wind turbine, Elements of nuclear power plants, nuclear reactors and fuels, Recent advances in power plants, (IGCC, super critical power plant, etc.), Case studies, Introduction to solar power generation, Sterling engine, Decentralized power technologies.

**ESL718 Power Generation, Transmission and Distribution**
3 credits (3-0-0)

**ESL720 Energy Conservation**
3 credits (3-0-0)

**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 energy concept and waste heat utilization, Energy modeling to optimize different systems.

**ESN72S Energy Audit**
0 credit (1-0-0)
Energy audit concepts, Basic elements and measurements, Mass and energy balances, Scope of energy auditing industries, Evaluation of energy conserving opportunities and environmental management, Preparation and presentation of energy audit reports, Some case study and potential energy savings.

**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, Applications of 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, Thermionic power conversion and plasma diodes, Thermodynamics and performance of fuel cells and their applications.

**ESL732 Bioconversion and Processing of Waste**
3 credits (3-0-0)
Biomass and solid wastes, Broad classification, Production of biomass, 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 fuels, Bioconversion into hydrogen, Thermo chemical conversion of biomass, conversion to solid, liquid and gaseous fuels, pyrolysis, gasification, combustion, Chemical conversion processes, hydrolysis and hydrogenation, Solvent extraction of hydrocarbons, Fuel combustion into electricity, case studies.

**ESL734 Nuclear Energy**
3 credits (3-0-0)
collisions, polyenergetic neutrons, critical energy of fission, fission cross sections, fission products, fission neutrons, energy released in fission, \( \gamma \)-ray 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 Confinement Schemes: Magnetic and inertial confinement, current status.

ESL735 Hazardous Waste Management 3 credits (3-0-0)

ESL736 Power from Renewables & Environmental Impacts 3 credits (3-0-0)
Environmental impacts of fossil fuel based power generation, Renewable electricity and key elements, Hydropower and its constraints, Wind energy: technology and economics, Resources, systems and regional strategies, Solar thermal power, Photovoltaic technology, Biomass power, tidal power, OTEC, Global climate change, CO\(_2\) reduction potential of renewable energy, Social considerations, standalone systems and grid integration.

ESL737 Plasma Based Materials Processing 3 Credits (3-0-0)
Pre-requisites: Nil
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 – oro enrichment, applications in ceramics, plasma assisted recycling.

ESL738 Power System Planning & Operation 3 credits (3-0-0)
Generation system capacity adequacy planning: Probabilistic models of generating unit outage performance and system load-evaluation of loss of load and loss of energy indices, Probabilistic production costing, Inclusion of power generation from renewable energy sources in the reliability analysis, Interconnected systems: multi-area reliability analysis, power pool operation and power/energy exchange contracts, Quantification of economic and reliability benefits by pool operation, Demand / energy forecasting: sector-wise peak demand and energy forecasting by trend and econometric projection methods, Optimal power system expansion planning: formulation of least cost optimization problem incorporating the capital, operating and maintenance costs of candidate plants of different types (thermal, hydro, nuclear, non conventional etc.) and minimum assured reliability constraint-optimization techniques for solution by linear and dynamic programming approaches-case studies.

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: gasification and pyrolysis, anaerobic digestion, combustion, conversion to electricity, Water energy: hydropower schemes, Tidal and wave energy: tidal barrage, Wave power and OTEC, Tidal and wind energy: wind energy potential and conversion efficiency, Mini / micro hydro power: classification of hydropower schemes, classification of water turbine, Turbine theory, Jet velocity and nozzle size in pelton wheel turbine, Essential components of hydroelectric system, system efficiency, grass root innovation energy technology, Fusion: Basic concepts, fusion reaction physics, Thermonuclear fusion reaction criteria, Confinement schemes, Inertial confinement fusion, Magnetic confinement fusion, Target gain requirements, Current status, Geothermal: Introduction, structure of the earth, Geothermal regions, Geothermal systems/fields, dry rock and hot aquifer analysis, Geothermal energy conversion technologies, OTEC.

ESL742 Economics & Financing of Renewable Energy Systems 3 credits (3-0-0)
Overview of renewable energy technologies, Relevance of economic and financial viability evaluation of renewable energy technologies, Basics of engineering economics, Financial feasibility evaluation of renewable energy technologies, Social cost – benefit analysis of renewable energy technologies, Technology dissemination models, Volume and learning effects on costs of renewable energy systems, Dynamics of fuel substitution by renewable energy systems and quantification of benefits, Fiscal, Financial and other incentives for promotion of renewable energy systems and their effect on financial and economic viability, Financing of renewable energy systems, Carbon finance potential of renewable energy technologies and associated provisions, Software for financial evaluation of renewable energy systems, Case studies on financial and economic feasibility evaluation of renewable energy devices and systems.

ESL743 Environmental Audit & Impact Assessment 3 credits (3-0-0)
Pollution sources and classification, air, water, soil and noise sampling and monitoring, Instrumentation, Environmental audit-detailed procedure, National environmental policy, Methodology of environmental impact studies, Methods of impact identification, Environmental setting, Production and assessment of impacts on the air environment, Prediction and assessment of impacts on surface water, soil and ground water environment, Socioeconomic environment, Evaluation alternatives, Public participation in environmental decision making.

ESL745 Environmental Audit & Impact Assessment 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

Electrochemical – Electrolysis – Photo electro chemical. Biological – Photo

Biological - Anaerobic - Digestion – Fermentative Micro-organisms

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

ESL750 Economics & Planning of Energy System 3 credits (3-0-0)

ESL755 Solar Photovoltaic Devices and Systems 3 Credits (3-0-0)
Pre-requisites: Direct Energy Conversion/ Solar Energy Utilization Electronics: Semiconductor device physics
Photovoltaic materials, Materials in bulk and thin film forms, The role of microstructure (single crystal, multicrystalline, polycrystalline, amorphous and nanocrystalline) in electrical and optical properties of the materials, Need for different cell design, 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. Concentrating Solar Power generation using photoelectron chemical systems

ESL756 Energy Policy & Planning 3 credits (3-0-0)

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.

ESL764 Environmental Economics 3 credits (3-0-0)

ESL766 Environmental Regulation 3 credits (3-0-0)
Environmental legislation and strategies to control pollution, Standards and setting criteria, Role of national and international agencies in dealing with environmental aspects, Standards developed by ministry of environment and forest, Sampling and analysis techniques, Data interpretations and relationships for the design of treatment facilities, Regulations for pollution controls of water, air industrial, automobile, Noise and hazardous waste environmental audit, Public liability insurance, Environmental management systems, Catalytic converts in vehicles in metropolitans, EURO standards, Bharat standards.

ESL768 Wind and Small Hydro Energy 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)

ESL771 Instrumentation & Control in Energy Systems 3 credits (3-0-0)
Basic measurement concepts, Measurement errors, Transducer classification, Static and dynamic characteristics of transducers, Instruments for measuring temperature, pressure, velocity and flow, heat flux, liquid level and concentration in energy systems, characterization of combustors, Fiue gas analysers, Exhaust gas analysers, Solar energy measurement requirements and instruments, Meteorological data measurements, Energy auditing instruments, Energy audit kit, humidity measurement, characterization of electrical power systems, Instruments for monitoring electrical parameters, Analysis of power system measurements. Analog signal conditioning, A/D and D/ A converters, Digital data processing and display, Computer data processing and control, Feed back control system, Stability and transient analysis of control systems, Application of PID controllers, General purpose control devices and controller design, Air pollution sampling and measurement of particulates, SOx, NOx, CO, O3, hydrocarbons.

ESL774 Quantitative Methods for Energy Management and Planning 3 credits (3-0-0)
A review of probability concepts, Forecasting and decision making in view of multi-variant techniques, Linear programming, Graphical solution, Simpex method, Duality and post-optimality analysis, Integer programming, Optimal technology mix in micro and macro level energy planning exercises, Sequencing, Quening theory, Networks, PERT and CPM, Decision theory, Markov analysis, Non linear programming,
Energy Studies

Decision making with uncertainty decision making with multiple objectives, Deterministic and probabilistic dynamic programming, Regression analysis.

**ESL776 Industrial Energy and Environment Analysis**
3 credits (3-0-0)

**ESL777 Environmental Science and Engineering**
3 credits (3-0-0)
Environmental Pollution Sources and their impact on environment, Air, Pollution, The green house effect, Radiative forcing, due to green house gases, aerosols and land use changes, Global warming potential, the Carbon Cycle, Changes in Atmospheric Ozone, International Treaties, Kyoto protocol, Montrelo protocol, Particulate Control Equipment (ESP), Performance Analysis, Risk assessment Analysis, Ozone depletion in the strato sphere and troposphere.

**ESL778 Industrial Waste Management and Recycling**
3 credits (3-0-0)

**ESL784 Cogeneration and Energy Efficiency**
3 credits (3-0-0)
The concept of cogeneration, main design parameters for cogeneration, cogeneration alternatives, Bottoming and topping cycles, Steam turbine plants, Gas turbine plant, 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)

**ESL788 Industrial and Commercial Applications of Renewable Energy Sources**
3 credits (3-0-0)
Commercial and industrial energy demand; Qualitative and quantitative features and characteristics, Renewables & electricity for a growing economy, Water heating, process heating and drying applications, Solar, Biomass and geothermal energy based systems, Combined space and building service hot water systems, Electricity generation from renewable to meet commercial and industrial power requirement, Stand alone and grid connected systems, Ethanol and methanol from cellulosic biomass, Use of renewable in commercial and industrial buildings for load leveling, lighting and space heating and cooling, Economics of renewable energy based commercial and industrial installations case studies, Thermal low and medium energy requirements of different industries.

**ESN791 Applied Mathematics and Computational Methods**
0 credit (1-0-0)
Fourier and laplace transform, Complex and vector analysis, Matrices, Numerical and computational methods, Finite difference, Numerical methods of integration, Least square curve fitting, Introduction to C++ and METLAB.

**ESL792 Advanced Energy Systems**
3 credits (3-0-0)

**ESN794 Principles of Chemical Processes and Combustion**
0 credit (1-0-0)
Process development and chemical manufacture in industries, Major unit operations and unit processes in chemical industries, Petrochemical industries, Food, Paint, Fertilizer, Drugs, Paper and pulp industries, Coal based chemicals and combustion.

**ESL795 Project Evaluation and Management**
3 credits (3-0-0)
Life cycle approach and analysis, conception, definition, planning, feasibility and analysis, Environmental impact analysis, Project planning matrix, Aim oriented Project planning, Network analysis for project management-PERT, CPM and CERT, Fuzzy logic analysis, Stochastic based formulations, Project design, Evaluation and management techniques, Funds planning, Project material management, Evaluation & analysis, Implementation & monitoring, Performance indices, Case studies; Supply chain management, Customer relation management.

**ESL796 Operation and Control of Electrical Energy Systems**
3 credits (3-0-0)
Introduction, Power plant operation and control, Heretical operation of the grid system, Power system, operation aspects: classification, Time decomposition, Network level decomposition, Mode decomposition, User oriented decomposition, Analysis decomposition, Control flow decomposition, Energy management: energy control centre functions, Power system control centre: hardware and software structure, Dispatcher’s activities, Power system and dispatch raining simulator, Energy management systems, Expert systems, Optimal operation of electrical power systems: modelling of fuel costs, equal incremental cost loading, transmission line losses, optimal operation of hydro thermal and all thermal systems. Energy conservation, Demand reduction options: industrial, illumination and electric traction, Cogeneration, Computer based flexible load balancing systems, Economic analysis tariffs, Power quality-voltage fluctuations and harmonics: Voltage fluctuations, Equipment design to withstand voltage fluctuations harmonics, Effect of harmonic currents and voltage, Harmonic standards, UPS selection, Installation operation and maintenance, Voltage and reactive power calculations and control: Voltage classes and nomenclature, voltage drop calculations, Voltage control, VAR requirements and power factor Capacitors unit and bank rating, Protection of capacitors and switching Controls for switched capacitors and fields testing.

**ESL804 Pollution Control in Power Plants**
3 credits (3-0-0)
Coal and Nuclear based Power Plants – Fly Ash generation and environment impact, Fly ash utilization and disposal, Nuclear fuel cycle, Radioactive wastes – treatment and disposal, Pollution control methods (i) Pre-combustion controls, (ii) Combustion controls Low NOx burners, fluidized bed boilers, (iii) Post Combustion Controls, Particulate controls, Cyclone, Wet scrubbers, ESP and fabric filters, Gaseous pollutants controls flue gas desulfurization (FGD) systems, CSR reduction applications of electron beam and non thermal plasma for SOx and NOx treatments, Thermal pollution and its impact on aquatic life.

**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)
Thermal comfort, sun motion, Building orientation and design, passive heating and cooling concepts, thumb rules, heat transfer in buildings: thermal modeling of passive concepts, evaporative cooling, Energy efficient windows and day lighting, Earth air tunnel and heat exchanger, zero energy building concept and rating systems, Energy conservation building codes, Softwares for building simulation, Automation and energy management of buildings.

**ESL850 Solar Refrigeration and Airconditioning**
3 credits (3-0-0)

**ESL860 Electrical Power System 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, Torroidal 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)
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 & 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.
RDL700 Biomass Production
3 credits (3-0-0)
Introduction to biomass and biomass classification.


RDL710 Rural India and Planning for Development
3 credits (3-0-0)
Historical and Geographical Aspects: Ancient and present structure of villages characteristics of rural life, zonal and regional peculiarities, social and religious stratifications.


RDL720 Rural Industrial Planning and Management
3 credits (3-0-0)
Basic Concepts in Rural Financing: Techniques of collecting, processing and reporting information for financial decision-making, aiding rural growth, subsidised versus self-growth incentives, subsidies, investment patterns, risk and uncertainty versus welfare, structure of capital and financing of projects, funds/cash flow, role of cooperatives, banks, insurance companies and macro planning techniques, methodology of project preparation and evaluation including market studies and shadow pricing, costing and pricing policies supporting organisational structures.

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 alternate technologies. Issues of technology transfer.

RDL740 Technology for Utilization of Wastelands and Weeds
3 credits (3-0-0)

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.


ITL702 Diagnostic Maintenance and Monitoring  
4 credits (3-0-2)  
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, Oil analysis including wear debris and contaminant monitoring, Performance monitoring, Acoustic emission and other techniques, Non-destructive techniques, Application and choice of the method, Computer aided monitoring including expert systems. Practical applications of diagnostic maintenance, Condition monitoring of mechanical and electrical machines, Case studies.

ITL703 Fundamentals of Tribology  
4 credits (3-0-2)  

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 carburising, 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)  

ITL710 Design of Tribological Elements  
4 credits (3-0-2)  
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.

Design of Fluid Frictional Elements- Fluid friction concepts, Design of hydrodynamically loaded journal bearings, externally pressurized bearings, Oscillating journal bearings, Externally pressurized bearings, Design of oil groove, Design of elliptical, multilobe and titled pad bearings, Rolling elements bearings, Performance analysis of bearings, gears, seals, piston rings, machine tool slide ways, cams and follower and wire rope.

Design exercises using TK-Solver, Finite Elements analysis software.

ITL711 Reliability, Availability and Maintainability 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, Fracture 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 repairability, Case Studies.

ITL716 Computer Application in Maintenance Management  
3 credits (2-0-2)  

ITL717 Corrosion and its Control  
3 credits (3-0-0)  
Importance of corrosion control in industrial practices. Thermodynamics of corrosion.


Corrosion fatigue and Corrosive wear.

Application of Non Destructive Techniques (NDT) for corrosion evaluation and monitoring.


**ITL730 Lubricants**
3 credits (2-0-2)
Overview of friction, wear and lubrication, Primary role of lubricants in mitigation of friction and wear & heat transfer medium. Composition and properties of lubricant, Fundamentals - Mineral oil based liquid lubricants, Synthetic liquid lubricants, Solid lubricants, greases and smart lubricants, Characteristics of lubricants and greases, Rheology of lubricants, Lubricants for industrial machinery - I.C. Engines, turbines, Hydraulic control systems, Lubricants for tribological components - sliding and rolling bearings, gearing, wire ropes and chains, etc., Metal working lubricants, Maintenance and conservation of lubricating oils, Storage and Handling of lubricants, Used lubricating oil -Environment and health hazards, and Disposability and Recycling, Technical regulation for lubricants - Test specifications, and standards for maintenance management of industrial lubricants including greases and used oils, Selection of optimum lubricant for given application.

**ITL740 Risk Analysis and Safety**
3 credits (2-1-0)
Introduction, Typical Hazards, Tools for hazard identification and analysis in plants and machinery, Accident indices, Check lists, Preliminary Hazard Analysis (PHA), Failure mode and effects analysis (FMEA) and Failure mode, effects and criticality analysis (FMECA), Hazard and operability studies (HAZOP), Fire and explosion hazards, Dow's fire and explosion index, Hazard analysis-Fault tree analysis (FTA), Event tree analysis (ETA), Cause consequence analysis (CCA), Mathematical models for cause consequence analysis, Risk evaluation and acceptance criteria, Human factors in safety, safety management, Disaster management plan, Safety aspects of lubricants, Safety codes, 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 and belt conveyors, 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, Octave and FFT analysis, Impulsive noise,Instrumentation for noise measurement and analysis, Sound power, Sound intensity technique, Noise source location, Noise diagnostics, Noise monitoring of machines with examples, Cepstrum analysis, Noise control methods, Maintenance and noise reduction, Vehicle and Machinery noise, Noise standards, Case studies.

**ITL770 Design for Maintenance**
3 credits (2-0-2)
Introduction; Overview of maintenance, Systems approach for maintenance, Modular design, Assembly and disassembly consideration for maintainability design, Accessibility of critical components, Optimisation of maintenance efforts, Evaluation, comparison and optimum selection of maintenance systems, Design for condition monitoring, Design of plant and machinery for a given maintenance strategy, Design for environment friendly maintenance Standardisation and interchangeability, Life cycle costing for optimum design and selection, Maintenance Logistics (facilities and resources), Human and safety factors, Design for maintenance through internet based technology (on-site and off-site), Developing reliable maintenance system, Design for simplicity and ease of maintenance, Design complexity versus mainenance complexity for enhanced availability, Built in diagnostics for fault detection, Fail safe design, Case studies.

**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 expensive experimentation.

**JID802 Major Project-Part II**
12 credits (0-0-24)
The research topic selected in Part I shall continue in part II also.

**ITL810 Bearing Lubrication**
3 credits (2-0-2)
Pre-requisite : ITL703
Introduction-Historical background, Bearing concepts and typical applications. Viscous flow concepts-Conservation of laws and its derivations: continuity, momentum (N-S equations) and energy, Solutions of Navier-Stokes equations. Order of magnitude analysis, General Reynolds equation-2D and 3D (Cartesian and Cylindrical), Various mechanisms of pressure development in an oil film, Performance parameters.

Instrument Design and Development Centre

DIC701 Seminars
1 credit (0-0-2)
Objective: To develop self study of social cultural aspects/ implications in design.

The students will be required to present a well researched seminar on a design subject chosen in consultation with the faculty.

DIC702 Product in Usage and Beyond (Seminar)
1 credit (0-0-2)
Objective: To become aware of man-made environment and to observe, analyse and formulate trends and possibilities.

The student will be required to survey a product and present a seminar on the same highlighting its development, usage and future trends.

IDP703 Instrument Technology Laboratory I
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 characterisation 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.

Study of optical and fibre-optics components, optical coatings, simple optical systems; Measurement of refractive index of solids (glass) and liquids, measurement of focal length of lenses and optical systems, Measurement of flatness, estimation of peak errors by optical methods, measurement of angles, prisms, parallel plates, radius of curvature, Vacuum deposition of thin films, experiments with optical fibres.

The structure of experiments is designed to impart design level familiarity with various subsystems of instrumentation set up.

IDP704 Instrument Technology Laboratory II
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. Microprocessor/ Microcontroller based system design with emphasis on real world interfacing. Study of optical instruments, interferometers and laser based instruments; Experiments on optical techniques; Experiments with Fizeau Interferometer, Fitness/curvature/surface quality, Experiments with optical fibres, Measurement of vibrations using optical methods, Digital speckle pattern interferometry/Talbot interferometry/Moire interferometry, grating based linear transducers, Laser speckel method for displacement measurement. Experiments on precision measurement methods and metrology. 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 above subsystems.

IDP705 Advanced Instrument Technology Lab
4 credits (0-0-8)

DIL711 Framework of Design
4 credits (2-0-4)
Objective: To develop insight into design in space, time, and evolution of products. Products as mimics of biological and physical functions/ situations.


Creativity : Criterion of connectivity, originality, institution, openness and self actualization. Visual thinking : Analogies, metaphors, lateral thinking, brain storming, synectics imagery, role playing etc.

IDL711 Instrumentation Transducers
3 credits (3-0-0)
Transducer Fundamentals : Transducer terminology, principals, design and performance characteristics, criteria for transducer selection, smart sensor; Resistive transducer; Inductive transducers; capacitive transducers; Piezoelectric transducers; semiconductor and other sensing structures. Displacement transducers; tachometers and velocity transducers; accelerometers and gyros; strain gauges; force and torque transducers; flowmeters and level sensors; pressure transducers; sound and ultrasonic transducer. Phototubes and photodiodes; photovoltaic and photoconductive cells, photomission, photoelectromagnetic, detectors pressure actuated photoelectric detectors, design and operation of optical detectors, detector characteristics. Transducer Performance : Electrical tests, measurement unit, measurement of voltage, current, frequency, impedance, noise, loading errors, resolution and threshold tests. Calibration, dynamic tests, environmental test, life test. Application of transducers: displacement, velocity, acceleration, force, stress, strain, pressure and temperature measurement. angular and linear encoders, Radar, laser and sonar distance measurement, Tachometers, Viscometer and densitometers.

IDL712 Electronic Techniques for Signal Conditioning and Interfacing
3 credits (3-0-0)
Analog and digital representation of data; comparisons and relative merits; multiplexing and demultiplexing of analog and digital data, ADC/ DAC: Microcontroller and DSP applications. Analog signal conditioning, Ultra-precision conditioning, Gain; attenuation; input and output impedances; single ended and differential signals; CMRR; system-module interfacing consideration; measurement and characterisation of electronic system modules. 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. Optoelectronic interfacing techniques. Application of CPUs in signal and data handling; response linearisation and drift compensation; data logger, computer aided measurement and control.

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.

IDL713 Advanced Electronic Components and Circuits
3 credits (3-0-0)
IDL714 Instrument Design and Simulations
3 credits (3-0-0)

IDL716 Quality Control & Standardisation
3 credits (3-0-0)

IDL720N Independent Study
3 credits (0-3-0)

DIP721 Exploratory Product Design Methods
3 credits (1-0-4)

IDL721 Materials and Mechanical Design
4 credits (3-0-2)

IDL722 Precision Measurement Systems
3 credits (3-0-0)
Measurements and errors; internal and external estimates of errors; least square method and its applications, to deviation from true line, plane and circle. Surface roughness and length measurements, study of some precision measuring systems, such as, profile projector, tool makers microscope, talsurf, talyond, floating micrometer, optical and mechanical comparator, interferometers, etc. Fundamentals of precision engineering; basic design principles for precision systems; basic fabrication principles for precision systems.

IDL724 Advanced Fabrication and Finishing
3 credits (3-0-0)

IDL730 Photochemical Machining
3 credits (2-0-2)

IDL731 Optical Components and Basic Instruments
3 credits (3-0-0)
Generation of light: Thermal, non-thermal and semiconductor light sources. Measurement of light; photometry, colorimetry 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, phase conjugated, dielectric multilayer and digital micro mirrors, AR-coatings, total internal reflection. Refracting components; Converging, diverging and combination of lenses, Design analysis and image formation by lenses, and micro-lenses, Eyepieces: Huygens, Ramsden, and special eyepieces; Prisms; Diffracting components; diffraction by single/multiple/ openings, types of gratings and fabrication techniques, gratings produced by acousto-optics, and electro-optics, and diffractive optical elements. Polarizing components; Polarization by reflection, and double refraction, birefringence crystals, and polarization based liquid-crystal optical displays. Wavefront aberrations: Monochromatic (Seidel), and chromatic aberrations, optical and modulation transfer function. Optical instruments: Microscopes; simple, compound phase contrast and confocal microscopes. Telescopes; Refracting, reflecting, interferometric telescopes. Interferometers; two- beam, multiple-beam, and shearing interferometers, Spectrum measuring instruments; Spectrometers/ monochromators, Spectrophotometers, and Spectro-radiometers, and Fourier transform spectrometers (FTIR-spectrometers). Detectors: Photodetectors, photo-multiplier tubes, multi-channel plates, image intensifiers, CCD and CMOS detectors, IR-detectors.

IDL732 Optical Materials and Techniques
IDL734 Laser Based Instrumentation
3 credits (3-0-0)
Basics of lasers; The photon and its properties, radiation and matter interaction; Generation and properties of laser light; laser systems and instrumentation (gas, liquid, solid state, semiconductor, and Ion laser systems); laser beam optics; The Gaussian, Hermite-Gaussian, Laguerre-Gaussian and Bessel beams and their properties; Holographic techniques; Basic holographic principle, Types of Holograms, Recording media, and applications of holography. Laser Applications; Holographic Interferometry; Double exposure, Real time H.I., Laser speckle techniques; speckle photography/interferometry, and digital speckle pattern interferometry and applications of laser speckles. Lengths, displacement and shape measurement; laser-heterodyne, two-wavelength or multiplewavelength and phase-shifting interferometry, Velocity measurement; Laser Doppler and particle image velocimetry, Laser remote sensing: Different types of LIDARs (Light Detection And Ranging), and Applications; Laser alignment, gaging inspection and Laser machine vision, Industrial laser systems and instrumentation, beam delivery systems; and applications laser material processing, Laser Applications to Chemical and Environmental Analysis; Laser-induced fluorescence, Temperature measurement techniques; Laser based point-by-point, full field, holographic interferometry, and laser speckle techniques. Laser Tweezers: Single-dual-and multiple-beam tweezers, and applications.

IDL735 Scientific and Engineering Applications of Moire Patterns
3 credits (2-0-2)
Prerequisites: EPL115/ EPL443/ PHL558/ EC90
General introduction, theory of Moire fringes, pure rotation, pure elongation, vernier mechanism of fringes. Linear and angular displacement transducers. Use of Moire technique in strain analysis, vibrations, deflections, reflectometry, surface roughness. Experimental techniques and fringe photography. Technology to generate moire grids for various applications. High resolution moire, photography and its application for deformation studies in small, medium and large size structures and in thermal strains.

IDL736 Optical 3d-Surface Profilometry and Tomography
3 credits (3-0-0)
Prerequisites: EPL105 or PHL558 and EC90
Introduction to optical micro/nano-metrology for industrial and biological applications. Basics of optical interferometry, grating and fringe projection profilometry. Digital interferogram analysis techniques: Phase-shifting and Fourier-transform fringe analysis techniques, their principles and algorithms.


Optical coherence tomography: technology imaging concepts, instruments and applications. Time, polarization, Doppler, frequency, and spectral-domain OCT and applications.


IDL737 Infromation Display Devices and Technologies
3 credits (3-0-0)
Prerequisites: EC 90 and EPL105

Transmissive, reflective, active and passive matrix, thin-film transistor (TFT), transflective, and back lighting technologies for LCDs.

Electronic-ink, electronic paper, and flexible display technologies and applications.

Display electronics and digital light processing technologies. Three-dimensional (3-D) imaging and display technologies; Microdisplays, STEREOSCOPIC 3D displays. HOLOGRAPHIC 3-D displays. Laser based 3D-TV.

DIP741 Product Form and Aesthetics
3 credits (1-0-4)
Objective: To develop awareness of form, its experiencing and creation. Spatial analysis, spatial organization, depth illusion. Spatial composition in 2D & 3D space. 2D form transitions and radi manipulation. Exercises in graphic composition and layout. Grids in page layouts and compositions. 3D form analysis, linear form, planar form, solid form, linear planar form, linear solid form, planar solid form, linear planar solid form. Boolean algebra of forms. Form in nature, form expressing function/material/production process. hands as tool, hands as form maker with or without constraints, three dimensional concept formation. Non-orientable forms, form and colour to accentuate and ameliorate perception and understanding of that form. Product styling and relationship to cultural personalities. Attitudes and attributes of the visual designer.

IDL741 Instrument Organisation and Ergonomics
3 credits (2-0-2)

DIP742 Studies in Product Configuration and Detailing
3.5 credits (1-0-5)

Transmission, reflective, active and passive matrix, thin-film transistor (TFT), transflective, and back lighting technologies for LCDs.

Display electronics and digital light processing technologies. Three-dimensional (3-D) imaging and display technologies; Microdisplays, STEREOSCOPIC 3D displays. HOLOGRAPHIC 3-D displays. Laser based 3D-TV.
in sheet metal, steel tubes and channel sections, aluminium sheets and extruded sections of different materials. Detailing for die casting and die design. Detailing for fabrication involving combination of materials like fabric, foam leather, cloth, rubber, plastic, metal, wood, adhesives, rivets, welding, brazing and mechanical fasteners. Selection of control panel elements, graphics and typography, colour schemes, safety and maintainability, operating manuals. Study of well detailed products, product design task Visual creativity and communication. Product design task, selecting a product with wide configuration options and alternative options. Preparation and presentation of models, sketches and renderings. Evaluation and presentation of options.

IDP742 Industrial Design Practice
3 credits (1-0-4)

DIP751 Communication and Presentation Skills
4 credits (1-0-6)
Objective : To develop communication/expression skills in visual presentation and provide opportunity for bridge studies. Developing sketching skills through studio exercises for coordinating eye, hand, body movements and developing necessary line control. Exercises to sharpen visual perception of line, form, colour, proportion, size, shape, mass and texture. Figure/ground factors, evaluating composition, positive negative character, proximity, similarity, closure, visual perception. Colour theory, subactive mixture, additive mixture, value and intensity. Exercises to produce rendering of products in different media. Photography as a means of visual recording and presenting of information. Isometric, Axonometric, perspective and exploded views and general assembly drawing as per BIS standards. Exercises to represent products. Learning photoshop: Exercises to produce product drawings. Preparing text and image files, preparing style-sheets, tags, fonts, windows and orphans, hyphenation, spacing and breaks, margins and columns, headers, footers, graphics, frames. Understanding these with reference to popular desk-top publishing packages. Exercises to produce a brochure as part of the studio exercises.

DIP752 Computer Aided Product Design
3 credits (1-0-4)
Objective : To learn the use of computers as a tool in product design. Introduction to computer aided industrial design. The technique of concurrent engineering. Using databases for material selection. Structure of CAD programmes and hardware. Relation of object space and screen space, 2D & 3D databases. Introduction to solid modelling. Detailed study of solid modelling software, studio exercises in solid modelling applications. Animation techniques and product animation. Product design tasks, communication of designs using CAD.

DIP762 Prototype and Die Development
2.5 credits (1-0-3)

DIP781 Engineering Function Material and Processes
3 credits (1-0-4)

DIL782 Advanced Materials, Processes and Finishes
3.5 credits (2-0-3)

DIP791 Product Interface Design (Project 1)
4 credits (1-0-6)

DID792 Project II
5.5 credits (0-0-11)
Objective : To experience product design through self expression and the experience with others. The industry will be invited to present a product for design consideration to the class. The product will be an appliance, instrument, equipment, where user interaction is of significant importance. The student will be required to prepare his own design reflecting his analysis of the problem and creativity in synthesizing. The solution will be presented in the form of sketch book and presentation of the model and renderings.

DIS802 Invited Faculty Seminars
1 credit (1-0-0)
Objective : To expose high level design research carried out by professionals and to reinforce inputs of earlier semesters.

DIP811 Product Systems Services and Environment
3 credits (1-0-4)
Objective: To relate/realize designing in a corporate indentity framework and understand design at the level of systems services.

**IDL811 Selected Topics in Instrumentation**  
3 credits (3-0-0)  
(No prescribed course contents)

**IDC812 Term and Seminar**  
3 credits (3-0-0)

**DIR812 Placement/Degree Show**  
2 credits (0-0-4)  
The student is required to plan & design various product elements needed for their own placement in the industry and preparation of exhibition/literative needed for exhibitions of their work.

**DIS812 Placement/Degree Show**  
2 credits (0-0-4)  
Objective : To work towards interaction with the industry/clients. The students will be required to visit industry, take up assignments from the industry and execute them to their highest professional capabilities. They would also be required to participate in a degree show and present their work to the public.

**DIR813 Designing for Sustainable Development**  
2.5 credits (1-0-3)  
The student will be required to understand what goes into designing products, systems and services for long term sustainable development.

**DIR821 Design Management and Professional Practice**  
2.5 credits (1-0-3)  

**DIR833 Designing for Export**  
2.5 credits (1-0-3)  
To study merchandise and product standards for specific foreign countries and to design appropriate product literature, packaging and product style.

**DIP841 Advanced Form Studies**  
3.5 credits (1-0-5)  
Objective : To develop insight into form, design and develop sophistication in its application to cultural products. Detailed study of the structural, perceptual and spatial properties of well ordered three-dimensional orientable and non-orientable forms, their composition and the process of designing them. Exercise in transport design and other consumer/industrial products.

**DIR843 Exhibitions and Environmental Design**  
2.5 credits (1-0-3)  
The student is required to study requirements and trends in Exhibition and environmental Design and propose design for public usage that is efficient for communication/pleasure.

**DIR853 Computer Aided Industrial Design**  
2.5 credits (1-0-3)  
Objective : To develop proficiency of use of computers for industrial design.

**DIR855 Creative Marketing Communication**  
2.5 credits (1-0-3)  
The student is required to study and practice a CAD modeling package and using advanced surface modeling and rendering features, model product to industrial design standards.

**DIR857 Animation**  
2.5 credits (1-0-3)  
The student is required to study the process of animation as is applied in visual communication. He/she is expected to conceptualize a storyboard and develop an animation experience.

**DIR859 Media Studies**  
2.5 credits (1-0-3)  
The student is required to study the potential and limits of a given material or process and develop design that exploits/extends the potential/limits of the material or process.

**DID891 Project III**  
8.5 credits (0-0-17)  
Objective : To create a carefully detailed product. This project will involve design and development of product chosen from a specific category common to the whole class. Emphasis will be on integration of user/environment aspects, safety and ergonomics, creativity, computer aided design and product detailing/presentation.

**DID892 Major Project**  
19 credits (0-1-36)  
Objective : To function as best as one can as an Industrial designer. This is the final project and should reflect student's competence in in- depth analysis/synthesis product detailing and prototype development, use of the resources of man, money, information, material, processes. He is expected to produce designs that are elegant in conceptualization and implementation. The project will have a plurality of guides and will also have the involvement of the user/manufacturing sector. The student is expected to submit a dissertation together with models/ drawings that brings out his grasp of the theoretical understanding of the design process and innovativeness in design.
Centre for Polymer Science and Engineering

PTL701 Polymer Chemistry
3 credits (3-0-0)
General characteristics of chain growth polymerisation, alkene polymerisation by free radical, ATRP anionic and cationic initiators, ring opening polymerization of ethers, acetals, lactones, lactams, copolymerisation, cyclopolymerisation, metathesis polymerisation. General characteristics of step growth polymerisation, synthesis by step polymerisation - polyesters, polycarbonates, polyamides, heterocromatic polymers, polysiloxanes, liquid crystalline polymers.

PTL702 Polymer Processing
3 credits (3-0-0)

PTL703 Polymer Physics
3 credits (3-0-0)

PTL705 Polymer Characterisation
3 credits (2-0-2)

PTL706 Polymer Testing and Properties
3 credits (3-0-0)

PTL707 Polymer Engineering and Rheology
3 credits (3-0-0)

PTL709 Polymer Technology
3 credits (3-0-0)
Polymers of commercial importance. Additives for plastics: stabilizers, fillers, plasticizers, lubricants, flame retarders, foaming agents, cross-linking agents, etc. Manufacture, properties and applications of major thermoplastic and thermosetting polymers: polyethylene, polypropylene, polyvinyl chloride, polystyrene and other styrenics, polyamides, polystyrene, phenolformaldehyde, urea and melamine - formaldehyde, unsaturated polyester, epoxy resins.

PTP710 Polymer Science Laboratory
2 credits (0-0-4)

PTL711 Engineering Plastics and Speciality Polymers
3 credits (3-0-0)
Definition. Characteristics of engineering plastics. Important engineering thermoplastics such as acrylics, ABS, polycarbonate, polylamides, polyurethanes, polyphenylene oxide, polyphenylene sulfide, PEEK and Engg. Thermosets such as USP, Epoxy, phenolics and aminoplasts.

Materials selection for engineering plastics for various application based on mechanical properties. High temperature stability, electrical properties, oxidative, UV, hydrolytic and chemical stability. Processing and application of engineering plastics. Definition and characteristics of speciality polymers. Important speciality polymers such as fluropolymer, silicone, liquid crystalline polymers, conducting polymers.

PTL712 Polymer Composites
3 credits (3-0-0)
Definition and Classification of Composites Reinforcing fibres-Natural fibres (cellulose, jute, coir etc), boron, carbon, ceramic glass, aramids, polyethylene (UHMWPE), polybenz-thiazoles etc.


PTL714 Polymer Blends and Alloys
3 credits (3-0-0)

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: colorant, flame retarders, blowing agents, deodorants, abrasive, retarders etc.

Processing and vulcanization test. Vulcanization theory and technology. Natural rubber and synthetic rubbers: styrene butadiene rubber,
polybutadiene and polyisoprene rubbers, ethylene-propylene rubber, butyl and halobutyl rubber, nitrile and silicone rubber, thermoplastics elastomers, latex and foam rubber. Acrylate and fluoro elastomers.

**PTL718 Polymer Reaction Engineering**  
3 credits (2-1-0)  
Polymerisation kinetics for both step growth as well as chain growth mechanism under ideal and real conditions. Chain growth includes free radical, anionic and cationic polymerisation. Prediction of molecular weight distribution for polymerisation conducted in batch reactors, continuous stirred tank reactors, plug flow reactors, comparison between batch and continuous system, the effect of mixing on kinetics and mwd, considerations for reactor design for commercial use.

**PTP720 Polymer Engineering Lab**  
1 credit (0-0-2)  
(a) Processing experiments: compounding of additives on two roll-mill/twin screw extruder, compression moulding, injection moulding, single screw and twin screw extrusion, thermoforming, melt flow index measurement, mixing in HAAKE rheomix, melt rheology on rheometers, mechanical proportion of polymers, mould flow demonstration.  
(b) Industry visit for demonstration of specific processing and testing operations.

**PTL720 Polymer Product and Mould Design**  
3 credits (2-0-2)  
Fundamentals of plastic moulding. Plastics product design. Type of moulds, tool making processes, equipment and methods. Materials for mould making designing and drafting practice. Design details for compression moulds, transfer moulds, blow and extrusion dies, typical exercises in mould design and production.

**PTL722 Polymer Degradation and Stabilization**  
3 credits (3-0-0)  

**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)  
Interdisciplinary M.Tech. Programmes

COURSE DETAILS

M. Tech. Programme in Computer Applications

JCD799 Minor Project
3 credits (0-0-6)

JCS800 Independent Study
3 credits (0-3-0)

JCD801 Major Project (Part-I)
6 credits (0-0-12)

JOD802 Major Project (Part-II)
12 credits (0-0-24)

M. Tech. Programme in Energy Studies

JED799 Minor Project
3 credits (0-0-6)

JES800 Independent Study
3 credits (0-3-0)

JED801 Major Project Part-1
6 credits (0-0-12)

JED802 Major Project Part-2
2 credits (0-0-24)

M. Tech. Programme in Energy & Environmental Management

JSS800 Independent Study
3 credits (0-3-0)

JSD801 Major Project (Part-I)
6 credits (0-0-12)

JSD802 Major Project (Part-II)
12 credits (0-0-24)

M. Tech. Programme in Tele Communication & Technology Management

JMD792 Minor Project
3 credits (0-0-6)

M. Tech. Programme in Industrial Tribology & Maintenance Engineering

JIS800 Independent Study
3 credits (0-3-0)

JID801 Major Project (Part-I)
6 credits (0-0-12)

JID802 Major Project (Part-II)
12 credits (0-0-24)

M. Tech. Programme in Opto-electronics and Optical Communications

JOS800 Independent Study
3 credits (0-3-0)

Detailed study on a contemporary topics in the area of Optoelectronics/Optical Communication as suggested by the course coordinator.

JOD801 Major Project (Part-I)
6 credits (0-0-12)

Studies on topics offered by the faculty in the area of Optoelectronics/Optical Communication

JCD802 Major Project (Part-II)
12 credits (0-0-24)

Detailed investigations on study of the topics offered by the faculties / supervisors. The project would generate simulations / experimentation.

JOP791 Fibre Optics and Optical Communication Lab-I
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.

JOP792 Fibre Optics and Optical Communication Lab-II
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.

M. Tech. Programme in Polymer Science & Technology

JP799 Minor Project
3 credits (0-0-6)

The student will work on a small project on any area of polymers. The topic of research may not be linked with JPD 801 or JPD 802.

JPS800 Independent Study
3 credits (0-3-0)

Objective: The student is expected to take a course from the PE category and will study the full course under the guidance of course teacher.

JPD801 Major Project (Part-I)
6 credits (0-0-12)

A student will select a topic on any area related with polymers and perform the research work for one semester (IIIrd semester).

JPD802 Major Project (Part-2)
12 credits (0-0-24)

The student will continue to work on the topic selected in the semester III, the work content will be further extended which will include additional studies, modifications/diversification of the broad research. The work will be done for the full 4th semester.
Abbreviations

B.Tech. Bachelor of Technology
BPGS&R Board of Postgraduate Studies and Research
CGPA Cumulative Grade Point Average
CRC Centre Research Committee
DGPA Degree Grade Point Average
DRC Department Research Committee
EC Earned Credits
IRD Industrial Research and Development
M.B.A. Master of Business Administration
M.Sc. Master of Science
M.S.(R) Master of Science (Research)
M.Tech. Master of Technology
PGS&R Postgraduate Studies and Research
Ph.D. Doctor of Philosophy
SGPA Semester Grade Point Average
SRC Standing Review Committee (for undergraduate programmes); also
Student Research Committee (for M.S.(R) and Ph.D. student)
UGS Undergraduate Studies
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**SLOT HOURS (General) effective from 1 semester 2011-12**


**A** TUT/B TUT/LAB

**B** TUT/LAB

**C** TUT/LAB

**D** TUT/LAB

**E** TUT/LAB

**F** TUT/LAB

**G** TUT/LAB

**H** TUT/LAB

**I** TUT/LAB

**J** TUT/LAB

**K** TUT/LAB

**L** TUT/LAB

**M** (17.00 - 18.20)

**Tu** (8.00 - 9.20) (9.30 - 10.50)
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**SLOT HOURS (1 YEAR M COURSES)**
effective from | semester 2011-12

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**SLOT HOURS (I YEAR P COURSES)** effective from 1st semester 2011-12

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Please note that the schedule includes various courses and sessions, such as CTUT, B/D TUT, HUN100, Q (PHY/CY LAB), A/TUT/LAB, N (INTRO TO PROG.), and Q (PHY/CY LAB), indicating a structured academic timetable for the mentioned semester.