Vision

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

Mission

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

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

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

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

Values

- Academic integrity and accountability
- Respect and tolerance for the view of every individual
- Attention to issues of national relevance as well as of global concern
- Breadth of understanding, including knowledge of the human sciences.
- Appreciation of intellectual excellence and creativity.
- A unfettered spirit of exploration, rationality and enterprises.
COURSES OF STUDY
2012-2013

Undergraduate programmes
Bachelor of Technology
Dual Degree
Integrated Master of Technology

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

INDIAN INSTITUTE OF TECHNOLOGY DELHI
Hauz Khas, New Delhi 110 016, India.
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<td>Department of Chemical Engineering</td>
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<td>Department of Chemistry</td>
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<td>Department of Humanities and Social Sciences</td>
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<td>Department of Management Studies</td>
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<td>Department of Mathematics</td>
<td>211</td>
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<td>Department of Mechanical Engineering</td>
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<td>Department of Physics</td>
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</table>
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</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>
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 programmes offered by IIT Delhi are presently classified as undergraduate and postgraduate programmes. This classification is based primarily on entry/admission qualification of students rather than the level of degree offered. For all undergraduate programmes, students are admitted after 10+2 schooling while for all postgraduate programmes, students are admitted after they have obtained at least a college level Bachelor’s degree. As this course of study would indicate, there is considerable overlap in courses for senior undergraduate students and junior postgraduate students. The various programmes and their specialization are listed below.

1.3.1 Undergraduate programmes

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

<table>
<thead>
<tr>
<th>Department</th>
<th>Specialization</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Engg.</td>
<td>B.Tech. in Chemical Engineering</td>
<td>CH1</td>
</tr>
<tr>
<td>Computer Sc. and Engg.</td>
<td>B.Tech. in Computer Science and Engineering</td>
<td>CS1</td>
</tr>
<tr>
<td>Civil Engg.</td>
<td>B.Tech. in Civil Engineering</td>
<td>CE1</td>
</tr>
<tr>
<td>Electrical Engg.</td>
<td>B.Tech. in Electrical Engineering</td>
<td>EE1</td>
</tr>
<tr>
<td></td>
<td>B.Tech. in Electrical Engineering (Power)</td>
<td>EE2</td>
</tr>
<tr>
<td>Mechanical Engg.</td>
<td>B.Tech. in Mechanical Engineering</td>
<td>ME1</td>
</tr>
<tr>
<td></td>
<td>B.Tech. in Production and Industrial Engineering</td>
<td>ME2</td>
</tr>
<tr>
<td>Physics</td>
<td>B.Tech. in Engineering Physics</td>
<td>PH1</td>
</tr>
<tr>
<td>Textile Technology</td>
<td>B.Tech. in Textile Engineering</td>
<td>TT1</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Department</th>
<th>Specialization</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biochemical Engg. and Biotechnology</td>
<td>B.Tech. in Biochemical Engineering and Biotechnology, and M. Tech. in</td>
<td>BE5</td>
</tr>
<tr>
<td></td>
<td>Biochemical Engineering and Biotechnology</td>
<td></td>
</tr>
<tr>
<td>Chemical Engg.</td>
<td>B.Tech. in Chemical Engineering, and M. Tech. in Chemical Engineering</td>
<td>CH7</td>
</tr>
<tr>
<td>Computer Sc. and Engg.</td>
<td>B.Tech. in Computer Science and Engineering, and M. Tech. in Computer Science and Engineering</td>
<td>CS5</td>
</tr>
<tr>
<td>Electrical Engg.</td>
<td>B.Tech. in Electrical Engineering, and M. Tech. in Information and Communication Technology</td>
<td>EE5</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>
C. Integrated Master of Technology: (Integrated M.Tech.)

<table>
<thead>
<tr>
<th>Department</th>
<th>Specialization</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics</td>
<td>M. Tech. in Mathematics and Computing</td>
<td>MT5</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MT</td>
</tr>
</tbody>
</table>

1.3.2 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>
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</table>

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

<table>
<thead>
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<th>Specialization</th>
<th>Code</th>
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<tbody>
<tr>
<td>Interdisciplinary</td>
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</tr>
<tr>
<td>Master of Design in Industrial Design</td>
<td>JDS</td>
</tr>
</tbody>
</table>

E. 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>CEGU</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>
</tbody>
</table>
### Courses of Study 2011-2012

#### Computer Science & Engg.
- M.Tech. in Computer Science and Engineering  
  - **MCS**

#### Electrical Engg.
- M.Tech. in Communications Engineering  
  - **EEE**
- M.Tech. in Computer Technology  
  - **EET**
- M.Tech. in Control and Automation  
  - **EEA**
- M.Tech. in Integrated Electronics and Circuits  
  - **EEN**
- M.Tech. in Power Electronics, Electrical Machines and Drives  
  - **EEP**
- M.Tech. in Power Systems  
  - **EES**

#### Mechanical Engg.
- M.Tech. in Design of Mechanical Equipment  
  - **MED**
- M.Tech. in Industrial Engineering  
  - **MEE**
- M.Tech. in Production Engineering  
  - **MEP**
- M.Tech. in Thermal Engineering  
  - **MET**

#### Physics
- M.Tech. in Applied Optics  
  - **PHA**
- M.Tech. in Solid State Materials  
  - **PHM**

#### Textile Technology
- M.Tech. in Fibre Science & Technology  
  - **TTF**
- M.Tech. in Textile Engineering  
  - **TTE**

#### Applied Research in Electronics
- M.Tech. in Radio Frequency Design and Technology  
  - **CRF**

#### Atmospheric Sciences
- M.Tech. in Atmospheric-Oceanic Science and Technology  
  - **AST**

#### Interdisciplinary Programme
- M.Tech. in Computer Applications  
  - **JCA**
- M.Tech. in Energy Studies  
  - **JES**
- M.Tech. in Energy and Environmental Management  
  - **JEN**
- M.Tech. in Industrial Tribology and Maintenance Engineering  
  - **JIT**
- M.Tech. in Instrument Technology  
  - **JID**
- M.Tech. in Optoelectronics and Optical Communication  
  - **JOP**
- M.Tech. in Polymer Science and Technology  
  - **JPT**
- M.Tech. in Telecommunication Technology Management  
  - **JTM**
- M.Tech. in VLSI Design Tools and Technology (*)  
  - **JVL**

**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>EEE</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
11 10 9 8 7 6 5 4 3 2 1
```

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 3 2 4

- **E**: Code of the Academic Unit offering the course. See Section 1 for all codes.
- **L**: Nature of the course. See details below.
- **3**: Level of the course as determined by pre-requisite or number of earned credits. See details below.
- **2**: Unique identification code for the course.

(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:

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>L</td>
<td>Lecture courses (other than lecture hours, these courses can have Tutorial and Practical hours, e.g. L-T-P structures 3-0-0, 3-1-2-, 3-0-2, 2-0-0, etc.)</td>
</tr>
<tr>
<td>P</td>
<td>Laboratory based courses (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>T</td>
<td>Training</td>
</tr>
<tr>
<td>C</td>
<td>Colloquium</td>
</tr>
<tr>
<td>R</td>
<td>Professional Practice</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>

(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,

- **100 – 400 level courses**: Core and elective courses for UG programmes. These courses are not open to any PG student.
- **500 level courses**: Courses for M.Sc. programmes. These courses are not open to other PG students.
600 level courses: Preparatory/introductory courses for M.Tech. programmes. These courses are normally not open to UG students.

700 - 800 level courses: Core and elective courses for M.Tech., M.Des., M.B.A., M.S.(Research) and Ph.D. programmes. Usually 800 level courses are advanced courses for PG students.

(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 EEL101 Fundamentals of Electrical Engineering; 4 credits (3-0-2)
The credits indicated for this course are computed as follows:

\[
\begin{align*}
3 \text{ hours/week lectures} & = 3 \text{ credits} \\
0 \text{ hours/week tutorial} & = 0 \text{ credit} \\
2 \text{ hours/week practical} & = 2 \times 0.5 = 1 \text{ credit}
\end{align*}
\]
Total $= 3 + 0 + 1 = 4 \text{ credits}$

Also, (3-0-2) 4 credit course $= (3 \text{ h Lectures} + 0 \text{ h Tutorial} + 2 \text{ h Practical})$ per week
$= 5 \text{ contact hours per week}$

For each lecture or tutorial credit, the self study component is 1 hour/week (for 100-600 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:

**CHL204 Transport Processes - II**
4 credits (3-1-0)
**Pre-requisites:** CHL110
**Overlaps with:** CHL251
Empirical correlations based on analogy between momentum, heat and mass transfer; mass balance in co-current and counter-current continuous contact equipment; operating line concept; ideal stage and stage efficiency; design on continuous contact equipment; HTU and NTU concept; batch and continuous distillation; absorption; adsorption: applications to chromatography; extraction and leaching operations; equipments and equilibrium diagrams; design procedures and calculations; humidification operations; design of cooling towers; drying of solids; design of batch and continuous dryers.

2.6 Pre-requisites
Each course, other than 100 level courses, has specified pre-requisites which may be another course or a fixed number of earned credits or both. A student who has not obtained a pass grade, viz., A, A(-), B, B(-), C, C(-), D, NP or S, in the pre-requisite or has not earned requisite number of credits will not be eligible to do that course. Examples:
AML310 Computational Mechanics
Pre-requisite: AML140/AML150/AML160/AML170/AML180/CHL231/CHL204 and E.C. 60

A student who has obtained a pass grade in any one of the courses AML140, AML150, AML160, AML170, AML180, CHL231, or CHL204, and has earned 60 credits will be eligible to register for this course.

BEL702 Bioprocess Plant Design
Pre-requisite: AML110 & MEL110 & CHL205 & CHL204 & BEL401 and E.C. 90.

A student who has obtained a pass grade in all these courses AML110, MEL110, CHL205, CHL204, and BEL401, and has earned 90 credits will be eligible to register for this course.

Pre-requisite earned credits for some courses of special nature are given below; the complete requirements are given in section 4.9:

- Independent Study 80
- Mini Project 80
- Minor Project (Dual Degree) 120
- B.Tech. Major Project Part 1 120
- Practical Training 90

Postgraduate students are deemed to have satisfied those pre-requisites that are of 100-400 level. They should use the pre-requisites information to evaluate their preparedness for registering in a course.

If no pre-requisite is specified for 700 and 800 level courses, a UG student needs to earn 90 and 120 credits to register for 700 and 800 level courses, respectively.

2.7 Overlapping/Equivalent courses

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

EEL301 Control Engineering - I
Overlapped course: MEL312, CHL261

A student who has earned a pass grade in EEL301 will not be eligible to register for and earn credits, under any category, for either MEL312 or CHL261. Further, registration in an overlapping course as an alternative to a core course of his/her programme is not allowed.

2.8 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.

2.9 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.
2.9.1 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>

2.9.2 Description of grades

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

Wgrade
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  

2.10 Evaluation of performance  

The performance of a student will be evaluated in terms of three indices, viz. the Semester Grade Point Average (SGPA) which is the Grade Point Average for a semester, Cumulative Grade Point Average (CGPA) which is the Grade Point Average for all the completed semesters at any point in time and Degree Grade Point Average (DGPA).

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 = \( \sum (\text{Course credits} \times \text{Grade point}) \) 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.

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

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.

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

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>(column 1)</td>
<td>(column 2)</td>
<td>(column 3)</td>
<td>(column 4)</td>
<td>(column 5)</td>
<td>(column 6)</td>
</tr>
<tr>
<td>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>PHPXXX</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
Courses of Study 2011-2012

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

CGPA = \[\frac{\text{Cumulative points secured in all passed courses (A-D grade)}}{\text{Cumulative earned credits, excluding audit and S/Z grade courses}}\] = \[\frac{106}{15} = 7.067\]

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

Table 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 \( (\text{total of column 2}) \) = 24
Credits registered in the semester excluding audit and S/Z grade courses = 23
Earned credits in the semester \( (\text{total of column 4}) \) = 20
Earned credits in the semester excluding audit & S/Z grade courses = 19
Points secured in this semester \( (\text{total of column 6}) \) = 154
Points secured in this semester in all passed courses \( (\text{total of column 6} \text{ & A-D grade}) \) = 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

\[
\begin{align*}
\text{SGPA} &= \frac{\text{Points secured in the semester}}{\text{Credits registered in the semester, excluding audit and S/Z grade courses}} \quad = \frac{154}{19} = 8.105 \\
\text{CGPA} &= \frac{\text{Cumulative points secured in all passed courses (A-D grade)}}{\text{Cumulative earned credits, excluding audit and S/Z grade courses}} \quad = \frac{106 + 154}{15 + 19} = 7.647
\end{align*}
\]

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 (Academics). In case of illness or absence during registration, the student should intimate the same to his/her course adviser and Dean (Academics). 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

An undergraduate course (100, 200, 300, 400 level course) will run if minimum of 12 students register for the course. Under special circumstances, a departmental elective course may be allowed to run with minimum registration of 8 students, with prior permission of Chairman, Senate. A 700 or 800 level course can run with 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 by the UG/PG section. 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 (Academics) for late registration. Dean (Academics) will consider and may approve late registration in genuine cases on payment of an extra fee called late registration fee. Late registration is permitted until 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.
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 (for both UG and PG students) 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 (Academics) as the case may be. All such applications must be processed before the beginning of the semester in which the leave will be taken. At present, JEE-entry B.Tech., dual degree and integrated M.Tech. students are allowed one extra semester for completion of the programme for every semester leave for industrial internship. Such students are permitted maximum of two semesters of leave. 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 similar to the provision of JEE entry students.

(d) When a student (UG or PG) 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 (Academics), 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 Ist 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. UNDERGRADUATE DEGREE REQUIREMENTS, REGULATIONS AND PROCEDURES

4.1 Overall requirements

4.1.1 B.Tech.
The total credit requirement for the B.Tech. (4-year programme) is 180 credits. For B.Tech. programmes and undergraduate part of the dual degree programmes, the total credits are distributed over two categories: undergraduate core (UC) and undergraduate elective (UE).

The Undergraduate core (UC) has following categories:

(i) Basic Sciences (BS) which include Mathematics, Physics and Chemistry courses.
(ii) Engineering Arts and Sciences (EAS) which include fundamental engineering courses.
(iii) Departmental Core (DC) which include courses of relevant discipline.

Undergraduate electives (UE) courses belong to basically three categories:

(i) Departmental Electives (DE): Electives related to the parent discipline.
(ii) Humanities and Social Sciences, and Management (HM): Electives to provide a wide exposure to different areas of Humanities, Social Sciences and Management.
(iii) Open Category (OC): Electives to provide an opportunity to the student to develop broad inter-disciplinary knowledge base or to specialize significantly in an area outside the parent discipline.

4.1.2 Dual degree programmes
The total credit requirement for the Dual Degree and Integrated M.Tech. programmes is 216-218 credits. In case of Dual degree programmes, credits of the M.Tech. part are divided into two categories:

(i) Programme Core (PC): Core courses related to the M.Tech. specialization.
(ii) Programme Electives (PE): Elective courses related to the M.Tech. specialization.

The B.Tech. credit requirements are same as those in 4.1.1 for the B.Tech. (4-year programme) but with major project parts 1 and 2 excluded.

4.1.3 Integrated M.Tech.
Total credit for the integrated M.Tech. programme is divided into two categories:

(i) Integrated Core (IC)
(ii) Integrated Electives (IE)

Integrated Core and Integrated Electives have components similar to those of the undergraduate core and undergraduate electives, respectively.

4.2 Degree requirements breakup
The degree requirements for the various programmes listed earlier are detailed below.

4.2.1 Earned credits

(a) Completion of 180 earned credits for 4-year B. Tech. Programmes.
(b) Completion of 216 earned credits for Integrated M.Tech. programme in Mathematics and Computing.
(c) For the Dual-Degree programmes, completion of 168-170 earned credits for the B. Tech. degree and 48-50 earned credits for the M. Tech. degree.

These credits are needed to be earned under different categories as specified in Section 4 for individual programmes.

4.2.2 Degree Grade Point Average (DGPA) requirement
A student must obtain a minimum DGPA of 5 to be eligible for award of the B.Tech. degree and 5.5 for the Integrated M.Tech. degree. The minimum DGPA requirement for M.Tech. part of dual degree programme is 6.0.

All exceptions to the above conditions will be dealt with as per following regulations:

(a) If a student completes required credits for B.Tech./Integrated M.Tech. with DGPA less than 5/5.5, respectively then the student will be permitted to do additional elective courses under appropriate category to improve the DGPA within the
maximum time limit for completion of B.Tech./ M.Tech. degree respectively, as the case may be. In case a DGPA of 5/ 5.5 or more is achieved within the stipulated period, a B.Tech./Integrated M.Tech. degree will be awarded and in case the same is not achieved no degree will be awarded.

(b) If a student completes requisite credits for Dual Degree Programme:
   (i) with B. Tech. DGPA less than 5 but M.Tech. DGPA more than 6.0
   The student will be permitted to do additional elective courses (under any appropriate category) to improve the DGPA for completion of B. Tech. part within the maximum time limit. In case a DGPA of 5 or more is achieved for B.Tech., the student will be eligible for award of the Dual Degrees (B.Tech. & M. Tech.) and in case the same is not achieved no degree will be awarded.

(ii) with B. Tech. DGPA more than 5 but M. Tech. DGPA less than 6.0
   The student will be eligible for grant of only B.Tech. degree provided a written request is made to the Dean (Academics). Alternatively, the student may opt to do additional elective courses (PE category only) to improve the DGPA within the maximum time limit. If no programme elective (PE) courses are available, other relevant 700 and 800 level courses as certified by the department can be done for the purpose of improving the DGPA. In case DGPA of 6.0 or more is achieved for the M. Tech. part, the student will be eligible for award of the dual degrees (B. Tech. & M. Tech.). However, in case the same is not achieved at the end of stipulated period, the student will be eligible for the award of only B.Tech. degree, provided a written request for the same is made to the Dean (Academics).

(iii) with B. Tech. DGPA less than 5 and M. Tech. DGPA less than 6.0
   The student will be permitted to do additional elective courses (under any category) to improve the DGPA for completion of B. Tech./M. Tech. degrees (PE category only) within the maximum time limit. (If no programme elective courses are available, relevant 700 and 800 level courses as certified by the department can be done for the purpose of improving the DGPA of the B.Tech./M. Tech. part). In case a DGPA of 5 or more for B.Tech. and 6.0 or more for M.Tech. is achieved, the student will be eligible for award of the Dual Degrees (B.Tech. & M.Tech.). However, in case a DGPA 5 or more for B.Tech. is achieved but the DGPA 6.0 or more for M.Tech. is not achieved at the end of stipulated period, the student will be eligible for award of only B.Tech. degree provided a written request for the same is made to the Dean (Academics).

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

(d) A student is eligible to apply for a Diploma provided he/ she has earned 120 credits and has exhausted the maximum number of permitted registered semesters for completion of his/ her degree. If the student has completed 60 credits (out of 120 credits) from his/ her DR+DC+PE+PC categories then the student will be awarded ‘Undergraduate Diploma in respective discipline’ on completion. If the student has not completed 50% credits from these categories but has completed 120 credits then he/ she will be awarded ‘Undergraduate Diploma in Engineering’. The Diploma is not equivalent to an undergraduate degree.

(e) No self-study course will be permitted for the purpose of improvement of DGPA for M. Tech. or B.Tech. part.

4.2.3 Practical Training
A student of the B.Tech., Dual-degree and Integrated M.Tech. programmes must complete the prescribed number of days of practical training to the satisfaction of the concerned department. This training will be normally arranged in the summer vacation following the 6th semester. Practical training duration is a minimum of 50 working days. Practical training should be carried out preferably in industry or R&D institutions in India. Practical training in academic institutions is not permitted. Details are given in section 4.7(f).

4.2.4 NCC/NSS/NSO
All students are required to enroll for either one of NCC, NSS or NSO in their first year. This requirement should be completed in one year. If, however, a student is not able to complete this requirement in the first year, he/she must complete it by the end of the 2nd year (4th semester). See also 4.7(a). All students will need to attend 10 hours of Counselling sessions as part of these activities on compulsory basis.

4.2.5 Break-up of earned credits
The minimum earned credit requirements for the B.Tech., Dual Degree and Integrated M.Tech. programmes along with detailed break-up of the credits in various categories are given in Table-7.
Maximum of 6 credits under open category can be taken from the departmental U.G. or P.G. courses, and other programme-relevant courses as identified by the department.

Exact requirements for each programme are detailed in Section 6. For completing graduation requirements, a student must complete a minimum of 8 credits of Mathematics category courses, and 6 credits each of Physics and Chemistry category courses with a valid pass grade. A student must also earn valid credits (audit not permitted) for a course of Environment Studies category under OC for graduation.

### 4.2.6 Audit courses

Audit facility is open to all students who have completed 100 earned credits. A student will be permitted to do any number of audit courses over and above the graduation requirements. The audit rules are:

(a) **B.Tech. (4-year) programme**: A maximum of 8 credits from the elective courses in any category out of 180 credits required for B.Tech. degree may be completed on audit basis.

(b) **Dual-degree programme**: A maximum of 8 credits from the elective courses in any category may be completed on audit basis from the UG part of the programme.

(c) **Integrated M.Tech. programme**: A maximum of 8 credits from the elective courses in any category may be completed on audit basis.

For completion of graduation requirements, a student must complete a minimum of 8 credits of Mathematics category courses and 6 credits each of physics and chemistry category courses with valid pass grade. A student must also earn valid credits (audit not permitted) for a course of “Environmental Studies” Category.

### Table 7: Degree requirements of undergraduate programmes (see section 4.2.5 for additional information).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. UG Core</td>
<td>UC</td>
<td>106</td>
<td>99-112</td>
<td>133 (IC)</td>
</tr>
<tr>
<td>1.1 Departmental core</td>
<td>DC</td>
<td>54 (min.)</td>
<td>48-50 (min.)</td>
<td>90</td>
</tr>
<tr>
<td>1.2 Basic Sciences*</td>
<td>BS</td>
<td>20 (min.)</td>
<td>20 (min.)</td>
<td>20 (min.)</td>
</tr>
<tr>
<td>1.3 Engineering Arts and Sciences</td>
<td>EAS</td>
<td>20 (min.)</td>
<td>20 (min.)</td>
<td>20 (min.)</td>
</tr>
<tr>
<td>1.4 Humanities and Social Sciences</td>
<td>HU</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2. UG Elective</td>
<td>UE</td>
<td>74</td>
<td>68</td>
<td>83 (IE)</td>
</tr>
<tr>
<td>2.1 Departmental electives</td>
<td>DE</td>
<td>26 (min.)</td>
<td>20 (min.)</td>
<td>40</td>
</tr>
<tr>
<td>2.2 Humanities and Social Sciences</td>
<td>HM</td>
<td>14</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>2.3 Open category*</td>
<td>OC</td>
<td>25 (min.)</td>
<td>25 (min.)</td>
<td>30</td>
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<tr>
<td>3. Departmental requirement</td>
<td>DR</td>
<td>90</td>
<td>78-80</td>
<td>130</td>
</tr>
<tr>
<td>4. TOTAL REQUIREMENT (B.Tech./Integrated)</td>
<td>UR (=UC+UE)/IR (=IC+IE)</td>
<td>180</td>
<td>168-170</td>
<td>216</td>
</tr>
<tr>
<td>5. M.Tech REQUIREMENT</td>
<td>PR</td>
<td>—</td>
<td>48-50</td>
<td>—</td>
</tr>
<tr>
<td>5.1 Programme core</td>
<td>PC</td>
<td>—</td>
<td>32</td>
<td>—</td>
</tr>
<tr>
<td>5.2 Programme elective</td>
<td>PE</td>
<td>—</td>
<td>16-18</td>
<td>—</td>
</tr>
<tr>
<td>6. TOTAL M.Tech. REQUIREMENT</td>
<td>PR (=PC+PE)</td>
<td>—</td>
<td>48-50</td>
<td>—</td>
</tr>
<tr>
<td>7. TOTAL REQUIREMENT (Dual degree)</td>
<td>UR+PR</td>
<td>—</td>
<td>216-218</td>
<td>—</td>
</tr>
</tbody>
</table>

* Maximum of 8 Credits can be earned through departmental courses.
4.3 Lower and upper limits for credits registered

A student must register for a minimum of 15 credits and a maximum of 26 credits in a semester. The minimum and maximum lecture credits that a student can register for in a semester are 9 and 18, respectively. For the dual-degree and integrated M.Tech. programmes, the above limits apply up to the 8th semester. In the 9th and 10th semesters, these students will normally register for a minimum of 12 credits and a maximum of 22 credits per semester.

Under exceptional circumstances, a student can register for a maximum of 28 credits including not more than 6 (six) ‘L’ (lecture) courses. However, this will be permitted at most twice during the programme in semesters other than 1st and 2nd, and those in which the student is registered for Major Project Part 1 or 2.

These conditions will not be applicable for those students who are on probation according to the criteria defined in section 4.5.

4.4 Absence during the semester

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

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

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

(d) In case a student cannot appear in a minor test on the same day in which he/she has appeared in a test, a medical certificate only from the institute’s medical officer will be acceptable.

(e) In case of absence on medical grounds or other special circumstances, before or during the major examination period, the student can apply for an I-grade. 75% attendance in a course is necessary for being eligible for request of an I-grade in that course. An application requesting an I-grade should be made at the earliest but not later than the last day of major tests. The application should be made to the Head of the Department of the student’s programme, who will grant approval depending on the merit of the case and inform course coordinators and U.G section. The student should complete all course requirements within ten days of the last date of Major Tests. The I-grade will then be converted to a proper grade (A to F, NP or NF).

(f) In special situations arising due to the student’s inability to be present at the institute during the stipulated period, in (e) above, the period for conversion of an I-grade can be extended to the first week of the next semester. Approval for this extension can be granted by Dean (Academics) on recommendations of the concerned Head of the department, course coordinators, and concerned warden. A request to this effect must be included in the application for an I-grade.

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

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

4.5 Conditions for termination of registration, probation and warning

1. Students admitted through JEE

If the performance at the end of first two registered semesters (not including summer semester) is poor, then the student can opt to start a fresh, or else his/her registration will be terminated. The criteria “poor” performance is defined in Table 8.
Table 8. Rules for termination of registration at the end of the 2nd registered semester.

<table>
<thead>
<tr>
<th>Quality of performance</th>
<th>Earned credits</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GE/OBC</td>
<td>SC/ST/PD</td>
</tr>
<tr>
<td>Poor performance</td>
<td>≤ 26</td>
<td>≤ 22</td>
</tr>
</tbody>
</table>

(a) If a student chooses to restart after the first two registered semesters, then his/her credits earned and semesters registered will not be carried over. The re-start will be indicated on the transcript. The re-start will be permitted only once. If at the end of two registered semesters after re-start, the earned credits are less than or equal to 26 for GE/OBC or less than or equal to 22 for SC/ST/PD students, then the registration will be terminated.

(b) Each student is expected to earn at least 12 credits in the first registered semester and 15 credits in each subsequent registered semester with a SGPA greater than or equal to 5.0. If the performance of a student at the end of any registered semester is below this minimum acceptable level, then he/she will be placed on probation and a warning shall be given to him/her and intimation sent to the parents.

(c) The student placed on probation shall be monitored, including mandatory attendance in classes, special tutorials and mentoring. Mentoring will comprise structured guidance under a senior/postgraduate student.

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

(e) The registration of any student will be limited to 1.25 times the average earned credits of the previous two registered semesters, subject to a minimum of 15 credits and a maximum of 26 credits.

1.1 Slow-paced programme

(i) A student who has earned between 27 and 36 credits at the end of the first two registered semesters will be eligible to opt for the slow-paced programme. A student opting for such a programme shall be permitted two additional registered semesters for completing degree requirements as indicated in section 4.6.

(ii) In the slow paced programme, the upper limit for credits registered in a semester will be 18. A student in this programme is expected to earn at least 12 credits with minimum SGPA 5.0 in any semester, falling which he/she will be issued a warning and placed on probation.

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

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

(iii) Slow-paced programme shall be defined by the respective department for each student.

4.6 Maximum duration for completing degree requirements

1. 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.
Table 9. Maximum permissible duration for completing degree requirements.

<table>
<thead>
<tr>
<th>Programme Name</th>
<th>Maximum number of registered semesters permitted for completing degree requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>B.Tech.</td>
<td>12 (*)</td>
</tr>
<tr>
<td>Dual Degree</td>
<td>14 (*)</td>
</tr>
<tr>
<td>Integrated M.Tech.</td>
<td>14 (*)</td>
</tr>
</tbody>
</table>

Note: (*) If a student opts for the slow-paced programme (as defined in clause B1), then the maximum permissible number of registered semesters shall be increased by two semesters.

(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.

2. The maximum permissible number of registered semesters for completing all degree requirements would be:

4.7 Courses of special nature

Courses of special nature are: National Cadet Corps (N.C.C.), National Sports Organization (N.S.O.) and National Service Scheme (N.S.S); Introduction to the Programme, Introduction to Humanities and Social Sciences; Independent Study, Mini Project, Practical Training, Colloquium, and Major Project. Salient features of these courses are given below. (See section 2.1 for numbering scheme).

(a) **N.C.C., N.S.O. and N.S.S.**

The B.Tech., Dual Degree and M.Tech. Integrated student have to complete 100 hours in any one of the activities, namely NCC, NSS, NSO to complete non-credit requirement. On completion of 100 hours, student is awarded "S" grade; 100 hours requirement over a period of one year is broken into 50 hours requirement per semester.

The student is registered in NCN100/NSN100/NPN100 level course in the Ist Semester and on obtaining “S” grade he/she is registered in NCN101/NSN101/NPN101 in the IInd Semester. Unless a student obtains “S” grade in both 100 and 101 level courses he/she does not complete the non-credit requirement of NCC, NSS, NSO. In case a student can not complete this requirement in the first year, he must do so by the end of second year; otherwise he/she will not be allowed to register for any course until he/she completes this requirement.

(b) **Introduction to the Programme**

A student is introduced to his/her engineering discipline through this course in the first semester itself. This is a 2 credit compulsory course. A student is required to complete this course in the first year by getting ‘S’ grade. In case, a student is not able to complete it in the first year, he/she must do so by the end of the second year, otherwise he/she will not be allowed to register in the 3rd year, as is the case for NCC/NSS/NSO courses.

(c) **Introduction to Humanities and Social Sciences**

A student is exposed to various facets of humanities and social sciences along with instructions for improving English language proficiency through this course. This is a compulsory 2 credit course that is normally done in first year. In case, a student is not able to complete it in the first year, he/she must do so by the end of the second year, otherwise he/she will not be allowed to register in the 3rd year, as is the case for NCC/NSS/NSO courses.

(d) **Independent Study**

‘Independent Study’ is an elective course that some departments may offer from fourth semester onwards. It is a 3-credit course covering one or more of the following:

(i) In-depth study and critical review of a specified topic;
(ii) Specialized laboratory work/experimental project/feasibility study;
(iii) Work on a research project;
(iv) Software development on a specified topic.

An individual student and teacher should decide upon the topic and submit an initial write-up to get the approval of the Course Coordinator before the end of the semester when the course is registered for (i.e. in the semester prior to doing the course). The duration of the course will be the entire semester. A written report should be submitted by the
student on completion of the course. The student's performance will be evaluated by a departmental committee via a mid-term and final evaluation. A student has to earn 80 credits and obtain at least 7.5 CGPA to become eligible to do Independent Study.

(e) Mini Project
An elective course under this title may be floated by departments from fifth semester onwards. Mini project will be a regular course to conduct a design and fabrication type project. The student and teacher would decide upon the topic, prepare a plan of work and get the approval of the Course Coordinator before the end of the semester when the course is registered for. The duration of the course will be the entire semester. A project report would be submitted by the student on completion of the course. The student's performance will be evaluated by a departmental committee via a mid-term and a final evaluation. Mini-project can be done jointly by 2 students, each having earned 80 credits with a CGPA of at least 6.5. A dual degree student can do either Mini Project or Minor Project.

(f) Practical Training
Practical Training is a non-credit departmental core course (NC) to be done typically in the summer semester following sixth semester. A student who has earned at least 90 credits at the end of 5 semesters is eligible to undergo practical training in the summer following sixth semester. The duration for practical training is 50 working days (minimum), preferably in an industry or R&D institution in India. Practical training in academic institutions is not permitted.

It is the joint responsibility of the departments and the Training and Placement (T&P) unit to arrange for training for all their students. In the beginning of each academic session, T&P unit will prepare programme-wise lists of potential training organizations in consultation with the respective departments. These organizations will be approached by the T&P unit with a request to provide training seats. Consolidated lists of training offers will be made available to the students through departments in the beginning of the second semester of the session. If a student is interested in making his/her own arrangement for the training seat, he/she will need to have the training organization approved and route the application through the departmental training incharge and T&P unit. All such applications must be completed before the end of first semester. No self-arranged practical training, not approved through the above process, will be allowed and faculty members will not sign any forms for the purpose.

The department will appoint a training supervisor for each student. The supervisor is expected to keep contact with the assigned students through e-mail and/or telephone. The students will be required to get their training plan reviewed by their supervisor within the first week and report their progress on weekly basis. The supervisor, if desires, may visit the organization. Visits within the country will be supported by the institute.

A student will be registered for practical training course in the summer semester in which the training is being done. At the end of the summer semester, a 'Z' grade will be awarded and he/she should register for practical training course in the following semester. The Department will scrutinize the training report and the training certificate and will award 'S' grade within the next semester, if the training is satisfactory. In case the training is considered to be unsatisfactory, a 'Z' grade will be awarded and the student may have to undergo fresh practical training for a part or full duration. Practical Training and submission of summer training report is a mandatory requirement for graduation.

(g) Colloquium
Colloquium is a 3-credit course and includes assessment of practical training. A student will be eligible to do Colloquium if he/she had registered for Practical Training earlier. Typically, a student will register for Colloquium in the regular semester following the summer semester in which he/she has done the practical training.

(h) B. Tech Project
The B. Tech Major Project is structured into two parts - Core and Elective. The Core B. Tech Project will have 4 credits. It will be scheduled in the seventh semester. The Elective B. Tech project will be of 8 credits. The students will be eligible to do Elective B. Tech project if he/she secures a grade not below 'B' in Core B. Tech Project. Elective B. Tech project will be scheduled in the eighth semester. Normally, Elective B. Tech project will be continuation of Core B. Tech project.

All awards based on B. Tech project will consider performance in Elective B. Tech project. Those students who do not qualify or does not opt for Elective B. Tech project will do DE category courses in its place to make up total credits.

(i) Major Project (Dual-Degree, Integrated M.Tech, 2yr M.Tech)
The Major Project is a core course spread over at least two regular semesters and comprises of Part 1 and Part 2. The allocation of major projects, faculty guides and tentative plan of work are to be done typically before the end of the previous semester. Part 2 is normally expected to be a continuation of Part 1, except under those exceptional circumstances in which the supervisor (guide) is changed at the end of Part 1. A mid-term assessment and an end semester assessment will be carried out for each part. Part 1 and Part 2 will be graded separately. C grade is considered as the minimum pass grade in each part of the M.Tech. Major Project in Dual Degree, Integrated M.Tech. Programmes & 2 year M.Tech. Programmes.
A student must have obtained a pass grade in Project Part 1 in order to be eligible for registering for Project Part 2. Major project will be spanned over one summer semester and two regular semesters. Typically a student will register for the Part 1 of major project in the summer semester. He/she will be automatically awarded an X-grade in the summer semester unless he/she is awarded an F grade. If a student is awarded X grade, he/she will be automatically registered for M.Tech. Project Part 1 (xxD8y1) in the following regular semester. Mid-term evaluation of the M.Tech. Project Part 1 will be held within first two weeks of the corresponding semester. At the end of the regular semester, the student will be awarded a proper grade in M.Tech. Project Part 1 (xxD8y1). If he/she obtains a valid pass grade in this course, he/she can register for M.Tech. Project Part 2 (xxD8y2-14 credits) in the following regular semester. His/her M.Tech. Project Part 2 will be evaluated at the end of the corresponding semester as per the stipulated deadline.

In case a student does not obtain an X-grade in M.Tech. Project Part 1 in the summer semester, he/she will require permission from the Head of the Department to register for M.Tech. Project Part 1 in a regular semester. In this situation, he/she will register for M.Tech. Project Part 1 with reduced credits, viz. 4 credits (xxD8y3). After completing this course with a valid pass grade he/she will be required to register for M.Tech. Project Part 2 with 16 credits (xxD8y4). In this case the project will either start in the regular semester and extend into the following summer semester or start in the summer semester and extend into the following regular semester. M.Tech. Project Part 2 will be evaluated taking into account the work done in both the semesters. Extension from one semester to the other will be permitted automatically by awarding X-grade to the student. An F grade instead of X will bar a student from continuing the M.Tech. Project Part 2 in the following semester. The student will need to do fresh registration for M.Tech. Project Part 2.

(xxD8ym – is the course number for M.Tech. Major Project as explained in section 2.1(c))

**Norms for conducting M.Tech. project of Dual degree and Integrated M.Tech. programmes at location outside IIT Delhi.**

(a) The student is permitted to work at location outside IIT, Delhi in summer or in the 2nd Semester of MTP when the student is not registered for other courses.

(b) Projects can be carried out at an University or Institute if it is linked through consultancy/sponsored project or covered under MoU. Else with approval of Dean on recommendation of HoD. However, the description of the proposed work must be approved by Departmental UG Committee.

(c) At the commencement of the project, a description of the proposed work will be made available and be approved by the Departmental Undergraduate Committee.

(d) An External Supervisor will be appointed by the Department with approval of the Head of the Department and conveyed to Dean (Academics) and notified by the UG Section.

(e) The student is required to come back for mid-term evaluation / presentation.

(i) **Special Module (V-category) Courses**

Special module courses are 1 or 2 credit courses that can be offered at the beginning of the semester or during the semester. These courses will usually cover specialized topics that are not generally available in the regular courses. Eligible students can register for these courses for credit. The course coordinator will evaluate the students’ performance and award a letter grade. The credits so earned will count towards the appropriate category for degree completion purposes.

### 4.8 Open category credits

Open category credits should provide an opportunity to a student to exercise his/her options in an unrestricted fashion.

A. A student can complete open category credits by choosing courses from different departments. The student will be permitted to register for maximum of 8 credits of departmental courses under open category.

B. A student, if he (she) so desires, can complete 20 credits out of the ‘Open Category’ basket by exercising one of the following options.

   (i) The 20 credits belong to one of the Minor Area programmes.

   (ii) The 20 credits could be utilised be for a specialization within the Department only by those students who opt for joining an M.Tech program in the third year as continuation of his/her current B.Tech programme as per existing provision. This will enable the student to earn credits towards his/her M.Tech degree.
The 20 credits could be utilised for inter-disciplinary specialisations in which a student can earn credits by doing courses from multiple departments (including the parent department). Such specialisations can be defined jointly by more than one participating department.

**Implementation rules**

(i) it will be possible for a student to register for a minor area / inter-disciplinary specialization. Registration for a Minor Area / specialization will be based on the performance of the student in a qualifier course which will be one of the core courses for the Minor Area / specialisation. Departments/Centres need to identify qualifier courses for the offered minor area programmes/specialisations. In order to discourage non-serious students, if someone registers for a minor area / specialization but does not complete it, that information will be recorded on the academic transcripts.

(ii) Interdisciplinary specialization: This requires two or more Departments/Centres to identify courses totalling 20 credits which will lead to an inter-disciplinary specialization. This will have courses from all the participating Departments/Centres and will also have a core component totalling 6-8 credits. The specialisation will be mentioned on the degree.

(iii) A student opting for Departmental Specialisation/Inter-disciplinary specialisation will not have the option for registering for departmental courses for remaining open category credits.

### 4.9 Minor Area

4.9.1 A set of pre-defined courses of total 20 credits in a focus area comprises a Minor Area. A student can use Open Category (OC) credits to complete the specific requirements.

4.9.2 Any student is eligible to take the Minor Area at the end of the 3rd semester and may register for Minor Area courses from 4th semester onwards.

4.9.3 A student registered in any programme of a specific department will not be eligible to take the minor area(s) offered by the same department; additional conditions and details of individual minor areas are given in Section 6.

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

For example, a student of BB5 programme intending to complete the minor area *Computational Mechanics* (that has CHL204, or any of its alternates, and AML310 as core courses) will take CHL204 as a DC category course and complete the minor area requirements by completing AML310 (core course of the minor area) and 16 credits (4 courses in this case) from the listed minor area elective courses, viz. AML410 AML430, AML440, AML705, and AML710.

4.9.5 For purposes of completing minor area requirements, the listed minor area course may be substituted by an equivalent course so identified in the course descriptions.

### 4.10 Self-study course

A self-study course will be from the regular UG courses listed in the *Courses of Study* bulletin. The main features of a self-study course are as follows:

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

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

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

(d) Grant of a course to be taken as a self-study course cannot be claimed by any student as a matter of right.

(e) Normally, no formal lectures will be held for a self-study course but laboratory, design and computation exercises will be conducted if they form an integral part of the course.
(f) The Course Coordinator will hold minor and major tests besides other tests/quizzes for giving his/her assessment at the end of the semester. In summer semester, there will be at least one mid-semester test and a major test.

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

(h) The grades after due moderation by the Moderation Committee will be sent by the Department to Officer In-charge (UGS) at the end of the semester along with grades of all other courses.

(i) Colloquium will not be offered as a self-study course.

### 4.11 Summer semester

In the summer semester, registration for ‘L’ (lecture) and ‘P’ (practical) category courses will be strictly limited to the students who have obtained an E grade in the subject earlier or whose load has been restricted by SRC. In a summer semester, a student cannot earn more than 12 credits (in all the categories) except when he/she is registered for M.Tech. Project Part 2 with maximum of 16 credits.

A summer course will run only if there is a minimum registration of 5 students.

### 4.12 Assistantship for Dual-degree and Integrated M.Tech. programmes

The students of dual-degree programmes and 5 year integrated M.Tech programmes will be considered for award of institute research/teaching assistantship if they have earned 165 credits. Only those students who have qualified GATE / have CGPA more than 8.0 will be eligible for this assistantship. The assistantship will be provided for a maximum period of 14 months beginning from the summer semester following 8th semester, provided the student is registered for M.Tech major project part-I in that semester. The student will be required to provide 8 hours of assistance per week besides his normal academic work. For continuation of assistantship a student will need to secure SGPA of 7.0. A student will be eligible to receive assistantship from sources other than institute fund or MHRD if he/she has a CGPA of 7.0 and has earned 165 credits.

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

### 4.13 Change of programme

#### 4.13.1 Programme change at the end of first year

The following regulations apply for change of programme at the end of first year, i.e. end of the 2nd semester.

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

(i) CGPA for general category student : 07.50

(ii) CGPA for SC/ST/PH category student : 06.50

(iii) Earned credits at the end of first academic session : 40

(b) Change of the discipline will be permitted strictly in the order of merit as determined by their CGPA at the end of first year subject to the limitation that the actual number of students in the third semester in the discipline to which the transfer is to be made, should not exceed the sanctioned strength and the strength of the discipline from which transfer is being sought does not fall below 90% of existing strength.

(c) For a student with CGPA 9.0 or more, even if a vacancy does not exist, he/she will be permitted to change provided the strength in the discipline to which the change is being sought does not exceed by 5 % of the approved strength.

(d) A student with CGPA 9.0 or more will be permitted to change discipline even if strength of discipline from which change is being sought falls below 90 % of the existing strength.

(e) Stipulation of minimum credits and CGPA requirements will not be insisted upon for change of discipline to a branch in which a vacancy exists and the concerned student was eligible for admission to that discipline at the time of entry to IIT Delhi. However, requirements of credits and CGPA will continue to apply in case of both general and SC/ST category students seeking change to a discipline to which the concerned student was not eligible for admission at the time of entry to IIT Delhi.

#### 4.13.2 Change from 4-year B.Tech. to dual degree programme

A student registered for a 4-year degree programme in a Department can be permitted to change his/her registration from the 4-year to a 5-year programme of the same department provided the B.Tech. part of the dual degree
programme into which the student is desirous of registering is the same as the programme for which the student was admitted through JEE subject to fulfilling the following criteria:

(a) The student must have completed at least 120 credits by the end of 6th semester and secured a minimum CGPA of 7.5.

(b) The maximum number of students that can be permitted such a change of registration will be limited to 10% of sanctioned strength of the intake into the relevant 4-year programme of the department.

4.14 Measures for helping SC/ST Students

A number of measures exist for helping students belonging to SC and ST categories. A senior faculty member is appointed as adviser to SC/ST students for advising them on academic and non-academic matters. Financial measures for helping SC and ST student are described in the Prospectus.

4.15 Admission of UG Students to PG Programmes with Advance Standing

UG students of IIT Delhi are eligible for admission to PG programmes with advance standing at IIT Delhi. For admission to PG programme minimum CGPA required at the end of sixth semester shall be 7.5. The student will be awarded both the degrees- B.Tech and a PG degree on successful completion of both the programmes. The student will be required to complete the major project in both the UG and PG programmes. A student can have maximum of 24 credits of the PG programme waived. A student can earn these credits through DE & OC courses.

5. POSTGRADUATE DEGREE REQUIREMENTS, REGULATIONS AND PROCEDURES

5.1 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.

5.2 Continuation requirements

The detailed requirements for continuation as a student in the respective programme for M.Sc., D.I.I.T., M.B.A., M.Des. M.Tech., M.S. (Research) and Ph.D. degrees 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.

5.3 Minimum student registration for a programme

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

5.4 Lower and upper limits for credits registered

For 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.
5.5 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 earn 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.

5.6 Award of D.I.I.T. to M.Tech. 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.

5.7 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.

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

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

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

5.9 Assistantship requirements

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

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. Continuation 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.

5.10 Summer registration
Summer semester registration for PG students is admissible. M.Tech./ M.S.(R)/ M. Des. students will be allowed to register for maximum of one course (upto 4 credits) and M.B.A./M.Sc. students upto 2 courses in the summer 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.

5.11 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”.

5.12 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 are given either by faculty members or by guest-speakers and specialists in the profession.

5.12.1 Course requirements
Candidates admitted to non-engineering departments and having a B.Tech./M.Sc./M.A. or equivalent degree are required to complete a minimum of 12 credits. Relaxation up to 6 credits in the course work can be considered for those with M.Phil. degree. The requirement of pre-Ph.D. Course Credits/work for Ph.D. student having B.Tech. and M.Sc. Degree (entering Engineering Departments only) will be 20 credits.
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 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
## Table 9: Continuation of Registration and Graduation Requirements for Postgraduate Programmes

<table>
<thead>
<tr>
<th>Degree</th>
<th>Registration limits (per semester)</th>
<th>Criteria for continuation of registration</th>
<th>Graduation requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Valid credits ($)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D.I.I.T. (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>M.Sc., Chemistry</td>
<td>Minimum 20 credits</td>
<td>At the end of the 1st registered semester, a student with SGPA of 4.0 or more will be permitted to continue. If the SGPA is less than 4.0 then registration will be terminated.</td>
<td></td>
</tr>
<tr>
<td>M.Sc., Mathematics</td>
<td>Maximum 28 credits</td>
<td>After the first registered semester, the minimum acceptable performance level in any registered semester is SGPA of 5.0 or more.</td>
<td></td>
</tr>
<tr>
<td>M.Sc., Physics</td>
<td>Minimum 12 credits</td>
<td>If at the end of any registered semester, the SGPA is less than 5.0 then the student will be issued a warning letter and placed on probation; a copy of the warning letter will be sent to the parents. The Chairperson DRC/CRC shall assess the feasibility of completing degree requirements and identify remedial measures for problems leading to poor performance.</td>
<td></td>
</tr>
<tr>
<td>M.Tech., full time</td>
<td>Minimum 12 credits</td>
<td>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>
</tr>
<tr>
<td>M.Tech., part time</td>
<td>Minimum one course and/or Minor/ Major Project. Minimum 12 credits with the condition that no. of lecture courses to be not more than 3.</td>
<td>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. Des.</td>
<td>Minimum 18 credits</td>
<td>At the end of the 1st registered semester, a student with SGPA of 5.0 or more will be permitted to continue. If the SGPA is less than 5.0 then registration will be terminated.</td>
<td></td>
</tr>
<tr>
<td>M.B.A., full time</td>
<td>Maximum 30 credits</td>
<td>After the first registered semester, the minimum acceptable performance level in any registered semester is SGPA of 5.0 or more.</td>
<td></td>
</tr>
<tr>
<td>M.B.A., part time</td>
<td>Same as M.Tech. full time</td>
<td>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 Chairperson DRC/CRC. The Chairperson DRC/ CRC shall assess the feasibility of completing degree requirements and identify remedial measures for problems leading to poor performance.</td>
<td></td>
</tr>
<tr>
<td>M.B.A., part time</td>
<td>Same as M.Tech. part time</td>
<td>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>
</tbody>
</table>

(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.

(ii) If at the end of any registered semester, the SGPA is less than 5.0 then the student will be issued a warning letter and placed on probation; a copy of the warning letter will be sent to the parents. The Chairperson DRC/CRC shall assess the feasibility of completing degree requirements and identify remedial measures for problems leading to poor performance.

(iii) 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.

(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.
### Courses of Study 2011-2012

| 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>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>M.S. (Res.) part time</td>
<td>See note ++</td>
<td>CGPA $\geq 7.5$. 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>10 sem.+++</td>
</tr>
<tr>
<td>Ph.D.</td>
<td>For details please refer to Ph.D. Ordinances and Regulations</td>
<td></td>
<td></td>
<td></td>
<td></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 DIIT even though the Department/Interdisciplinary Programme does not have a regular Diploma programme provided: (i) he/she has a minimum of 45 valid credits; and (ii) he/she has secured a minimum CGPA of 5.50. The request for the award of D.I.I.T. must be made within 5 years of the date of joining the programme.

+ 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 (Academics).

@ 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.

### 5.12.2 Time limit

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

### 5.12.3 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.

5.12.4 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.

5.12.5 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 (Academics). 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 (Academics).

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 (Academics) will appoint a Board of Examiners for each candidate. The Board will consist of one (or two) internal examiner(s), normally the supervisor(s), and two external examiners, one from within India and one from abroad who shall be expert in the subject of thesis. These external examiners shall be chosen from a list of eight, to be recommended by the supervisor(s) through the DRC/CRC 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 (Academics). 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, Research & Development, 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, RD, 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.
6. UNDERGRADUATE PROGRAMME STRUCTURES

The following pages give details of the programme definitions that includes courses in each category, for every B.Tech., dual degree and integrated M.Tech. programme.

The left page gives the category-wise credits requirement followed by the list of courses in each category. Students are also required to complete the NCC/NSS/NSO requirements. A student must also earn valid credits (audit not permitted) for a course of Environmental Studies category under OC for graduation.

The table on the right page is 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 course advisor.

<table>
<thead>
<tr>
<th>Program Type</th>
<th>Page Nos.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bachelor of Technology programmes</td>
<td>38 to 55</td>
</tr>
<tr>
<td>Dual degree programmes</td>
<td>56 to 63</td>
</tr>
<tr>
<td>Integrated Master of Technology programme</td>
<td>64 &amp; 65</td>
</tr>
<tr>
<td>Minor Area Structures</td>
<td>66 &amp; 67</td>
</tr>
</tbody>
</table>
Programme Code: CH1 / (CH)
Bachelor of Technology in Chemical Engineering
Department of Chemical Engineering

The overall credits structure

<table>
<thead>
<tr>
<th>Category</th>
<th>Credits</th>
<th>Category</th>
<th>Credits</th>
</tr>
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<tr>
<td>DC</td>
<td>64</td>
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<td>BS</td>
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<td>EAS</td>
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<td>OC</td>
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<tr>
<td>HU</td>
<td>2</td>
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</tr>
<tr>
<td>TOTAL</td>
<td>106</td>
<td>TOTAL</td>
<td>74</td>
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</table>

Total credits = 180

Basic Sciences (BS) Core

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CYL110 Physical Chemistry: Concepts and Applications</td>
<td>3-1-0 4</td>
</tr>
<tr>
<td>CYL120 Inorganic and Organic Chemistry: Concepts and Applications</td>
<td>3-1-0 4</td>
</tr>
<tr>
<td>MAL110 Mathematics - I</td>
<td>3-1-0 4</td>
</tr>
<tr>
<td>MAL120 Mathematics - II</td>
<td>3-1-0 4</td>
</tr>
<tr>
<td>PHP100 Physics Laboratory</td>
<td>0-0-4 2</td>
</tr>
<tr>
<td>TOTAL BS Core</td>
<td>12-4-8 20</td>
</tr>
</tbody>
</table>

In addition to the above BS core courses, either PHL110 or PHL120 has to be taken as an open category course for graduation.

Engineering Arts and Sciences (EAS) Core

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>AML120 Materials Science</td>
<td>3-0-2 4</td>
</tr>
<tr>
<td>CSL101 Introduction to Computer Programming</td>
<td>3-0-2 4</td>
</tr>
<tr>
<td>CSL102 Introduction to Computer Science</td>
<td>3-0-2 4</td>
</tr>
<tr>
<td>EEL102 Principles of Electrical Engineering</td>
<td>3-0-2 4</td>
</tr>
<tr>
<td>MEL110 Graphic Science</td>
<td>2-0-4 4</td>
</tr>
<tr>
<td>MEL120 Manufacturing Practices</td>
<td>2-0-4 4</td>
</tr>
<tr>
<td>TOTAL EAS Core</td>
<td>13-0-14 20</td>
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</tbody>
</table>

Humanities and Social Sciences (HC) Core

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>HUN100 Introduction to Humanities and Social Sciences</td>
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</table>

Departmental Electives (DE)

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DC = 64, EAS = 20, BS = 20, HC = 2 (either in 1st or 2nd sem.)
Reqd. DE=26, plan DE = 7 courses, or 5 courses & Major Project Part 2.
Reqd. OC=34, plan OC = 7@4 + 2@3 = 34 cr. from 9 courses.

TOTAL = 180.0
The overall credits structure

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Total credits = 180

### Basic Sciences (BS) Core

- **CYL110** Physical Chemistry: Concepts and Applications 3-1-0 4
- **CYP100** Chemistry Laboratory 0-0-8 4
- **MAL110** Mathematics - I 3-1-0 4
- **MAL120** Mathematics - II 3-1-0 4
- **PHL110** Fields and Waves 3-1-0 4
- **PHP100** Physics Laboratory 0-0-2 2
- **TOTAL BS Core** 12-4-8 20

### Engineering Arts and Sciences (EAS) Core

- **AML110** Engineering Mechanics 3-0-2 4
- **AML120** Materials Science 3-0-2 4
- **AML150** Mechanics of Solids and Fluids 3-1-2 5
- **CSL101** Introduction to Computers and Programming 3-0-2 4
- **CSL102** Introduction to Computer Science 3-0-2 4
- **MEL110** Graphic Science 2-0-4 4
- **TOTAL EAS Core** 14-1-12 21

### Humanities and Social Sciences (HC) Core

- **HUN100** Introduction to Humanities and Social Sciences 0-0-4 2

### Departmental Core (DC)

- **CEC410** Colloquium (CE) 0-3-0 3
- **CED411** Major Project Part 1 (CE) 0-0-8 4
- **CEL212** Environmental Engineering 3-0-2 4
- **CEL222** Engineering Geology and Soil Mechanics 3-1-3 5.5
- **CEL231** Structural Analysis – I 3-1-2 5
- **CEL232** Concrete Material and Design 3-1-4 6
- **CEL241** Transportation Engineering – I 3-0-2 4
- **CEL251** Hydrology and Hydraulics 3-1-4 6
- **CEL271** Elements of Surveying 2-0-2 3
- **CEL321** Geotechnical Engineering 3-1-3 5.5
- **CEL331** Structural Analysis – II 3-1-2 5
- **CEL332** Design of Steel Structures 3-1-2 5
- **CEL351** Design of Hydraulic Structures 2-0-2 3
- **CEN110** Introduction to Civil Engineering 0-0-4 2
- **CEP200** Design Concepts in Civil Engineering 0-0-4 2
- **CET410** Practical Training (CE) NC
- **TOTAL DC** 31-10-42 62

### Departmental Electives (DE)

- **CED310** Mini Project (CE) 0-0-6 3
- **CEL311** Advanced Water and Wastewater Engineering 3-0-2 4
- **CEL341** Transportation Engineering – II 3-1-0 4
- **CEL362** Construction Management 3-1-0 4
- **CEL411** Industrial Waste Management 3-0-0 3
- **CEL412** Environmental Assessment Methodologies 3-0-0 3
- **CEL421** Ground Improvement 3-0-2 4
- **CEL422** Rock Engineering 3-0-0 3
- **CEL423** Designs of Foundation, Earth and Earth Retaining Structures 3-1-0 4
- **CEL431** Advanced Structural Analysis 2-0-2 3
- **CEL432** Design of Prestressed Concrete and Industrial Structures 3-0-2 4
- **CEL433** Advanced Structural Design 3-0-2 4
- **CEL442** Traffic and Transportation Planning 2-1-0 3
- **CEL443** Transportation Safety and Environment 3-0-0 3
- **CEL451** Water Power Engineering 3-0-2 4
- **CEL453** Water Resources Management 3-1-0 4
- **CEL455** Introduction to Geographic Information Systems 2-0-2 3
- **CEL459** River Mechanics 2-0-2 3
- **CEL464** Construction Contract and Economics 2-1-0 3
- **CEL466** Construction Equipment and Methods 2-1-0 3
- **CEP452** Computational Aspects in Water Resources 1-0-4 3
- **CED412** Major Project Part 2 (CE) 0-0-16 8
### B.Tech. in Civil Engineering

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Reqd. DE=28, plan DE = 8 courses, or 6 courses +Major Project Part 2. 
Reqd. OC=33, plan OC = 6@4 + 3@3 = 33 cr. from 9 courses.
**Programme Code: CS1 / (CS)**

*Bachelor of Technology in Computer Science and Engineering*

Department of Computer Science and Engineering

### The overall credits structure

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**Total credits = 180**

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**TOTAL = 180.0**

DC = 62, EAS = 20, BS = 20, HC = 2  (* either in 1st or 2nd sem.)

HU = 2@4 + 2@3 = 14 cr. from 4 courses.

Reqd. DE=32, plan DE = 8 courses, or 6 courses+Major Project Part 2.

Hu. = 2@4 + 2@3 = 14 cr. from 8 courses.

Reqd. OC=30, plan OC = 6@4 + 2@3 = 30 cr. from 8 courses.
Programme Code: EE1 / (EE)  
**Bachelor of Technology in Electrical Engineering**  
Department of Electrical Engineering

The overall credits structure

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Total credits = 180

### Basic Sciences (BS) Core
- CYP100 Chemistry Laboratory 0-0-4 2
- MAL111 Introduction to Analysis & Differential Equations 3-1-0 4
- MAL124 Introduction to Algebra and Matrix Analysis 3-1-0 4
- MAL250 Introduction to Probability Theory and Stochastic Processes 3-1-0 4
- PHL110 Fields and Waves 3-0-4 2
- PHP100 Physics Laboratory 0-0-4 2

**TOTAL BS Core** 12-4-8 20

*In addition to the above BS core courses, either CYL110 or CYL120 has to be taken as an open category course for graduation.*

### Engineering Arts and Sciences (EAS) Core
- AML110 Engineering Mechanics 3-0-2 4
- CSL101 Introduction to Computers and Programming 3-0-2 4
- CSL102 Introduction to Computer Science 3-0-2 4
- CSL201 Data Structures 3-0-4 5
- EEL101 Fundamentals of Electrical Engineering 3-0-2 4
- MEL120 Manufacturing Practices 2-0-4 4

**TOTAL EAS Core** 14-0-14 21

### Humanities and Social Sciences (HC) Core
- HUN100 Introduction to Humanities and Social Sciences 0-0-4 2

### Departmental Core (DC)
- EEC410 Colloquium (EE) 0-3-0 3
- EED411 Major Project Part 1 (EE) 0-0-8 2
- EEL201 Digital Electronic Circuits 3-1-0 4
- EEL202 Circuit Theory 3-1-0 4
- EEL203 Electromagnetics 3-1-0 4
- EEL204 Analog Electronic Circuits 3-1-0 4
- EEL205 Signals and Systems 3-1-0 4
- EEL207 Engineering Electromagnetics 3-1-0 4
- EEL301 Control Engineering - I 3-0-4 2
- EEL303 Power Engineering - I 3-1-0 4
- EEL306 Communication Engineering 3-1-0 4
- EEL308 Computer Architecture 3-1-0 4
- EEN110 Introduction to Electrical Engineering 0-0-4 2
- EEP201 Electronics Laboratory - I 0-0-3 1.5
- EEP203 Electromechanics Laboratory 0-0-3 1.5
- EEP204 Electronics Laboratory - II 0-0-3 1.5
- EEP211 Design (EE) 0-0-4 2
- EEP301 Control Laboratory 0-0-3 1.5
- EEP303 Power Laboratory 0-0-3 1.5
- EEP306 Communication Engineering Laboratory 0-0-3 1.5
- EEP307 Electromagnetics Laboratory 0-0-3 1.5
- EEP308 Computer Technology Laboratory 0-0-3 1.5
- EET410 Practical Training (EE) — NC

**TOTAL DC** 30-13-38 62

### Departmental Electives (DE)
- EED310 Mini Project (EE) 0-0-6 3
- EEL212 Measurements and Instrumentation 3-0-0 3
- EEL218 Physical Electronics 3-0-0 3
- EEL311 Graph Theory and its Appl. to Elect. Engg. 3-0-0 3
- EEL315 Analog Integrated Circuits 3-0-0 3
- EEL316 Digital Communications 3-0-2 4
- EEL319 Digital Signal Processing 3-0-2 4
- EEL322 Integrated Circuits Technology 3-0-0 3
- EEL324 Digital Hardware Design 3-0-0 3
- EEL325 Control Engineering - II 3-0-0 3
- EEL326 Microprocessors and their Applications 3-0-0 3
- EEL327 Fault Diagnosis of Digital Circuits 3-0-0 3
- EEL329 VLSI Technology and Design 3-0-2 4
- EEL330 Selected Topics in Communication Engineering 3-0-0 3
- EEL331 Electromagnetics and Advanced Electromechanics 3-0-0 3
- EEL338 Antennas and Propagation 3-0-0 3
- EEL340 Selected Topics in Power and Machines 3-0-0 3
- EEL342 DSP based Control of Electric Drive 3-0-0 3
- EEL346 Electrical Machines and Industrial Drives 3-0-0 3
- EEL358 Operating Systems 3-0-0 3
- EEL360 Selected Topics in Control Engineering - I 3-0-0 3
- EEL365 Intelligent Control 3-0-0 3
- EEL370 Selected Topics in Computers - I 3-0-0 3
- EEL375 Embedded Systems 3-0-4 5
- EEL380 Selected Topics in Electronics - I 3-0-0 3
- EEL390 Selected Topics in Information and Communication Technology – I 3-0-0 3
- EEL404 Flexible AC Transmission System 3-0-0 3
- EEL420 Selected Topics in Electronics - II 3-0-0 3
- EEL422 Computers in Biomedicine 3-0-0 3
- EEL430 Selected Topics in Communication Engineering - II 3-0-0 3
- EEL432 Satellite Communication 3-0-0 3
- EEL433 Communication Systems - II 3-0-0 3
- EEL435 Optical Communication 3-0-0 3
- EEL441 Industrial Electronics 3-0-2 4
- EEL451 Power Systems Protection 3-0-0 3
- EEL452 HVDC Transmission 3-0-0 3
- EEL453 Power System Dynamics and Control 3-0-0 3
- EEL455 Power System Planning 3-0-0 3
- EEL456 Power Engineering - II 3-0-2 4
- EEL462 Selected Topics in Control Engineering - II 3-0-0 3
- EEL467 Identification and Adaptive Control 3-0-0 3
- EEL470 Selected Topics in Computers - II 3-0-0 3
- EEL472 Parallel and Distributed Processing 3-0-0 3
- EEL473 Computer Communication 3-0-0 3
- EEL482 Mechatronics 3-0-0 3
- EEL704 Robotics and Automation 3-0-0 3
- EEL706 Soft Computing 3-0-0 3
- EEL710 Coding Theory 3-0-0 3
- EEL713 Microwave Theory and Circuits 3-0-0 3
- EEL715 Image Processing 3-0-2 4
- EEL716 Telecommunication Switching and Transmission 3-0-0 3
- EEL736 Medical Electronics 3-0-0 3
- EEL746 Non-conventional Energy Sources and Energy Converters 3-0-0 3
- EEL749 Special Electromechanical Systems 3-0-0 3
- EEL754 Computer Graphics 3-0-2 4
- EEL758 Intelligent and Knowledge Based Systems 3-0-0 3
- EEL772 Optimal Control Theory 3-0-0 3
- EEL781 Neural Networks 3-0-0 3
- EEL790 Selected Topics in Information and Communication Technology - II 3-0-0 3
- EEP321 Measurements and Instrumentation Laboratory 0-0-3 1.5
- EEP443 FEM Analysis of Machines Laboratory 0-0-3 1.5
- EEP444 Electrical Machines and Industrial Drives Lab 0-0-3 1.5
- EEP467 Computer Control Laboratory 0-0-3 1.5
- EEP719 Communication Engineering Laboratory - II 0-0-3 1.5
- ES310 Independent Study (EE) 0-0-3 3
- EV401 Special Module in Communication Engineering 1-0-0 1
- EV402 Special Module in Power Systems, Machines and Power Electronics 1-0-0 1
- EV404 Special Module in Control Engineering 1-0-0 1
- EV405 Special Module in Computers 1-0-0 1
- EV704 Special Module in Computers 1-0-0 1
- MAL341 File Structures and Information Systems Design 3-0-2 4
- MAL342 Analysis and Design of Algorithms 3-1-0 4
- MAL373 Wavelets and Applications 3-1-0 4
- MAL382 Theory of Automata 3-1-0 4
- MAL710 Database Management Systems 3-0-2 4
- MAL717 Fuzzy Sets and Applications 3-1-0 4
- MAL745 Software Engineering 3-0-2 4
- MAL786 Cryptology 3-1-0 4
- EED412 Major Project Part 2 (EE) 0-0-16 8

### Elective Streams (DE-A, B, C)

#### Course Advice
- Information & Communication Technology: EEL358, EEL316, EEL319
- Integrated Electronics and Circuits: EEL219, EEL320, EEL319
- Control and Automation Engineering: EEL325, EEL704, EEL375
- Power, Machines and Power Electronics: EEL331, EEL441, EEL456

The student has to opt for one elective stream and must take all courses of that stream.
# B.Tech. in Electrical Engineering

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**Notes:**

- DC = 62, EAS = 21, BS = 20, HC = 2 (*either in 1st or 2nd sem.*)
- HU = 2@4 + 2@3 = 14 cr. from 4 courses.
- DC = 62, EAS = 21, BS = 20, HC = 2 (*either in 1st or 2nd sem.*)
- HU = 2@4 + 2@3 = 14 cr. from 4 courses.
- Req. DE=28, plan DE = 8/9 courses (or 6/7 courses+Major Project Part 2) + 1V course.
- Req. OC=33, plan OC = 6@4 + 3@3 = 33 cr. from 9 courses.

**TOTAL = 180.0**
Programme Code: EE2 / (EP)
Bachelor of Technology in Electrical Engineering (Power)
Department of Electrical Engineering

The overall credits structure

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Total credits = 180

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* In addition to the above BS core courses, either CYL110 or CYL120 has to be taken as an open category course for graduation.

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**TOTAL**: 180.0

DC = 62, EAS = 21, BS = 20, HC = 2 (* either in 1st or 2nd sem.*)

HU = 2@4 + 2@3 = 14 cr. from 4 courses.

Reqd. DE=28, plan DE = 8/9 courses (or 6/7 courses+Major Project Part 2) + 1V course.

Reqd. OC=33, plan OC = 6@4 + 3@3 = 33 cr. from 9 courses.
Programme Code: PH1 / (PH)
Bachelor of Technology in Engineering Physics
Department of Physics

The overall credits structure

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Total credits = 180

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**Total Credits:** 180.0

**Notes:**
- DC = 63, EAS = 20, BS = 20, HC = 2  (*either in 1st or 2nd sem.*)
- Reqd. DE=27, plan DE = 8 courses or 6 courses+Major Project Part 2.
- HU = 2@4 + 2@3 = 14 cr. from 4 courses.
- Reqd. OC=34, plan OC = 4@4 + 6@3 = 34 cr. from 10 courses.
# Programme Code: ME1 / (ME)

**Bachelor of Technology in Mechanical Engineering**

Department of Mechanical Engineering

## The overall credits structure

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*Total credits = 180*

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### Humanities and Social Sciences (HC) Core

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### Departmental Electives (DE)

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|          | MEL211 Kin & Dynamics | 5 | 10 |
|          | MEL212 Mec Engg Dwg | 5 | 10 |
|          | MAL120 Math 2 | 2 | 4 |
|          | PHP100 Phys Lab | 2 | 4 |
|          | HUN100 Intro Hu & So. Sc | 2 | 4 |
|          | CYP100 Engg Chemistry Lab | 2 | 4 |

| III      | MEL140 Mech Engg Fluids | 3 | 6 |
|          | MEL211 Kin & Dynamics | 5 | 10 |
|          | MAL120 Math 2 | 2 | 4 |
|          | PHP100 Phys Lab | 2 | 4 |
|          | HUN100 Intro Hu & So. Sc | 2 | 4 |
|          | CYP100 Engg Chemistry Lab | 2 | 4 |

| IV       | MEL211 Kin & Dynamics | 5 | 10 |
|          | MEL212 Mec Engg Dwg | 5 | 10 |
|          | MAL120 Math 2 | 2 | 4 |
|          | PHP100 Phys Lab | 2 | 4 |
|          | HUN100 Intro Hu & So. Sc | 2 | 4 |
|          | CYP100 Engg Chemistry Lab | 2 | 4 |
|          | HUL2xx Hu & So. Sc. #1 | 2 | 4 |

| V        | MEL241 Energy Conv. | 3 | 6 |
|          | MEL231 Mech. Lab | 3 | 6 |
|          | MEL232 Cast West Form | 3 | 6 |
|          | MEL233 Fluid Solid Lab | 3 | 6 |
|          | MEL241 Energy Conv. | 3 | 6 |
|          | MEL241 Energy Conv. | 3 | 6 |
|          | MEL241 Energy Conv. | 3 | 6 |

| VI       | MEL241 Energy Conv. | 3 | 6 |
|          | MEL231 Mech. Lab | 3 | 6 |
|          | MEL232 Cast West Form | 3 | 6 |
|          | MEL233 Fluid Solid Lab | 3 | 6 |
|          | MEL241 Energy Conv. | 3 | 6 |
|          | MEL241 Energy Conv. | 3 | 6 |
|          | MEL241 Energy Conv. | 3 | 6 |

| VII      | MEL410 Practical Training (ME) | 6 | 12 |
|          | MEL411 Colloquium | 6 | 12 |
|          | MEL411 Colloquium | 6 | 12 |
|          | MEL411 Colloquium | 6 | 12 |

| VIII     | MEL411 Colloquium | 6 | 12 |

|         | MEL411 Colloquium | 6 | 12 |

Total Credits: 180.0

DC = 59, EAS = 24, BS = 20, HC = 2 # either in 1st or 2nd sem. Reqd. OC = 30, plan OC = 9 courses.

Reqd. DE = 30, plan DE = 8 courses or 6 courses + Major Project Part 2.

HU = 2@4 + 2@3 = 14 cr. from 4 courses.

DC = 59, EAS = 24, BS = 20, HC = 2 # either in 1st or 2nd sem. Reqd. OC = 30, plan OC = 9 courses.
Programme Code: ME2 / (PE)
Bachelor of Technology in Production and Industrial Engineering
Department of Mechanical Engineering

The overall credits structure

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Total credits = 180

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Programme Code: TT1 / (TT)
Bachelor of Technology in Textile Technology
Department of Textile Technology

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Total credits = 180

Basic Sciences (BS) Core

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Engineering Arts and Sciences (EAS) Core

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### B.Tech. in Textile Technology

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Bachelor of Technology in Biochemical Engineering and Biotechnology, and Master of Technology in Biochemical Engineering and Biotechnology
Department of Biochemical Engineering and Biotechnology

The overall credits structure

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### B.Tech. + M.Tech. in Biochemical Engineering and Biotechnology

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| DC = 60, EAS = 20, BS = 20, HC = 2; PC = 32. (* either in 1st or 2nd sem.)

Reqd. OC=34, plan OC = 7@4 + 2@3 = 34 cr. from 9 courses.

Reqd. PE=16, plan PE = 1@4 + 4@3 = 16 cr. from 5 courses.

**TOTAL** = 218.0
**Programme Code: CH7**

**Bachelor of Technology in Chemical Engineering, and Master of Technology in Chemical Engineering**

**Department of Chemical Engineering**

### The overall credits structure

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**Total credits = 218**

### Basic Sciences (BS) Core

- CYL110 Physical Chemistry: Concepts and Applications 3-1-0 4
- CYL120 Inorganic and Organic Chemistry: Concepts and Applications 3-1-0 4
- CYP100 Chemistry Laboratory 0-0-4 2
- MAL110 Mathematics - I 3-1-0 4
- MAL120 Mathematics - II 3-1-0 4
- PHP100 Physics Laboratory 0-0-4 2
- TOTAL BS Core 12-4-8 20

*In addition to the above BS core courses, either PHL110 or PHL120 has to be taken as an open category course for graduation.*

### Engineering Arts and Sciences (EAS) Core

- AML120 Materials Science 3-0-2 4
- CSL101 Introduction to Computers and Programming 3-0-2 4
- CSL102 Introduction to Computer Science 3-0-2 4
- EEL102 Principles of Electrical Engineering 3-0-2 4
- MEL110 Graphic Science 2-0-4 4
- MEL120 Manufacturing Practices 2-0-4 4
- TOTAL EAS Core 13-0-14 20

### Humanities and Social Sciences (HC) Core

- HUN100 Introduction to Humanities and Social Sciences 0-0-4 2

### Departmental Electives (DE)

- CHL133 Powder Processing and Technology 3-1-0 4
- CHL260 Application of Programming in Chemical Engg. 3-0-2 4
- CHL275 Safety and Hazards in the Process Industries 3-1-0 4
- CHL277 Materials of Construction 3-0-0 3
- CHL291 Introduction to Biochemical Engineering 3-1-0 4
- CHL296 Nano Engineering of Soft Materials 3-0-0 3
- CHL332 Fluidization Engineering 3-1-0 4
- CHL353 Modern Separation Processes 3-1-0 4
- CHL390 Process Utilities and Pipeline Design 3-0-2 4
- CHL392 Polymer Science and Engineering 3-1-0 4
- CHL705 Electrokinitic Transport Phenomena 3-0-2 4
- CHL707 Adsorption Separation Processes 3-0-0 3
- CHL710 Process Dynamics and Control 3-1-2 5
- CHL722 Fundamentals of Fuel Cell Technology 3-0-2 4
- CHL724 Environmental Engng. and Waste Management 3-1-0 4
- CHL727 Heterogeneous Catalysis and Catalytic Processes 3-0-2 4

### Program Core (PC)

- CHL731 Introduction to Soft Matter 3-0-0 3
- CHL743 Petrochemical Technology 3-0-0 3
- CHL751 Multi-component Mass Transfer 3-0-0 3
- CHL766 Interfacial Engineering 3-0-0 3
- CHL768 Fundamentals of Computational Fluid Dynamics 2-0-2 3
- CHL773 Planning of Experiments and Analysis of Engineering Data 3-0-2 4
- CHL777 Bioprocessing and Bioseparation 3-0-0 3
- CHL792 Structure and Properties of Polymer in Solution 3-0-0 3
- CHL793 Membrane Science and Engineering 3-0-0 3
- CHL794 Petroleum Refinery Engineering 3-0-2 4
- CHR310 Professional Practices (CH) 0-1-2 4
- CHS310 Independent Study (CH) 0-3-0 3

**Total PC** 61-50 32

*CHD873 and CHD874 together are alternatives to CHD871 and CHD872.*

### Program Electives (PE)

- CHL704 Polymer Matrix Composites- Processes and Process Modelling 3-1-0 4
- CHL705 Electrokinitic Transport Phenomena 3-0-2 4
- CHL710 Process Dynamics and Control 3-1-2 5
- CHL711 Numerical Methods in Chemical Engineering 3-0-2 4
- CHL717 Mechnical Design of Process Equipment 3-0-2 4
- CHL724 Environmental Engineering & Waste Mgmt 3-1-0 4
- CHL727 Heterogeneous Catalysis & Catalytic Process 3-0-2 4
- CHL731 Introduction to Soft Matter 3-0-0 3
- CHL732 Soft Lithographic Methods for Nano-Fabrication 3-0-3 3
- CHL735 Design of Separation Processes 3-0-0 3
- CHL740 Special Topics 3-0-0 3
- CHL751 Multicomponent Mass Transfer 3-0-0 3
- CHL761 Chemical Engineering Mathematics 3-0-0 3
- CHL766 Interfacial Engineering 3-0-0 3
- CHP768 Fundamentals of Computational Fluid Dynamics 2-0-2 3
- CHL771 Process Operation Scheduling 3-0-2 4
- CHL774 Process Optimization 3-0-2 4
- CHL792 Structure and Properties of Polymer in Solution 3-0-0 3
- CHL793 Membrane Science and Engineering 3-0-0 3
- CHL794 Petroleum Refinery Engineering 3-0-2 4
- CHL807 Population Balance Modelling 3-0-0 3
- CHL869 Applications of Computational Fluid Dynamics 2-0-2 3

**Total DC** 35-15-20 60
## B.Tech. in Chemical Engg. + M.Tech. in Chemical Engineering

### Sem. I
- **CHN110**: Instr to Chem Engg (4 cr.)
- **CSL101/102**: Int Comp Prj/Sc (4 cr.)
- **MEL110**: Graphic Science (4 cr.)
- **MAL110**: Mathematics - I (4 cr.)
- **CYL120**: Inorg & Org Chem (4 cr.)
- **CYP100**: Chemistry Lab (2 cr.)
- **HUN100**: Intro Hu & So Sc (2 cr.)

### Sem. II
- **CHL110**: Transp Phen (4 cr.)
- **EEL102**: Ptn Elec Engg (4 cr.)
- **MEL120**: Mfg Practices (4 cr.)
- **MAL120**: Mathematics - II (4 cr.)
- **CYL110**: Physical Chem. (4 cr.)
- **PHP100**: Physics Lab (2 cr.)

### Sem. III
- **CHL111**: Matl Energy Bal. (4 cr.)
- **CHL121**: Ch Engg Thermo (4 cr.)
- **CHL231**: Fl Mech Ch Engr (3 cr.)
- **CHL251**: Heat Mass Trans (3 cr.)
- **AML120**: Materials Science (4 cr.)

### Sem. IV
- **CHL112**: Chem Proc Techn (4 cr.)
- **CHL122**: Ch React Engg-I (4 cr.)
- **CHL351**: Mass Transf Opms (4 cr.)
- **CHL301**: F M & H T Lab (4 cr.)

### Sem. V
- **CHL221**: Ch Read Engg-II (4 cr.)
- **CHL261**: Instr Proc Control (4 cr.)
- **CHL331**: Fluid-particle Mech (4 cr.)
- **CHP302**: MT & F P M Lab (4 cr.)

### Sem. VI
- **CHL471**: Proc Eq Des Eco (4 cr.)
- **CHL303**: Ch CE & PC Lab (4 cr.)
- **DE-1**: (3 cr.)
- **DE-2**: (3 cr.)
- **OC-3**: (2 cr.)

### Summer
- **CHT410**: Practical Training (CH) (6 cr.)

### Fall
- **CHC410**: Colloquium (CH) (3 cr.)
- **CHL701**: Process Engg (3 cr.)
- **DE-3**: (3 cr.)
- **DE-4**: (3 cr.)

### Winter
- **CHL721**: Adv Ch E Thermo (3 cr.)
- **CHD771**: Minor Project (3 cr.)
- **DE-5**: (3 cr.)

### Spring
- **CHD871**: Major Project Part 1 (CM) (12 cr.)

### Summer
- **CHD872**: Major Project Part 2 (CM) (12 cr.)

**TOTAL Credits:** 218.0

**Notes:**
- DC = 60, EAS = 20, BS = 20, HC = 2; PC = 32.
- Reqd. DE=20, plan DE = 5 courses.
- HU = 2@4 + 2@3 = 14 cr. from 4 courses.
- Reqd. PE=16, plan PE = 4@4 = 16 cr. from 4 courses.
- Req. OC=34, plan OC = 7@4 + 2@3 = 34 cr. from 9 courses.
Programme Code: CS5 / (CO)

Bachelor of Technology in Computer Science and Engineering, and
Master of Technology in Computer Science and Engineering
Department of Computer Science and Engineering

The overall credits structure

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Total credits = 216

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Departmental Core (DC)

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<td>CSL356 Analysis and Design of Algorithms</td>
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## Programme Code: EE5 / (EI)
**Bachelor of Technology in Electrical Engineering, and Master of Technology in Information and Communication Technology**

### Department of Electrical Engineering

#### The overall credits structure

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### Program Electives (PE)

#### Basic Sciences (BS) Core

- CYP100 Chemistry Laboratory 0-0-4 2
- MAL11 Introduction to Analysis and Differential Equations 3-1-0 4
- MAL250 Introduction to Probability Theory and Stochastic Processes 3-1-0 4
- PHL110 Fields and Waves 3-1-0 4
- PHP100 Physics Laboratory 0-0-4 2
- **TOTAL BS Core** 12-4-8 20

#### Program Core (PC)

- EED851 Major Project Part 1 (EI) 0-0-12 6
- EED852 Major Project Part 2 (EI) 0-0-28 14
- EED853 Major Project Part 1 (EI) 0-0-8 4
- EED854 Major Project Part 2 (EI) 0-0-32 16
- EEL703 Computer Networks 3-0-0 3
- EEL707 Multimedia Systems 3-0-2 4
- EEL711 Signal Theory 3-0-0 3
- EEP702 Software Laboratory 0-0-4 2
- **TOTAL PC** 9-0-46 32

* EED853 and EED854 together are alternatives to EED851 and EED852.

#### Program Electives (PE)

- CSL858 Advanced Computer Networks 3-0-2 4
- CSL859 Advanced Computer Graphics 3-0-2 4
- CSL867 Special Topics in High Speed Networks 3-0-0 3
- EED750 Minor Project (EI) 0-0-6 3
- EEL702 Computer System Software 3-0-2 4
- EEL704 Robotics and Automation 3-0-0 3
- EEL706 Soft Computing 3-0-0 3
- EEL708 Information Retrieval 3-0-0 3
- EEL709 Pattern Recognition 3-0-0 3
- EEL710 Coding Theory 3-0-0 3
- EEL714 Information Theory 3-0-0 3
- EEL715 Image Processing 3-0-2 4
- EEL718 Statistical Signal Processing 3-0-0 3
- EEL754 Computer Graphics 3-0-2 4
- EEL758 Intelligent and Knowledge Based Systems 3-0-0 3
- EEL767 Telecommunication Systems 3-0-0 3
- EEL768 Detection and Estimation Theory 3-0-0 3
- EEL781 Neural Networks 3-0-0 3
- EEL804 Scientific Visualization 3-0-0 3
- EEL806 Computer Vision 3-0-0 3
- EEL817 Access Networks 3-0-0 3
- EEL851 Special Topics in Computers - I 3-0-0 3
- EEL852 Special Topics in Computers - II 3-0-0 3
- EEL853 Agent Technology 3-0-0 3
- EEL854 Protocol Engineering 3-0-2 4
- EEL855 Internet Technologies 3-0-2 4
- EEL857 Network Security 3-0-2 4
- EEL858 Mobile Computing 3-0-0 3
- EEL859 Network Management 3-0-2 4
- EEL861 Selected Topics in Communication Engineering - I 3-0-0 3
- EEL862 Selected Topics in Communication Engineering - II 3-0-0 3
- EEL863 Selected Topics in Communication Engineering - III 3-0-0 3
- EEV704 Special Module in Computers 1-0-0 1

### Humanities and Social Sciences (HC) Core

- HUN100 Introduction to Humanities and Social Sciences 0-0-4 2

### Departmental Electives (DE)

The list of Departmental Elective courses for this dual degree program is identical to the list of Departmental Elective courses for the 4-year Bachelor of Technology in Electrical Engineering program. Please refer to the list given on page no. 26. Also see EE1 Programme for Elective streams DE-A, -B, -C.
63

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AML110

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EEP201

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Maj Proj P-2 (EI)

EED852

0

Maj Proj P-1 (EI)

EED851

3

0

Reqd. DE=21, plan DE = 6 courses + 1 V-course.

0

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2

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3

2

4

3 1
DE-A

3

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2

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0

Computer Arch

EEL308

0

Data Structures

CSL201

3

4

3

4

5

4

Int Comp Prg/Sc

3 1.5 3 0
DE-B
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PE-2
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DE-3

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DE-1

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DE-5

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OC-5

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OC-2

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OC-9

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OC-7

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OC-6

3

OC-3

3

OC-1

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HUN100 ¿
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3

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0

0

0

0

4

Hu. & So. Sc. #4

HUL2xx

2

Hu. & So. Sc. #3

HUL2xx

3

Hu. & So. Sc. #2

HUL2xx

3

Hu. & So. Sc. #1

HUL2xx

0

Intro Hu & So Sc

Reqd. PE=16, plan PE = 4@3 + 1@4 = 16 cr. from 5 courses.

Reqd. OC=33, plan OC = 6@4 + 3@3 = 33 cr. from 9 courses.

EED852 Major Project Part 2 (EI)

3

0

0

0

Des Practice (EE)

EEP211

3 1.5 0

Comp Tech Lab

EEP308

3

Prob Stoch Proc.

MAL250

0

2

EED851 Major Project Part 1 (EI)
PE-3
PE-4
PE-5
OC-8

3

PE-1

4

Chemistry Lab

EET410 Practical Training (EE)
DE-C
OC-4

3

0

(¿ either in 1st or 2nd sem.)
HU = 2@4 + 2@3 = 14 cr. from 4 courses.

4

Software Lab

3

Compu Networks Multimedia Sys

0

0

EEP702

3

0

EEL707

0

EEL703

3

3 1.5

EEL711

2

Signal Theory

3

EEC410

0

Colloquium (EE)

0

Electromag Lab

3

Power Engg Lab

0

EEP307

1

EEP303

3

3 1.5 0 0
DE-2

EEP306

3 1.5 3

EEP301

1

PHP100
Physics Lab

CSL101/102 CYP100

3

3 1.5 3

EEL306

0

Electromech Lab

EEP203

3

Alg Matrix Analy

4

4

4

4

0

Electronics Lab - II Communic Engg

4

1

MAL124

3

Control Engg Lab Comm Engg Lab

EEL303

0

4

PHL110

Analysis Diff Eqns Fields & Waves

Engg Electromag Power Engg - I

EEL207

1

EEP204

3 1.5 3

Analog Elec Cir

4

4

Control Engg - I

0

EEL204

1

EEL301

3

Digital Electronics Electronics Lab - I Circuit Theory

EEL201

3

Electromechanics Engg Mechanics

3

Signals Systems

2

EEL203

4

EEL205

0

DC = 59, EAS = 21, BS = 20, HC = 2; PC = 32.

summer

X

IX

summer

VIII

VII

summer

VI

V

IV

III

II

0

Mfg Practices

MAL111

0

5

5

5

NC

6

6

5

5

5

4

Intro to Elec Engg Fund Elec Engg

MEL120

I

EEL101

Sem.

EEN110

Lect
cour

8

8

2

0 28

TOTAL =

0

15 1 14

16 0

15 5

18 1 10

17 4.0 6

15 4 10

15 4 10

15 3

11 2 18

L T P

(EI) EE5

28

30

24

22

29

14

23

20

21

24

24

24

24

22

22

218.0

27.0

29

29

26

31

Week
cont.

B.Tech. in Electrical Engg. + M.Tech. in Information and Communication Technology
Cr.


## Programme Code: MT5 / (MT)
**Master of Technology in Mathematics and Computing**

Department of Mathematics

### The overall credits structure

<table>
<thead>
<tr>
<th>Integrated Core (IC)</th>
<th>Integrated Elective (IE)</th>
</tr>
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<tbody>
<tr>
<td><strong>Category</strong></td>
<td><strong>Credits</strong></td>
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<td>EAS</td>
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<tr>
<td>HU</td>
<td>2</td>
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Total credits = 216

### Basic Sciences (BS) Core

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<thead>
<tr>
<th>Course</th>
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<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>CYL110 Physical Chemistry: Concepts and Applications</td>
<td>BS</td>
<td>3-1-0 4</td>
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<tr>
<td>CYP101 Chemistry Laboratory</td>
<td>BS</td>
<td>0-0-4  2</td>
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<tr>
<td>MAL115 Multivariable Calculus and Matrix Theory</td>
<td>BS</td>
<td>3-1-0  4</td>
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<tr>
<td>MAL122 Real and Complex Analysis</td>
<td>BS</td>
<td>3-1-0  4</td>
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<tr>
<td>PHL120 Physics of Materials</td>
<td>BS</td>
<td>3-1-0  4</td>
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<tr>
<td>PHP100 Physics Laboratory</td>
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<tr>
<td><strong>TOTAL BS Core</strong></td>
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### Engineering and Sciences (EAS) Core

<table>
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<tr>
<th>Course</th>
<th>Category</th>
<th>Credits</th>
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<tbody>
<tr>
<td>AML110 Engineering Mechanics</td>
<td>EAS</td>
<td>3-0-2  4</td>
</tr>
<tr>
<td>CSL101 Introduction to Computers and Programming OR</td>
<td>EAS</td>
<td>3-0-2  4</td>
</tr>
<tr>
<td>CSL102 Introduction to Computer Science</td>
<td>EAS</td>
<td>3-0-2  4</td>
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<tr>
<td>CSL201 Data Structures</td>
<td>EAS</td>
<td>3-0-4  5</td>
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<td>EEL101 Fundamentals of Electrical Engineering</td>
<td>EAS</td>
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<tr>
<td>MEL110 Graphical Science</td>
<td>EAS</td>
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<td><strong>TOTAL EAS Core</strong></td>
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### Humanities and Social Sciences (HC) Core

<table>
<thead>
<tr>
<th>Course</th>
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<th>Credits</th>
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<tr>
<td>HUN100 Introduction to Humanities and Social Sciences</td>
<td>HC</td>
<td>0-0-4  2</td>
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### Integrated Core (IC)

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<tr>
<th>Course</th>
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<tbody>
<tr>
<td>EEL201 Digital Electronic Circuits</td>
<td>IC</td>
<td>3-1-0  4</td>
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<tr>
<td>EEL308 Computer Architecture</td>
<td>IC</td>
<td>3-1-0  4</td>
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<tr>
<td>EEP201 Electronics Laboratory - I</td>
<td>IC</td>
<td>0-0-3  1.5</td>
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<td>EEP308 Computer Technology Laboratory</td>
<td>IC</td>
<td>0-0-3  1.5</td>
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<tr>
<td>MAC450 Colloquium (MT)</td>
<td>IC</td>
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<td>MAD854 Major Project Part 2 (MT)</td>
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<td>MAL180 Discrete Mathematical Structures</td>
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<td>MAL230 Numerical Methods and Computation</td>
<td>IC</td>
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<td>MAL245 Topology and Functional Analysis</td>
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<td>3-1-0  4</td>
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<tr>
<td>MAL250 Introduction to Probability Theory and Stochastic Processes</td>
<td>IC</td>
<td>3-1-0  4</td>
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<tr>
<td>MAL255 Linear Algebra</td>
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<td>3-1-0  4</td>
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<td>MAL335 Differential Equations: Theory and Numerical Methods</td>
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<tr>
<td>MAL342 Analysis and Design of Algorithms</td>
<td>IC</td>
<td>3-1-0  4</td>
</tr>
<tr>
<td>MAL358 Operating Systems</td>
<td>IC</td>
<td>3-0-2  4</td>
</tr>
<tr>
<td>MAL390 Statistical Methods and Algorithms</td>
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<td>3-1-0  4</td>
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<tr>
<td>MAL710 Database Management Systems</td>
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<td>3-0-2  4</td>
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<tr>
<td>MAL715 Digital Image Processing</td>
<td>IC</td>
<td>3-0-2  4</td>
</tr>
<tr>
<td>MAL745 Software Engineering</td>
<td>IC</td>
<td>3-0-2  4</td>
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<td>MAL754 Principles of Computer Graphics</td>
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<td>MAN150 Introduction to Mathematics and Computing</td>
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<td>0-0-4  2</td>
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<tr>
<td>MAP290 System Design Laboratory</td>
<td>IC</td>
<td>0-0-4  2</td>
</tr>
<tr>
<td>MAT450 Practical Training (MT)</td>
<td>IC</td>
<td>0-0-4  2</td>
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<tr>
<td><strong>TOTAL IC</strong></td>
<td></td>
<td>45-13-64 90</td>
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* MAD853 and MAD854 together are alternatives to MAD851 and MAD852.
## Integrated M.Tech. in Mathematics and Computing

### MA5

<table>
<thead>
<tr>
<th>Sem.</th>
<th>MAN150</th>
<th>MEL101</th>
<th>CSL 101/102</th>
<th>MAL115</th>
<th>CYL110</th>
<th>CYP100</th>
<th>HUN100</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>Week</th>
<th>Total</th>
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<tr>
<td>I</td>
<td>Inter Math &amp; Comp</td>
<td>Graphic Science</td>
<td>Intro Comp Prog</td>
<td>Multivar Calculus</td>
<td>Physical Chem.</td>
<td>Chemistry Lab</td>
<td>Intro Hu &amp; So Sc</td>
<td>4</td>
<td>11</td>
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<td>II</td>
<td>AML110</td>
<td>CSL201</td>
<td>EEL101</td>
<td>MAL122</td>
<td>PHL120</td>
<td>PHP100</td>
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<td>MAL710</td>
<td>MAL715</td>
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<td>Topo Func Analy</td>
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<td>HUL2xx</td>
<td>Hu &amp; So. Sc. #3</td>
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<td>VIII</td>
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<td>DE-8</td>
<td>DE-9</td>
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<td>DE-11</td>
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<td>X</td>
<td>MAD852</td>
<td>Maj Proj P-3 (MT)</td>
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</tbody>
</table>

### Notes
- **IC = 90, EAS = 21, BS = 20, HC = 2.** (*either in 1st or 2nd sem.*)
- Reqd. DE=40, plan DE = 7@4 + 4@3 = 40 cr. from 11 courses.
- HU = 2@4 + 2@3 = 14 cr. from 4 courses.
- Reqd. OC=29, plan OC = 5@4 + 3@3 = 30 cr. from 8 courses.
- TOTAL = 216.0
7. MINOR AREA STRUCTURES

Minor Area in Computer Science and Engineering
Department of Computer Science and Engineering

Eligibility/Restrictions
This minor area is not available to students of the following programmes: (i) B. Tech. in Electrical Engineering, (ii) Dual degree B.tech. in Electrical Engineering + M.Tech. in (information and Communication Technology), and (iii) Integrated M.Tech. in Mathematics and Computing.

Core courses
CSL201 Data Structures 3-0-2 4
CSL211 Computer Architecture 3-1-2 5

Elective courses
CSL302 Programming Languages 3-0-4 5
CSL332 Introduction to Database Systems 3-0-3 4.5
CSL356 Analysis and Design of Algorithms 3-1-0 4
CSL373 Operating Systems 3-0-4 5
CSL374 Computer Networks 3-0-3 4.5
CSL433 Artificial Intelligence 3-0-2 4

Minor Area in Computational Mechanics
Department of Applied Mechanics

Eligible/Restrictions
As per section 3.12.

Core courses
Any one of the following
AML140 Mechanics of Solids 3-1-0 4
AML150 Mechanics of Solids and Fluids 3-1-2 5
AML160 Mechanics of Fluids 3-1-0 4
AML170 Fluid Mechanics 3-1-2 5
AML180 Solid Mechanics 3-1-2 5
CHL204 Transport Processes-II 3-1-0 4
CHL231 Fluid Mechanics for Chemical Engineers 3-1-0 4

And
AML310 Computational Mechanics 3-0-2 4

Elective courses
AML300 Constitutive Modelling and Application of New Materials 3-0-0 3
AML340 Chaos in Engineering Systems 3-0-0 3
AML360 Engineering Fluid Flows 3-1-0 4
AML410 Computational Methods in Fluid Dynamics 3-0-2 4
AML430 Advanced Computational Methods 3-1-0 4
AML440 Parallel Processing in Computational Mechanics 3-0-2 4
AML705 Finite Element Methods 3-0-2 4
AML710 Computer Aided Design and Design Methods 3-0-2 4

Minor Area in Biochemical Engineering and Biotechnology
Department of Biochemical Engineering and Biotechnology

Eligibility/Restrictions
As per section 3.12.

Core Courses
BEL110 Molecular Cell Biology 3-0-0 3
CHL291 Introduction to Biochemical Engineering 3-1-0 4

Elective Courses
BEL401 Bioprocess Technology 3-0-0 3
BEL413 Modelling and Simulation of Bioprocesses 3-0-2 4
BEL416 Membrane Applications of Bioprocessing 3-0-0 3
BEL418 Bioinformatics 2-0-2 3
BEL422 Solid State Cultivation 3-0-0 3

BEL701 Biotechnology Resource Planning and IPR Issues 2-0-0 2
BEL713 Microbial Engineering 3-0-0 3
BEL714 Protein Science and Engineering 3-0-0 3
BEL715 Biological Waste Treatment 3-0-2 4
BEL720 Biotechnology in Processiong 3-0-0 3
BEL721 Bionanotechnology 3-0-0 3

Minor Area in Process Engineering
Department of Chemical Engineering

Eligibility/Restriction
This minor area is nor available to students of Dual degree B.Tech. and M.tech in Biochemical Engineering and Biotechnology.

Core courses
CHL110 Transport Phenomena 3-1-0 4
CHL111 Material and Energy Balance 2-2-0 4

Elective Courses
CHL112 Chemical Process Technology 3-1-0 4
CHL231 Fluid Mechanics for Chemical Engineers 3-1-0 4
CHL251 Heat and Mass Transfer 3-1-0 4
CHL122 Chemical Reaction Engineering-I 3-1-0 4
CHL261 Instrumentation and Process Control 3-1-0 4
CHL331 Fluid-particle Mechanics 3-1-0 4
CHL275 Safety and Hazards in the Process Industries 3-1-0 4

Minor Area in Business Management
Department of Management Studies

Eligibility/Restrictions
As per section 3.12.

Core courses
SML391 Organization and Human Resource Management 3-1-0 4
SML494 Management Accounting and Financial Management 3-1-0 4

Elective courses
SML720 Business Environment and Corporate Strategy 2-0-2 3
SML745 Operations Management 2-0-2 3
SML760 Marketing Management 2-0-2 3
SML740 Quantitative Methods in Management 2-0-2 3
SML780 Managerial Economics 2-0-2 3
SML710 Creative Problem Solving 2-0-2 3
SML713 Information Systems Management 2-0-2 3
SML887 Business Law 2-0-2 3

Minor Area in Energy Technology
Department of Mechanical Engineering

Eligibility/Restrictions
As per section 3.12.

Core Courses
MEML140 Engineering Thermodynamics 3-1-0 4
MEML241 Energy Conversion 3-0-2 4

Elective courses
MEML242 Heat and Mass Transfer 3-1-0 4
MEML0341 Thermal Engineering Laboratory 1.5
MEML341 Bio Energy and Propulsion 3-0-2 4
MEML342 Power Plant Technology 3-0-2 4
MEML343 Fuels, Combustion and Pollution 3-0-2 4
MEML345 I.C. Engines 3-0-2 4
MEML346 Turbo-machinery 3-0-2 4
**Minor Area in Systems Dynamics and Control**  
Department of Mechanical Engineering

Eligibility/Restrictions  
As per Section 3.12.

Core courses  
MEL211 Kinematics and Dynamics of Machines 3-0-2 4

Elective courses  
MEL312 Control Theory and Applications 3-1-2 5
MEL316 Mechanical Vibrations 3-0-2 4
MEL411 Mechatronics 3-0-2 4
MEL415 Vibrations Engineering Design 3-0-2 4
MEL416 Robotics Engineering 3-1-0 4

---

**Minor Area in Nano Science and Engineering**  
Department of Physics

Eligibility/Restrictions  
As per Section 3.12

Core courses  
PHL120 Physics of Materials 3-1-0 4
EPL206 Solid State Physics 3-1-0 4

Elective courses  
EPL211 Principles of Material Synthesis 3-1-0 4
EPL335 Low Dimensional Physics 3-1-0 4
EPL444 Functional Nanostructures 3-0-0 3
EPL446 Applied Electrodynamics and Radiation 3-0-0 3
CHL296 Nano Engineering of Soft Materials 3-0-0 3
BEL721 Bionanotechnology 3-0-0 3
PHL727 Quantum Heterostructures 3-0-0 3
EPV430 Special Topics in Nano-Technology 1-0-0 1
EPV450 Selected Topics in Nano-Technology 2-0-0 2

---

**Minor Area in Photonics**  
Department of Physics

Eligibility/Restrictions  
As per Section 3.12

Core courses  
PHL110 Fields and Waves 3-1-0 4
EPL105 Optics 3-1-0 4

Elective Courses  
EPL334 Lasers 3-0-0 3
EPL336 Semiconductor Optoelectronics 3-1-0 4
EPL440 Quantum Electronics 3-0-0 3
EPL442 Fiber and Integrated Optics 3-0-0 3
EPL443 Holography and Optical Information Processing 3-0-0 3
EPL445 Engineering Optics 3-0-0 3
EPV431 Special Topics in Photonics and Opto-electronics 1-0-0 1
EPV451 Selected Topics in Photonics and Opto-electronics 2-0-0 2

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**Minor Area in Atmospheric Sciences**  
Center for Atmospheric Sciences

Eligibility/Restrictions  
As per Section 3.12

Core courses  
ASL310 Fundamentals of Atmosphere and Ocean 3-0-2 4
ASL320 Climate Change: Impacts. Adaptation and Mitigation 3-0-2 4

Elective Courses  
ASL410 Numerical Simulation of Atmospheric and Oceanic Phenomena 3-0-2 4
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
ASL707 Mathematical & Statistical Methods in Atmospheric Sciences 3-0-0 3
ASL710 Atmospheric Physics 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
ASL804 Air Quality Monitoring and Health Risk Assessment 2-0-2 3
ASL808 Atmospheric Chemistry and Aerosols 3-0-0 3
ASL819 High Performance Computing in Atmospheric Science 2-0-2 3

**Minor Area in Biological Sciences**  
School of Biological Sciences

Eligibility/Restrictions :  
As per Section 3.12

Core courses  
SBL101 Modern Biology for Engineers 3-0-0 3
SBL201 High-Dimensional Biology 3-0-0 3
SBP200 Introduction to Practical Modern Biology 0-0-4 2

Elective Courses  
SBL701 Biometry 3-0-0 3
SBL702 Systems Biology 3-0-0 3
BEL421 Metabolic Regulation and Engineering 3-0-0 3
CYL726 Cheminformatics and Molecular Modeling 3-0-0 3
BEL412 Immunology 3-0-2 4
SBL704 Human Virology 3-0-0 3
SBL707 Bacterial Pathogenesis 3-0-0 3
SBL708 Epigenetics in Health and Disease 3-0-0 3
BEL511 Physical and Chemical Properties of Biomolecules 3-0-0 3
SBL705 Biology of Proteins 3-0-0 3
BEL714 Protein Science and Engineering 3-0-0 3
BEL722 Genomics and Proteomics 3-0-0 3
SBL703 Advanced Cell Biology 3-0-0 3
SBL706 Biologics 3-0-0 3
SBL709 Marine Bioprospecting 3-0-0 3
SBL710 Chemical Biology 3-0-0 3
BML700 Introduction to Basic Medical Sciences for Engineers 3-0-0 3
CHL291 Introduction to Biochemical Engineering 3-1-0 4
SBD301 Mini Project 0-0-6 3

Guidelines: It is expected that students would complete the requirements of the Minor Area by exploring any of the above elective courses to be able to explore a variety of areas within the diverse field of biological sciences. However, an option of focusing on a particular aspect of biological sciences in the Minor Area has also been provided based on grouping of electives. For example: Choosing any 3 electives from S.Nos. 1-4 will equip students with background in computational biology, S.Nos. 5-8 will equip students with background in infectious diseases, S.Nos. 9-12 will equip students with proteomics, and, S.Nos. 13-18 will equip students with background in applied biological sciences. On the same lines, S.Nos. 2, 3 and 12 will equip the students with background in systems biology.
8. COURSES OF “ENVIRONMENTAL STUDIES” CATEGORY

**UG COURSES**

- CEL100 Earth and earth process
- CEL110 Basic concepts in sustainable development
- CEL120 Pollution, prevention and control
- CEL140 Environmental studies
- HUL262 Environment psychology
- CHL274 Environmental Engineering and waste Management
- CHL275 Safety and hazards in the process industries
- HUL275 Environment, development and society
- ESL330 Energy, Ecology and Environment
- ESL340 Non-conservational sources of energy
- RDL340 Technology and community development
- CEL411 Industrial waste management
- CEL412 Environmental assessment methodologies
- CEL443 Transportation safety and environment

**PG COURSES**

- ESL710 Energy, ecology and environment
- ESL720 Energy conservation
- ESL722 Integrated energy systems
- ESL725 Energy auditing
- 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
9. 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.

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<thead>
<tr>
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<td>Master of Business Administration programmes</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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**Total PC**  
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**Course Structure**

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**TOTAL = 53**
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<td>CEP770</td>
<td>Construction Engineering and Information Technology Lab</td>
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<td>Human Resources Management</td>
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### Programme Electives (PE)

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<td>Environmental Systems Analysis</td>
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<td>Life Cycle Analysis and Design for Environment</td>
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### P.G. Diploma in Metro Rail Transport

**Courses**

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<td>Const. Engg. &amp; Infr. Tech. Lab</td>
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**PE-1**

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**Summer**

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**TOTAL = 36**
# Master of Science in Chemistry

## Department of Chemistry

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#### Programme Core (PC)

- **CYD660** Project Part 1 (CYS) 0-0-6 3
- **CYD670** Project Part 2 (CYS) 0-0-16 8
- **CYL501** Molecular Thermodynamics 3-0-0 3
- **CYL502** Stereochemistry and Organic Reaction Mechanisms 3-0-0 3
- **CYL503** Main Group Chemistry and Inorganic Solids 3-0-0 3
- **CYL504** Biochemistry I 3-0-0 3
- **CYL505** Instrumental Methods of Analysis 3-0-0 3
- **CYL561** Quantum Chemistry 3-0-0 3
- **CYL562** Organic Synthesis 3-0-0 3
- **CYL563** Transition and Inner Transition Metal Chemistry 3-0-0 3
- **CYL564** Biochemistry II 3-0-0 3
- **CYL565** Chemical Dynamics and Surface Chemistry 3-0-0 3
- **CYL566** Physical Methods of Structure Determination of Organic Compounds 3-0-0 3
- **CYL601** Group Theory and Spectroscopy 3-0-0 3
- **CYL602** Pericyclic Reactions and Photochemistry 3-0-0 3
- **CYL603** Basic Organometallic Chemistry 3-0-0 3
- **CYL604** Biochemistry III 3-0-0 3
- **CYP501** Physical Chemistry Laboratory Course I 0-0-4 2
- **CYP502** Organic Chemistry Laboratory Course I 0-0-4 2
- **CYP503** Inorganic Chemistry Laboratory Course I 0-0-4 2
- **CYP504** Biochemistry Laboratory Course I 0-0-4 2
- **CYP561** Organic Chemistry Laboratory Course II 0-0-4 2
- **CYP562** Inorganic Chemistry Laboratory Course II 0-0-4 2
- **CYP563** Biochemistry Laboratory Course II 0-0-4 2

**Total PC**: 45-0-54 72

#### Programme Electives (PE)

- **CYL665** Solid State Chemistry 3-0-0 3
- **CYL666** Chemistry of Macromolecules 3-0-0 3
- **CYL667** Selected Topics in Spectroscopy 3-0-0 3
- **CYL668** Statistical Mechanics and Molecular Simulation Methods 3-0-0 3
- **CYL669** Biophysical Chemistry I 3-0-0 3
- **CYL675** Chemistry of Heterocyclic Compounds and Natural Products 3-0-0 3
- **CYL676** Bio-organic and Medicinal Chemistry 3-0-0 3
- **CYL677** Supramolecular Chemistry 3-0-0 3
- **CYL678** Recent Trends in Organic Chemistry 3-0-0 3
- **CYL685** Applied Organometallic Chemistry 3-0-0 3
- **CYL686** Inorganic Polymers 3-0-0 3
- **CYL687** Bioinorganic Chemistry 3-0-0 3
- **CYL688** Physical Methods in Inorganic Chemistry 3-0-0 3
- **CYL695** Applied Biocatalysis 3-0-0 3
- **CYL696** Non-aqueous Enzymology 3-0-0 3
- **CYL697** Selected Topics in Biochemistry 3-0-0 3

#### Semester-wise Breakup

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## Master of Science in Mathematics

**Department of Mathematics**

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**TOTAL = 90**
## Master of Science in Physics

### Department of Physics

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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.*

### M.Sc. in Physics

#### Courses

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**Total: 90 Credits**
**Master of Business Administration (Focus on Management Systems)**

Department of Management Studies

The overall credits structure

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<th>Non-credit core CA</th>
<th>Non-credit core NC</th>
<th>Cross Focus Elective FE</th>
<th>Specialization Elective SE</th>
<th>Non-credit Elective NE</th>
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**CORE COURSES**

**Programme Core (PC)**

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**Compulsory Bridge Core Courses (credits not to be counted for SGPA/CGPA calculation)**

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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:

- SML700 Fundamentals of Management of Technology 3-0-0 3
- SML723 Telecommunications Systems Management 3-0-0 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 page No. 80.

Students specializing in one particular stream should take 12 credits from that stream; and he/she 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)**

- SMCB91 Strategic Leadership Practice 0-0-2 NC
- Open Elective (OE)
  - SML714 Organizational Dynamics and Environment 3-0-0 3 Enterprises
  - SML734 Management of Small Scale Industrial 3-0-0 3
  - SMP783 Management Laboratory 0-0-6 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

Note: Also see the stipulation under Specialization Elective above.

---

**Programme Code:** SMF

**Sem.** | **Courses** (Number, abbreviated title, L-T-P, credits) | **Contact h/week** | **Credits**
--- | --- | --- | ---
I | SML710 Creative Prob Solving (2-0-2) | 14 0 12 26 | 18
II | SML713 Info Systems Management (2-0-2) | 17 0 7.5 24.5 | 18
Summer | SMT893 Industrial Training | 0 | 0

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

TOTAL = 72
**Programme Code:** SMT

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

**Department of Management Studies**

The overall credits structure

<table>
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**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. 80.

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)**

- SMC891 Strategic Leadership Practice 0-0-2 NC

**Compulsory Bridge Core Courses (credits not to be counted for SGPA/CGPA calculation)**

- SMP791 Computer Laboratory 0-0-2 1
- SMN793 Statistics for Management 1-0-0 1
- SMN794 Communication Skills 1-0-1 1.5
- SMN795 Systems Thinking 1-0-0 1
- SMN895 Management Research Methodology 1-0-0 1
- SMN896 Human Values in Management 1-0-0 1

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

**Non-credit core (NC)**

SMT893 Industrial Training -- NC

**Sem. Courses**

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

**TOTAL = 72**
**M.B.A. in Focus on Technology Management (Part Time)**

**Sem.** | Courses (Number, abbreviated title, L-T-P, credits) | Lecture Courses | Contact h/week | Total Credits |
---|---|---|---|---|
**I** | SML710 Creative Prob Solg (2 - 0 - 2) 3 | CA-1 (0 - 0 - 2) 1 | 6 11 0 6 17 12 |
| SML730 Organization Mgmt (3 - 0 - 0) 3 | CA-2 (1 - 0 - 0) 1 | | |
| SML731 Hum Resc Mgmt (3 - 0 - 0) 3 | | | |
| SML740 Quant. Meth Mgmt (2 - 0 - 2) 3 | | | |
**II** | SML702 Mgmt Innv R&D (3 - 0 - 0) 3 | CA-3 (1 - 0 - 0) 1 | 5 12 0 4 16 12 |
| SML745 Operations Mgmt (3 - 0 - 0) 3 | | | |
| SML770 Mgmt Acc & FM (2 - 0 - 2) 3 | | | |
| SMC894 Seminar (0 - 0 - 2) 1 | | | |
| Summer | | | | |
**III** | SML700 Fund of Mgmt Tech (3 - 0 - 0) 3 | CA-4 (1 - 0 - 0) 1 | 5 11 0 6 17 12 |
| SML720 Buss Env & CS (2 - 0 - 2) 3 | | | |
| SML760 Marketing Mgmt (2 - 0 - 2) 3 | | | |
| SML780 Managerial Econo (2 - 0 - 2) 3 | | | |
| SML701 Strategic Tech Mgmt (2 - 0 - 2) 3 | | | |
**IV** | SML703 Mgmt Tech T & A (2 - 0 - 2) 3 | OE-1 (3 - 0 - 0) 3 | 5 11 0 4 15 12 |
| SML701 Strategic Tech Mgmt (2 - 0 - 2) 3 | | | |
| Summer | SMD801 Major Project Part (SMN) | OE-3 (3 - 0 - 0) 3 | | |
**V** | SMD890 Major Proj (SMN) (0 - 0 - 12) 6 | SE-2 (3 - 0 - 0) 3 | 4 12 0 0 12 12 |
| SMD890 Major Proj (SMN) (0 - 0 - 12) 6 | SE-3 (3 - 0 - 0) 3 | | |
| SMD890 Major Proj (SMN) (0 - 0 - 12) 6 | SE-4 (3 - 0 - 0) 3 | | |
| SMD890 Major Proj (SMN) (0 - 0 - 12) 6 | OE-4 (3 - 0 - 0) 3 | | |
| VI | SMD890 Major Proj (SMN) (0 - 0 - 12) 6 | CA-6 (3 - 0 - 0) 3 | 3 7 0 12 19 12 |

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

### Specialization- Strategic Management

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<td>Strategic Change and Flexibility</td>
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<td>Database Design and Data Management</td>
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<td>Advertising and Sales Promotion Management</td>
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## Master of Design in Industrial Design

**Interdisciplinary Programme**

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<td>Communication and Presentation Skills</td>
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<td>Product Form and Aesthetics</td>
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| Total PC    | 16-3-125 | 81.5 |

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### M.Des. in Industrial Design

#### Summer

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### Summer

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### Summer

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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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**Total PC**: 21-3-42 45

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### M.Tech. in Engineering Mechanics

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**Total = 60**
### Master of Technology in Design Engineering

**Department of Applied Mechanics**

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#### Programme Core (PC)

- **AML813** Major Project Part 1 (AMD) 0-0-12 6
- **AML814** Major Project Part 2 (AMD) 0-0-24 12
- **AML710** Computer Aided Design 3-0-2 4
- **AML771** Decision Theory and Design Optimization 3-0-0 3
- **AML773** Modelling and Analysis 1 3-0-0 3
- **AML774** Modelling and Analysis 2 3-0-0 3
- **AML775** Design Methods 3-0-0 3
- **AML883** Properties and Selection of Engineering Materials 3-0-0 3
- **AMP772** Feasibility Study 1-0-4 3
- **AMP776** Product Design Project 1 1-0-4 3
- **AMP777** Product Design Project 2 0-0-4 2

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

#### Programme Electives (PE)

- **AML700** Experimental Methods for Solid and Fluids 3-0-2 4
- **AML734** Advanced Dynamics 3-1-0 4
- **AML835** Mechanics of Composite Materials 3-0-0 3
- **AML852** Engineering Failure Analysis and Prevention 3-0-0 3
- **AML871** Product Reliability and Maintenance 3-0-0 3
- **AML873** Design for Production 3-0-0 3
- **AMS802** Independent Study (AMD) 0-3-0 3
- **CEL717** Advanced Structural Analysis 3-0-0 3
- **DIP741** Product Form and Aesthetics 1-0-4 3
- **DIR813** Designing for Sustainable Development 1-0-3 2.5
- **EEL723** Microprocessor Based Industrial Control 3-0-0 3
- **EEL781** Neural Networks 3-0-0 3
- **MEL731** Design of Mechanisms and Manipulators 3-0-2 4
- **MEL749** Mechatronic Product Design 3-0-2 4

#### M.Tech. in Design Engineering

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**TOTAL = 60**
Master of Technology in Chemical Engineering
Department of Chemical Engineering

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**Total PC** 12-1-46 36

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**TOTAL = 60**
## Master of Technology in Molecular Engineering: Chemical Synthesis and Analysis

### Department of Chemistry

The overall credits structure

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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.

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

**Programme Code:** CYM

**Courses**

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**Total Credits:** 60
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**Total PC 21-0-54 48**

*CED701 (For Part time students only)*

*To be offered for other specialisations only.*

## Programme Electives (PE)

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### M.Tech. in Geotechnical and Geoenvironmental Engineering

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**TOTAL = 60**

*CED701 (For Part time students only)*
Master of Technology in Rock Engineering and Underground Structures
Department of Civil Engineering

The overall credits structure

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- **CED760** Minor Project in Rock Engineering and Underground Structures (CEU) 0-0-6 3
- **CED851** Major Project Part 1 (CEU) 0-0-12 6
- **CED852** Major Project Part 2 (CEU) 0-0-24 12
- **CEL751** Engineering Properties of Rocks and Rock Masses 3-0-0 3
- **CEL752** Slopes and Foundations 3-0-0 3
- **CEL753** Structural Geology 2-0-2 3
- **CEL754** Geotechnical Processes in Rock Engineering 3-0-0 3
- **CEL755** Excavation Methods and Machinery 3-0-0 3
- **CEL756** Field Exploration and Insitu Measurements 3-0-0 3
- **CEL757** Analysis and Design of Under Ground Structures 3-0-0 3
- **CEP751** Rock Mechanics Laboratory 1 0-0-6 3
- **CEP752** Rock Mechanics Laboratory 2 0-0-6 3

*Total PC 20-0-50 45

Programme Electives (PE)

- **CEL651** Rock Engineering 3-0-0 3
- **CEL760** Finite Element Method in Geotechnical Engineering 3-0-0 3
- **CEL761** Underground Space Technology 3-0-0 3
- **CEL762** Special Topics in Rock Engineering 3-0-0 3
- **CEL763** Environmental Rock Engineering 3-0-0 3
- **CEL801** Advanced Rock Mechanics 3-0-0 3
- **CES850** Independent Study (CEU) 0-3-0 3

*To be offered to other specialisations in Civil Engineering.

M.Tech. in Rock Engineering and Underground Structures

CEU

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* CED 760 for Part-time students only.

TOTAL = 60
## Master of Technology in Structural Engineering

**Department of Civil Engineering**

The overall credits structure

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

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### M.Tech. in Structural Engineering

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**TOTAL = 60**
# Master of Technology in Water Resources Engineering

**Department of Civil Engineering**

## The overall credits structure

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**Programme Core (PC)**

- **CED841** Major Project Part 1 (CEW) 0-0-12 6
- **CED842** Major Project Part 2 (CEW) 0-0-24 12
- **CEL735** Hydrologic Processes and Modeling 3-0-0 3
- **CEL737** Optimization Techniques in Water Resources 3-0-0 3
- **CEL738** Advanced Hydraulics 3-0-0 3
- **CEL739** Groundwater Hydrology 3-0-0 3
- **CEL741** Surface Water Quality Modelling and Control 3-0-0 3
- **CEL742** Finite Elements in Water Resources 3-0-0 3
- **CEP740** Simulation Laboratory 1-0-6 4

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

**Programme Electives (PE)**

- **CEL736** Environmental Dynamics and Management 3-0-0 3
- **CEL743** Economics Aspects of Water Resources Development 3-0-0 3
- **CEL744** Ground Water Flow and Pollution Modelling 3-0-0 3
- **CEL745** Water Management 3-0-0 3
- **CEL746** Hydroelectric Engineering 3-0-0 3
- **CEL747** Geographic information Systems 2-0-2 3
- **CEL748** Hydrologic Applications of Remote Sensing 3-0-0 3
- **CEL749** Water Resources Systems 3-0-0 3
- **CEL840** Stochastic Hydrology 3-0-0 3
- **CEP724** Water Resources Management Laboratory 1-0-4 3
- **CES840** Independent Study (CEW) 0-3-0 3

## M.Tech. in Water Resources Engineering

**CEW**

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**TOTAL = 61**
# Master of Technology in Construction Engineering and Management

Department of Civil Engineering

## The overall credits structure

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**Total PC** 19-2-48 45

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

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* 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

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## Master of Technology in Environmental Engineering and Management

Department of Civil Engineering

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**TOTAL = 60**
Master of Technology in Transportation Engineering
Department of Civil Engineering

The overall credits structure

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M.Tech. in Transportation Engineering (CEP)

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TOTAL = 60

M.Tech. in Computer Science and Engineering

- 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.
- Areas of specialization:
  2. Computer Networks and Distributed Systems, CSL724, CSL860, CSL867, CSV887, CSL838, CSL730.
## Master of Technology in Communications Engineering

**Department of Electrical Engineering**

The overall credits structure:

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**Total PC**

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

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## M.Tech. in Computer Technology

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**TOTAL =60**
# Master of Technology in Control and Automation

## Department of Electrical Engineering

The overall credits structure

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## M.Tech. in Control and Automation

### Sem.

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**TOTAL =61**
**Master of Technology in Integrated Electronics and Circuits**
Department of Electrical Engineering

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**Programme Electives (PE)**

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**M.Tech. in Integrated Electronics and Circuits**

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**TOTAL =60**
### Master of Technology in Power Electronics, Electrical Machines and Drives

Department of Electrical Engineering

The overall credits structure

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**Total PC**

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#### Programme Electives (PE)

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

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**TOTAL = 60**

*Ind. Training and seminar (EEP)

#Students opting for OE-1 in 1st sem should take PE-1 in 2nd sem and vice versa
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**TOTAL = 61**
Master of Technology in Design of Mechanical Equipment
Department of Mechanical Engineering

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**Total PC** | | | | **18-0-60 45** |

Programme Electives (PE)

List A1: Design Technology Elective
- MEL832 Multibody Systems and Vibration Design | 3-0-2 | 4 |
- 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 | 3-0-2 | 4 |
- MEL844 Designing With New Materials | 3-0-2 | 4 |

List A2: Equipment Design Elective
- MEL732 Machine Tool Design | 3-0-2 | 4 |
- MEL736 Automotive Design | 3-0-2 | 4 |
- MEL743 Plant Equipment Design | 3-0-2 | 4 |

List A3: Specialized Elective
- MEL734 Noise Engineering | 3-0-2 | 4 |
- MEL738 Dynamics of Multibody Systems | 3-0-2 | 4 |
- MEL739 Robotics | 3-0-2 | 4 |
- MEL741 Blade and Disc Dynamics | 3-0-2 | 4 |
- MEL842 Advanced Concurrent Engineering | 3-0-2 | 4 |
- MEL831 Advanced Theory of Vibrations | 3-0-2 | 4 |
- MEL835 Special Topics (MED) | 3-0-2 | 4 |
- MEL836 Advanced Lubrication | 3-0-2 | 4 |
- MEL837 Advanced Mechanisms | 3-0-2 | 4 |
- MEL838 Rotor Dynamics | 3-0-2 | 4 |
- MEL839 Precision Engineering | 3-0-2 | 4 |
- MEL840 Experimental Modal Analysis and Dynamic Design | 3-0-2 | 4 |
- MEL841 Advanced Structural Dynamics | 3-0-2 | 4 |
- MES830 Independent Study (MED) | 0-4-0 | 4 |

**TOTAL** | | | | **60** |

M.Tech. in Design of Mechanical Equipment

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**TOTAL** | | | | **60** |
# Master of Technology in Industrial Engineering

**Department of Mechanical Engineering**

The overall credits structure

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

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**Total = 60**
Master of Technology in Production Engineering
Department of Mechanical Engineering

The overall credits structure

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M.Tech. in Production Engineering

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# Master of Technology in Thermal Engineering

## Department of Mechanical Engineering

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* These are audit Courses

## M.Tech. in Thermal Engineering

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**TOTAL = 60-62**
## Master of Technology in Applied Optics

Department of Physics

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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**

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## M.Tech. in Solid State Materials

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

Department of Textile Technology

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Programme Electives (PE)

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

**Programme Code:** TTF

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

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**TOTAL = 60**
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Programme Electives (PE)

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M.Tech. in Radio Frequency Design and Technology

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TOTAL = 62
# Master of Technology in Atmospheric-Oceanic Science and Technology

Centre for Atmospheric Science

**The overall credits structure**

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Master of Technology in Computer Applications
Interdisciplinary Programme

The overall credits structure

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Programme Core (PC)

- JCD801 Major Project Part 1 (JCA) 3-0-2 4
- JCD802 Major Project Part 2 (JCA) 3-0-2 4
- CSL630 Data Structures and Algorithms# 3-0-2 4
- MAL701 Introduction to Programming and Data Structures# 3-0-2 4
- MAL704 Numerical Optimization# 3-0-2 4
- MAL708 Computer Organization and Operating Systems* 3-0-2 4
- CSL665 Introduction to Logic and Functional Programming 3-0-2 4
- EEL702 System Software 3-0-2 4
- MAL705 Discrete Mathematical Structures 3-0-0 3
- MAL710 Database Management Systems 3-0-2 4
- MAP706 Scientific Software Laboratory 0-0-6 3
- MAP707 Programming Languages Laboratory 0-0-4 2

Total PC 18-0-56 46

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

Programme Electives (PE)

- CSL758 Advanced Algorithms 3-0-0 3
- CSL781 Computer Graphics 3-0-3.5
- CSL783 Digital Image Analysis 3-0-3.5
- CSL840 Computer Vision 3-0-2 4
- CSL862 Special Topics in Software Systems 3-0-0 3
- CSL864 Special Topics in Artificial Intelligence 3-0-0 3
- CSL865 Special Topics in Computer Applications 3-0-0 3
- CSL866 Special Topics in Data Base Systems 3-0-0 3
- EEL703 Computer Networks 3-0-0 3
- EEL706 Computer Vision 3-0-2 4
- EEL707 Multimedia Systems 3-0-2 4
- EEL708 Information Retrieval 3-0-0 3
- EEL709 Pattern Recognition 3-0-0 3
- EEL715 Image Processing 3-0-2 4
- EEL751 Computer System Software 3-0-2 4
- EEL754 Computer Graphics 3-0-2 4
- EEL758 Intelligent and Knowledge Based Systems 3-0-0 3
- EEL804 Scientific Visualization 3-0-0 3
- EEL853 Agent Technology 3-0-0 3
- JCD799 Minor Project (JCA) 3-0-0 3
- JCS800 Independent Study (JCA) 3-0-0 3
- MAL702 Files Systems and Data Management 3-0-0 3
- MAL703 Numerical Algorithms for Parallel Computing 3-0-0 3
- MAL711 Algorithmic Combinatorics 3-0-0 3
- MAL714 Finite Element Techniques and Computer Implementation 3-0-0 3
- MAL715 Statistical Computing 3-0-0 3
- MAL717 Fuzzy Sets and Applications 3-0-0 3
- MAL720 Neuro-Computing and Applications 3-0-0 3
- MAL724 Cryptology 3-0-0 3
- MAL732 Financial Mathematics 3-1-0 4
- MAL733 Stochastics of Finance 3-1-0 4
- MAL754 Principles of Computer Graphics 3-0-2 4
- MAL803 Pattern Recognition 3-0-0 3
- MAL823 Special Topics in Computer Applications 3-0-0 3
- SML815 Decision Support and Expert Systems 2-0-2 3

The overall credits structure

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Programme Electives (PE)

- CSL665 Introduction to Logic and Functional Programming 3-0-2 4
- EEL702 System Software 3-0-2 4
- MAL705 Discrete Mathematical Structures 3-0-0 3
- MAL710 Database Management Systems 3-0-2 4
- MAP706 Scientific Software Laboratory 0-0-6 3

Total PC 18-0-56 46

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

Programme Electives (PE)

- CSL630 Data Structures and Algorithms# 3-0-2 4
- OR
- MAL701 Introduction to Programming and Data Structures# 3-0-2 4
- OR
- MAL708 Computer Organization and Operating Systems* 3-0-2 4

TOTAL = 60
Master of Technology in Energy Studies
Interdisciplinary Programme

The overall credits structure

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M.Tech. in Energy Studies

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TOTAL = 60
**Master of Technology in Energy and Environmental Management**

**Interdisciplinary Programme**

The overall credits structure

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**Compulsory bridge core courses (credits not to be counted for SGPA/CGPA calculation)**

- ESN704 Basic Thermal Engineering #
- ESN712 Basic Electrical Engineering*
- ESN794 Principles of Chemical Processes and Combustion +
- ESN735 Energy Auditing 1-0-0 0
- ESN791 Applied Mathematics and Computational Methods 1-0-0 0

**Total PC**

- 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 3-0-0 3
- ESL784 Cogeneration and Energy Efficiency 3-0-0 3

**Module – B**

- ESL756 Energy Policy and Planning 3-0-0 3
- ESL764 Environmental Economics 3-0-0 3
- ESL766 Environmental Regulation 3-0-0 3

**Module – C**

- ESL718 Power Generation, Transmission and Distribution 3-0-0 3
- ESL860 Electrical Power System Analysis 3-0-0 3
- ESL804 Pollution Control in Power Plants 3-0-0 3

**Module – D**

- ESL788 Industrial and Commercial Applications of Renewable Energy Sources 3-0-0 3
- ESL736 Power from Renewable and Environmental Impacts 3-0-0 3
- ESL742 Economics and Financing of Renewable Energy Systems 3-0-0 3

**Total Credits**

**M.Tech. in Energy and Environmental Management**

**JEN**

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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.

**Total = 60**
### 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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**TOTAL = 61**
## Programme Code: JID

### Master of Technology in Instrument Technology

#### Interdisciplinary Programme

The overall credits structure

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**TOTAL = 61**
**Master of Technology in Optoelectronics and Optical Communication**

Interdisciplinary Programme

The overall credits structure

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**Programme Code:** JOP

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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**

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

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### Summer Courses

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**Total** 60

**TOTAL= 60**
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**Total PC** 3-0-42 24

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## VLSI Design Stream

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## VLSI Systems Stream

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### Notes

- VLSI Design Stream
- VLSI Systems Stream
- Overall credits structure of the two streams
- Programme Electives (PE)

---

*Programme Code: JVL*
**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
Master of Technology in Telecommunication Technology and Management

The overall credits structure

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Programme Core (PC)

- EEL711 Signal Theory 3-0-0 3
- EEL762 Digital Communications 3-0-0 3
- EEL818 Telecommunication Technologies 3-0-0 3
- EEP773 Telecommunication Software Laboratory 0-1-4 3
- EEP775 Telecommunication Networks Laboratory 1 0-1-4 3
- EEP776 Wireless Communication Laboratory 0-1-4 3
- JMD801 Major Project Part 1 (JTM) 0-0-12 6
- JMD802 Major Project Part 2 (JTM) 0-0-24 12
- SMD792 Minor Project (SMF, SMN, SMT, JTM) 0-0-6 3
- SML723 Telecommunication Systems Management 3-0-0 3

Total PC 18-2-50 42

Programme Electives (PE)

- EEL703 Computer Networks 3-0-0 3
- EEL707 Multimedia Systems 3-0-2 4
- EEL716 Telecommunication Switching & Transmission 3-0-0 3
- EEL731 Digital Signal Processing 3-0-0 3
- EEL767 Telecommunication Systems 3-0-0 3
- EEL817 Access Networks 3-0-0 3
- EEL854 Protocol Engineering 3-0-2 4
- EEL855 Internet Technologies 3-0-0 3
- EEL867 Network Security 3-0-2 4
- EEL868 Mobile Computing 3-0-0 3
- EEL859 Network Management 3-0-2 4
- EEL860 Wireless Communication Networks 3-0-2 4
- EEL861 Selected Topics in Communication Engineering 1 3-0-0 3
- EEL862 Selected Topics in Communication Engg. 2 3-0-0 3
- EEL863 Selected Topics in Communication Engg. 3 3-0-0 3
- EEL871 Selected Topics in Communication Engg. 4 1-0-0 1
- EEL872 Selected Topics in Communication Engg. 5 1-0-0 1
- EEL882 Introduction To Telecommunication Systems (Audit/Bridge) 3-0-0 3
- EEP757 Embedded Telecommunication Systems Laboratory 0-1-4 3
- EEP856 Telecommunication Networks Laboratory 2 0-1-4 3
- EEP881 Network Software Laboratory 0-1-4 3
- JMS800 Independent Study (JTM) 3-0-0 3
- SMD792 Minor Project (SMF, SMN, SMT, JTM) 0-0-6 3
- SML726 Telecommunication Systems Analysis, Planning and Design 3-0-0 3
- SML728 International Telecommunication Management 3-0-0 3

M.Tech. in Telecommunication Technology and Management

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TOTAL = 60
10. COURSE DESCRIPTIONS

The details about every course are given in this section. Information about each course includes course number, credits, L-T-P structure, pre-requisites, overlapped courses and course contents.

For some 700 and 800 level courses, the pre-requisites have been explicitly indicated. Where 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.
AML110 Engineering Mechanics
4 credits (3-0-2)
Laws of mechanics, equivalent force systems and equations of equilibrium. Internal forces in structures and beams, friction and its applications, Kinematics of point mass and rigid body, Center of mass, System of particles, Inertia tensor, Dynamics of rigid bodies, Euler's equations of motion, Impulse-momentum, Work-energy methods with applications, Principle of virtual work and stability.

AML120 Materials Science
4 credits (3-0-2)

AML130 Experimental Methods and Analysis
5 credits (3-1-2)
(a) Experimental Analysis: measurements and errors, internal and external estimates of errors, statistical analysis, accuracy and precision, best estimate, accuracy of the mean, significant digits, methods of least squares, curve fitting, linear regression, comparison and combination of measurements, extensions least square method. Theory of errors, Gaussian distribution, confidence limits, significance test, and goodness of fit.

(b) Instrumentation: Principle of measurements, Basic elements of measurement device, various types of measurement systems, standards and calibration, Dynamic characteristics of first and second order instruments, Transducers.

(c) Experimental Devices: displacement measurement dial gauge, optical method pneumatic transducer, variable resistance, inductance and capacitance transducer, Seismic devices for motion measurement. Principle of planimeter, Strain and stress measurements, Force and torque measurements, various types of load cells and their applications.

AML140 Mechanics of Solids
4 credits (3-1-0)
Overlaps with: AML150, AML180
Introduction, Definition of stress, Equations of equilibrium, Principal stress, Maximum shear stress, Plane stress, Concept of strain, Strain displacement relations, Principal strains, Plane strain, Constitutive relations, Uniaxial tension test, Idealized stress-strain diagram, Isotropic linear elastic, viscoelastic and plastic materials, Uniaxial deformations, Thermal stresses, Torsion of shafts, Bending and shear of beams, Energy methods, Fracture, Deflection, Stability.

AML150 Mechanics of Solids and Fluids
5 credits (3-1-2)
Overlaps with: AML140, AML160, AML170, AML180, CHL231, CHL204, AMP262
Introduction, fundamental concepts, mathematical preliminaries. Analysis of strain deformation, strain displacement relations, Normal and shear strains, Transformation, Principal strains and Maximum shear strains, Volumetric strain, Compatibility equations, Plane strain, Stain rosettes, Velocity field and strain rates.

Constitutive relations; Hookean elastic solids, Yield criteria and plasticity, Viscoelasticity, Non-viscous fluid, Newtonian fluid. Solid mechanics applications – Axisymmetric thin shells, Uniaxial deformation. Torsion, bending, buckling, etc.

Fluid mechanics applications – Fluid statics, fluid motion; Material and spatial description. Integral and differential flow analysis, ideal fluid flow, simple viscous flow, Dimensional analysis.

AML160 Mechanics of Fluids
4 credits (3-1-0)
Overlaps with: AML150, AML170, CHL231, CHL204

AML170 Fluid Mechanics
5 credits (3-1-2)
Overlaps with: AML150, AML160, CHL231, CHL204, AMP262
Introduction, fluid properties, classification, fluid statics, rigid body motions, kinematics of fluid motions, Reynolds transport theorem, mass, momentum and energy laws with applications, governing equations for Newtonian fluids, exact solutions, laminar and turbulent pipe flow. Introduction to boundary layer theory, Dimensional analysis and modeling, open channel flow.

AML180 Solid Mechanics
5 credits (3-1-2)
Overlaps with: AML140,AML150, AMP262
Introduction, Definition of stress, Equations of equilibrium, Principal stress, Maximum shear stress, Plane stress, Concept of strain, Strain displacement relations, Principal strains, Plane strain, Constitutive relations, Uniaxial tension test, Idealized stress-strain diagram, Isotropic linear elastic, viscoelastic and plastic materials, Uniaxial deformations, Thermal stresses, Torsion of shafts, Bending and shear of beams, Energy methods, Fracture, Deflection, Stability.

AML190 Design Engineering
5 credits (3-1-2)

AMP262 Fluids and Solids Laboratory
1.5 credits (0-0-3)
Pre-requisites: AML140 & AML160
Overlaps with: AML150 / AML170 / AML180
Experiments will build-up on knowledge of Mechanics of Solids and Mechanics of Fluids. Applications of uncertainty analyses. A professional report is to be prepared for each experiment. Students work in a group of two.

AML300 Constitutive Modelling and Application of New Materials
3 credits (3-0-0)
Pre-requisites: AML140 / AML150 / AML180 and EC 60

AMD310 Mini Project (AM)
3 credits (0-0-6)
Pre-requisites: EC 80
A project will be specified by the concerned teacher and it is expected that under his/her guidance the students will carry out all the activities related to the project.
AML310 Computational Mechanics
4 credits (3-0-2)
Pre-requisites: AML140 / AML150 / AML160 / AML170 / AML180 / CHL231 / CHL204 and EC 60

AML340 Chaos in Engineering Systems
3 credits (3-0-0)
Pre-requisites: AML110 and EC 60
Introduction to chaos. Various examples of chaos in engineering systems, electrical systems (Van Der Pol oscillator); electrical systems (Van Der Pol oscillator); Fluid mechanical systems (Lorenzequations, Aeroelastic flutter, Vibration (Duffing equation), Chemical reactions (Belousov-Zhabotinski reaction) etc. Basic concepts in the mathematical treatment of non linear systems. Note: The emphasis in this course will be on developing a physical understanding of chaotic systems. The laboratory sessions will be partly experimental demonstrations and partly computer simulations (performed by the students).

AML350 Corrosion and Prevention
3 credits (3-0-0)
Pre-requisites: EC 60
Aqueous corrosion, theory and mechanism, corrosion kinetics, corrosion behaviour of specific metals and alloys, effects of stress, strain temperature and environment, corrosion fatigue, stress corrosion cracking, corrosion testing methods, Prevention of corrosion in practice (cathodic and anodic protection, corrosion inhibitors, protective coating etc., case studies.

AML360 Engineering Fluid Flows
4 credits (3-1-0)
Pre-requisites: AML150 / AML160 / AML170 / CHL231 / CHL204 and EC 60
Overlaps with: AML711 / AML713 / AML715
Fundamentals. Governing equations: Equation of motion; Stress at a point; Relative motion near a point; Constitutive laws for Newtonian fluid; Navier-Stokes equations; Boundary conditions; Energy equation. Exact Solutions: Solutions involving one and two variables; Conversion of PDEs to ODEs. Non-dimensionalization: Non-dimensionalization of the N.S. equations; Order of magnitude analysis; Thin layer approximation. Low Reynolds number flows: Stokes and Oseen approximations; Hydrodynamic lubrication. Inviscid Flows: Vorticity equation; Irrotational flows. Flow at High Reynolds number: Prandtl's boundary layer equations; Blasius solution; Falkner-Skan solution; Momentum Integral equation; Jets and Wakes. Hydrodynamic Stability: Experimental results; Fundamentals of stability theory; Orr-Sommerfield equation. Turbulence: Fundamentals; Reynolds averaging; Closure problem; Turbulence Models. CFD: Finite difference and finite volume methods.

AML370 Pipeline Engineering
3 credits (3-0-0)
Pre-requisites: AML150 / AML160 / AML170 / CHL231 / CHL204 and EC 60
Overlaps with: CHL390

AML380 Biomechanics
4 credits (3-0-2)
Pre-requisites: AML110 and EC 60

AML410 Computational Methods in Fluid Dynamics
4 credits (3-0-2)
Pre-requisites: AML310
Conservation laws, boundary layer theory and similarity solutions, finite difference and finite volume methods, primitive and secondary variable formulations, explicit, implicit and semi-implicit methods, panel methods for inviscid flows, turbulence modeling, application to laminar and turbulent flows, introduction to finite element methods, grid generation.

AML430 Advanced Computational Methods
4 credits (3-1-0)
Pre-requisites: AML310
Overlaps with: AML806
Advanced topics in Computational Solid/Fluid mechanics to suit specific student needs and topics chosen from the following: (i) finite element analysis of plates and shells, (ii) finite elements in fluids, (iii) reduced integration patch test, (iv) dynamic FE analysis, (v) geometrically nonlinear problems. (vi) material nonlinearity. (vii) automated mesh generation. (viii) pre and post processing. (ix) solid fluid interaction problems. (x) efficient solution technique-PCG, domain decomposition. (xi) point source method. (xii) boundary element method. (xiii) aero elastic flutter. (xiv) other special topics.

AML440 Parallel Processing in Computational Mechanics
4 credits (3-0-2)
Pre-requisites: AML310
Advanced topics in computational solid/liquid mechanics to suit specific student needs and topics chosen from the following: Finite element analysis of plates and shells, Finite elements in fluids, Reduced integration patch test, Dynamic FE analysis, Geometrically nonlinear problems, Material nonlinearity, Automated mesh generation, Pre and Post processing, Solid fluid interaction problems, Efficient solution technique-PCG, domain decomposition, Point source method, Boundary element method, Aero elastic flutter, Other Special Topics.

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)
AM704 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
Overlap with: MALS81

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
Overlap with: MEL414
B-rep solid modellers and constructive solid geometry-CAD system utilization and application-Hidden surface algorithms and shading. Finite element systems. Computer aided drafting system.

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)

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)
Introduction, Structure- Property correlation: role of crystal structure, substructure and microstructure on properties.

High performance structural metallic alloys – Alloy steels, Selected Cu, Al, Ti, & Mg alloys and their applications. Advanced composite materials – Important reinforcements and matrix materials (metal, ceramics, polymer), micro mechanics of composites, role of interface, mechanical & thermal behavior, load transfer from matrix to fiber, nano structural composites.

Processing & characterization of composites - Forming and fabrication methods, testing and evaluation, strength, fracture and fatigue of composites.

Surface engineering of materials & their applications – Techniques for modification of surfaces for wear, corrosion and high temperature applications, typical structural applications.

Structure, property and processing of some new engineering materials, nanocrystalline materials, metallic foams, functionally graded materials, smart materials, shape memory materials.

Applications of materials to automobile and transport vehicles, Aerospace applications, materials for power generation, etc.

Materials for armament applications, marine environment and ocean structures, materials for other specialized applications.

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)
Modelling and analysis in the context of design morphology, CAD and concurrent Engineering Analysis of stress, fluid flow and heat transfer.


AML774 Modelling & Analysis-II
3 credits (3-0-0)
Design of products subjected to vibration, Balancing, self excited vibrations. Modelling and analysis of heat transfer in products, thermal stresses, case studies.


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 ergonomical factors in product design.

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

Hull propeller interaction, Cavitation, Wave-wake interference, Thrust computations, Scale effect, Propeller design, Various propulsion devices, Ship standardisation trials.

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 Design
3 credits (3-0-0)

AML794 Warship Design
3 credits (3-0-0)
AMSL801 Independent Study
3 credits (0-3-0)

AMSL802 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 finiteelement methods, considerations in discretization of turbulence models, rotating reference frame, hybrid methods grindinless 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)

AMD814 Major Project Part-II
12 credits (0-0-24)

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 Mechanics
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.

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. Spinodal decomposition. Specific transformations such as martensitic, polymorphic, recrystallization, particle coarsening, etc. Crystallographic aspects of phase transformations.

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

Analysis of micrographs and diffraction patterns. SEM contrast in SEM and applications to the study of material problems. High voltage electron microscopy. TEM & STEM base methods of microdiffraction.

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.

AMD885 Major Project (M.S. Research)
40 credits (0-0-80)

AMD897 Minor Project
4 credits (0-0-8)

AMD899 Design Project
10 credits (0-0-20)
Department of Biochemical Engineering and Biotechnology

BEL101 Biochemistry
5.5 credits (3-1-3)
Course contents (about 100 words): Introduction-aims and scope; Non-covalent interactions in biological systems, Carbohydrates-structure and function; Proteins-structure and function; Nucleic acids-structure and function; Protein purification techniques; Introduction to enzymes; Vitamins and coenzymes; Lipids and biological membranes; Transport across cell membrane; Design of metabolism; Metabolic pathways for breakdown of carbohydrates-glycolysis, pentose phosphate pathway, citric acid cycle, electron transport chain, Photo-phosphorylation; Oxidation of fatty acids; Gluconeogenesis and control of glycolycan metabolism, Signal transduction.

Laboratory: Estimation of proteins and nucleic acids; Extraction of lipids; Separation of lipids using thin layer chromatography, Gel filtration and ion exchange chromatography; Gel electrophoresis, Determination of enzymatic activities and determination of K_m, V_max; Identification of intermediates of EMP pathway.

BEL102 Bioprocess Calculations
4 credits (3-1-0)
Overlaps with: CHL231, CHL251

BEL103 General Microbiology
4.5 credits (3-0-3)

Laboratory: Preparation and sterilization of media, examination of possible sources of contamination; microscopic examination of different groups of microorganisms; aseptic technique; simple and differential staining; isolation of a pure culture - use of enrichment media; growth and enumeration of microorganisms; effect of physical and chemical environment on growth; selected biochemical tests; isolation of auxotrophic mutants; microbiological assay of antibiotics.

BEL110 Molecular Cell Biology
3 credits (3-0-0)
Overlaps with: BEL101, BEL103
Biolog-technology interface; Cell structure and function; Noncovalent interactions in living cells; Molecules in cell; Enzymes: Structure, Catalysis, Industrial applications; Membrane transport; Bioenergetics; Introduction to metabolism; Information storage and processing in cells; Cell signaling; Nerve cells and electrical properties; Techniques in cell and molecular biology; Cell evolution: biochemical capacities.

BEL104 Molecular Biology and Genetics
4.5 credits (3-0-3)
Pre-requisites: BEL101 & BEL103

Laboratory: Isolation of DNA, Denaturation of DNA, isolation of chromatin, lambda DNA, transformation, conjugation. Gene induction.

BEL301 Bioprocess Engineering
3 credits (3-0-0)
Pre-requisites: BEL101 & BEL103 and EC 60
Overlaps with: CHL291
Microbial growth, substrate utilisation and product formation kinetics; simple structured models; air sterilization; media sterilization; batch, fed-batch and continuous processes; aeration and agitation; rheology of fermentation fluids; scale-up concepts; design of fermentation media; aseptic transfer; various types of microbial and enzyme reactors; instrumentation in bioreactors.

BEL302 Fluid Solid Systems
3 credits (3-0-0)
Pre-requisites: CHL203
Overlaps with: CHL331
Size reduction; crushing and grinding; equipment for size reduction; screening; design procedure; Flow of fluids past a stationary particle for low, medium and high Reynolds numbers; sedimentation and sedimentation theory; thickeners and classifiers; flow through packed beds; flow distribution, packings and pressure drop calculations; fluidization; filtration theory and its application in plate and frame and rotary vacuum filters; solid-liquid separation using centrifugation; ‘S’ concept in centrifugation for scale-up; different types of centrifuges and their design; application for biological suspensions.

BEP303 Design of Bioprocesses
2.5 credits (0-1-3)
Pre-requisites: BEL101 & BEL103 and EC 60
Design and execution of simple laboratory scale experiments on the following topics: Estimation of cell mass; different phases of microbial growth; Mass and energy balance in a typical bioconversion process; Concept of limiting nutrient and its effect on cell growth; growth inhibition kinetics; product formation kinetics in a fermentation process; aerobic and anaerobic bioconversion process; power consumption in a fermentation process and its correlation with rheology of the fermentation fluid; different agitator types; mixing time in a bioreactor; quantification of KLa in a fermentation process; Heat balance across a batch sterilization process; Assembly and characterization of pH/DO electrodes.

BEL311 Physical and Chemical Properties of Biomolecules
3 credits (2-1-0)
Pre-requisites: BEL101 and EC 60
Introduction: characteristic features of biological systems, structure-functions relationships in biomolecules; Characterization of macromolecules: molecular shape and size; molecular weight; Transport properties of solution- Applications in deducing conformation of biomolecules: viscosity, Diffusion, Ultra centrifugation, electrophoresis; Optical properties of biomacromolecules; Spectroscopic methods: IR, NMR, optical rotary and circular dichroism.
BEL312 Carbohydrates and Lipids in Biotechnology  
3 credits (2-1-0)  
Pre-requisites: BEL101 and EC 60  
Introduction; Molecular Structure of polysaccharides; Enzymes degrading polysaccharides; Physical properties of polysaccharides; Production of microbial polysaccharides; Food usage of exopolysaccharides; Industrial Usage of exopolysaccharides; Medical applications of exopolysaccharides. Molecular structure of lipids; Physical properties of lipids; oleaginous microorganisms and their principal lipids; Production of microbial lipids; Modification of lipids for commercial application; Extracellular microbial lipids and biosurfactants; Micelles and Reverse micelles in biology, Liposomes in drug delivery.

BEV330 Special Module in Biochemical Engineering and Biotechnology  
1 credit (1-0-0)  
Pre-requisites: EC 60  
Special module that focuses on state of the art and research problems of importance in biochemical engineering and biotechnology.

BED350 Mini Project (BB)  
3 credits (0-0-6)  
Pre-requisites: EC 80  
No fixed course content. Study to concentrate on a selected topic under the supervision of a faculty member of the department.

BER350 Professional Practices (BB)  
2 credits (0-1-2)  
Pre-requisites: EC 60  
No fixed course content. Activities to include visits to industry, interactive meetings with personnel from industry and R&D organizations.

BES350 Independent Study (BB)  
3 credits (0-3-0)  
Pre-requisites: EC 80  
No fixed course content. Study to concentrate on a selected topic under the supervision of a faculty member of the department.

BEL401 Bioprocess Technology  
2 credits (2-0-0)  
Pre-requisites: BEL 301  
Bioprocessing vs. chemical processing. Substrates for bioconversion processes. Inoculum development. Process technology for production of primary metabolites, such as baker's yeast, ethanol, citric acid, amino acids, polysaccharides and plastics. Microbial production of industrial enzymes-glucose isomerase, cellulase, amylase, protease etc.; Production of secondary metabolites-penicillins and cephalosporins.

BEL403 Enzyme Engineering and Technology  
4 credits (3-0-2)  
Pre-requisites: BEL 401  
Introduction and Scope; Chemical and Functional nature of enzymes; Application of enzymes in process industries and health care; Microbial production and purification of industrial enzymes, Kinetics of enzyme catalyzed reactions; Immobilization of enzymes; Stabilization of enzymes. Bioreactors for soluble and immobilized enzymes, Mass transfer and catalysis in immobilized enzyme reactors. Enzyme based biosensors; Enzyme catalyzed processes with cofactor regeneration; Enzymatic reactions in micro-aqueous medium and non-conventional media. Laboratory: assay of enzyme activity and specific activity; Kinetic analysis of an enzyme catalyzed reaction; Immobilization of enzymes by adsorption and covalent binding; Salt precipitation of an enzyme; Immobilization of microbial cells by entrapment; Effect of water activity and solvent on the lipase catalyzed esterification reaction.

BEL411 Food Science and Engineering  
3 credits (3-0-0)  
Pre-requisites: BEL301  
Chemical constituents of foods, their properties and functions; Characteristic features of natural and processed foods; Chemical/biological reactions in storage/handling of foods; Units operations in food processing – size reduction, evaporation, filtration etc.; Methods for food preservation; Rheology of food products; Flavour, aroma and other additives in processed foods; Case studies of a few specific food processing sectors, cereals, protein foods, meat, fish and poultry, vegetable and fruit, milk products; legislation, safety and quality control.

BEL412 Immunology  
4 credits (3-0-2)  
Pre-requisites: BEL204 and EC 90  

BEL413 Modelling and Simulation of Bioprocesses  
4 credits (3-0-2)  
Pre-requisites: BEL 301  
Types of kinetic models, Data smoothing and analysis, Mathematical representation of Bioprocesses, Parameter estimation, Numerical Integration techniques, Parameter Sensitivity analysis, Statistical validity, Discrimination between two models. Physiological state markers and its use in the formulation of a structured model, Development of compartment and metabolic pathway models (Software Probe) for intracellular state estimation. Dynamic Simulation of batch, fed-batch steady and transient culture metabolism, Numerical Optimization of Bioprocesses using Mathematical models.

BEL414 Thermodynamics of Biological Systems  
3 credits (3-0-0)  
Pre-requisites: CHL101 and EC 90  
Biological systems as open, non-equilibrium systems, failure of classical thermodynamics in describing biological processes, concepts of thermodynamic flux and force, concept of entropy production, constitutive equations, Onsager reciprocal relations, Prigogine's principle, coupling in biological processes, thermodynamics of coupled biochemical reactions, thermodynamic analysis of oxidative phosphorylation, Nath's principle for coupling in bioenergetic processes, active transport.

BEL415 Advanced Bioprocess Control  
3 credits (3-0-0)  
Pre-requisites: CHL202 and EC 90  
The course begins with a detailed analysis of the stability of bioreactors and gradually brings in the general concept of Lyapunov stability. The contrast between classical control and modern control is illustrated through state space techniques and concepts of reachability (Controllability) and reconstructability (Observability). Then several techniques of differential are brought and the power of the method demonstrated through various techniques such as the input-output linearization. In the final phase of the course several case studies are undertaken and future trends in the field of research presented.

BEL416 Membrane Applications in Bioprocessing  
3 credits (3-0-0)  
Pre-requisites: BEL301  
Introduction; Organic/inorganic membranes and its manufacture; transport theories for MF/UF/NF membranes; Laboratory/ commercial modules of membranes: Applications of membranes: Milk/ cheese processing, Fruit/ sugarcane juice processing, Pharmaceuticals/ Therapeutic drugs processing and membrane-coupled separation of biomolecules; Membrane based bioreactor for cell/enzyme recycle; Mammalian/ plant cell culture; Case studies.

BEL417 Biophysics  
3 credits (3-0-0)  
Pre-requisites: PHL110 and EC 90  
Spectroscopic methods in biophysics, conformational changes in biological processes, transport across biomembranes, the biophysics of motility, the biophysics of the nerve impulse.
BEL418 Bioinformatics
3 credits (2-0-1)
Pre-requisites: CSL110 / CSL120 and EC 90
Introduction to Bioinformatics and its Application, Molecular Biology for bioinformatics (Central Dogma), Biological data bases (primary, secondary hybrid etc), and its Annotation, Protein and Nucleotide (DNA) sequencing techniques, Pairwise and multiple sequence alignment algorithm, Phylogenetic Analysis, Hidden Markov Model (HMM) and its Application, Microbial Genomics, Metabolic Flux Analysis.

BEL419 Enzyme Catalyzed Organic Synthesis
3 credits (2-0-2)
Pre-requisites: BEL101 and EC 90
Enzyme as biocatalysts, Enzyme catalyzed reactions in organic solvents, Structure of enzyme in organic solvents, pH memory and molecular imprinting, Biocatalyst design and challenges, cofactor recycling, enzyme stability and stabilization. Biocatalytic applications in organic synthesis-hydrolytic reactions, oxidation reduction reactions, formation of C-C bond, addition and elimination reactions, glycosyl transfer reactions, isomerization, halogenation/ dehalogenation reactions.

Laboratory: Use of lipases to demonstrate esterification and isomerification reactions. Effect of solvents on lipase catalyzed reactions, Use of proteins for synthetic reactions. Cofactor recycling. Immobilized biocatalysts for bioconversion.

BEL420 Analytical Methods in Biotechnology
3 credits (2-0-2)
Pre-requisites: BEL101 and EC 90

BEL421 Metabolic Regulation and Engineering
3 credits (3-0-0)
Pre-requisites: BEL204 & BEL301

BEL422 Solid State Cultivation
3 credits (3-0-0)
Pre-requisites: BEL301
Definition, Microbial basis of processes, Substrate for processes, Quantification of biomass, Environmental parameters, Growth patterns, Growth kinetics and the modeling of growth in SSC, General principles of reactor design and operation for SSC, Overall process concepts in fungal biomass production, product leaching and downstream processing.

BEL423 Solid State Cultivation
3 credits (3-0-0)
Pre-requisites: BEL301
Definition, Microbial basis of processes, Substrate for processes, Quantification of biomass, Environmental parameters, Growth patterns, Growth kinetics and the modeling of growth in SSC, General principles of reactor design and operation for SSC, Overall process concepts in fungal biomass production, product leaching and downstream processing.

BEL424 Metabolic Pathway Engineering
3 credits (2-0-1)
Pre-requisites: BEL101 and EC 90
Enzyme as biocatalysts, Enzyme catalyzed reactions in organic solvents, Structure of enzyme in organic solvents, pH memory and molecular imprinting, Biocatalyst design and challenges, cofactor recycling, enzyme stability and stabilization. Biocatalytic applications in organic synthesis-hydrolytic reactions, oxidation reduction reactions, formation of C-C bond, addition and elimination reactions, glycosyl transfer reactions, isomerization, halogenation/ dehalogenation reactions.

Laboratory: Use of lipases to demonstrate esterification and isomerification reactions. Effect of solvents on lipase catalyzed reactions, Use of proteins for synthetic reactions. Cofactor recycling. Immobilized biocatalysts for bioconversion.

BEL425 Colloquium (BB)
3 credits (0-3-0)
Pre-requisites: registered for BET450
Each student is to make a minimum of three presentations of about 30 minutes duration. Topics for these presentations could be drawn from the practical training experience or other scientific documents/publications.

BEL426 Practical Training (BB)
Non credit
Pre-requisites: EC 90 at the end of 5th sem.
Observation of processes, operating procedures, construction techniques, management procedures, amongst others, and executing a project related to the industry.

BEL427 Biotechnology Data Handling and IPR Issues
2 credits (3-0-4)
Pre-requisites: BEL410 & 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.

BEL428 Bioprocess Plant Design
5 credits (3-0-4)
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.

BEL429 Downstream Processing in Biotechnology
5 credits (3-0-4)
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 electrodialysis, Electrophoresis, Crystallization, 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 (2-0-4)
Pre-requisites: BEL204
Restriction and modification phenomena, Other enzymes used in rDNA research, Plasmid, I 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, alpha/Beta domain, Antiparallel 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)
Characteristic 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 fibre 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

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-phosphorylation and dephosphorylation system. Enzymes and their applications in processing techniques-starch and sugar conversion processes, baking by amylases, deoxygenation and desugaring by glucoamylase, 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 nanostructures 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 pharmagenomics, 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, Graphic, 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, Allotrophic 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, Chromatography, Ultrafiltration, Reverse osmosis, Isoelectric focussing, Affinity based separations, Case Studies.

**BEL830 Microbial Biochemistry**
3 credits (3-0-0)
Structure and function of biomolecules amino acids, proteins, lipids, nucleotides and nucleic acids: Enzymes-structure and kinetics, Vitamins and coenzymes, Metabolic pathways: Carbohydrate metabolism: glycolysis, pentose phosphate pathway, citric acid cycle; Bioenergetics oxidative phosphorylation and photo-synthesis: Fatty acid metabolism; Amino acid metabolism; Regulatory mechanisms-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 transfer studies in fermentation; Mixing and agitation in fermenters; RTD studies; Mass transfer in immobilized cell/enzyme reactors.

**BED851 Major Project Part 1 (BB)**
6 credits (0-0-12)
Pre-requisites: EC 165
Overlaps with: BED853
Initial phase of the major project chosen by the student under a pre-designated supervisor. Projects are to be individual and should be an in-depth intensive effort.

**BED852 Major Project Part 2 (BB)**
14 credits (0-0-28)
Pre-requisites: BED851
Overlaps with: BED854
Continuation and completion of the work started in Major Project Part 1.

**BED853 Major Project Part 1 (BB)**
4 credits (0-0-8)
Pre-requisites: EC 165
Overlaps with: BED851
Initial phase of the major project chosen by the student under pre-designated supervisor. Projects are to be individual and should be an in-depth intensive effort.

**BED854 Major Project Part 2 (BB)**
16 credits (0-0-32)
Pre-requisites: BED853
Overlaps with: BED852
Continuation and completion of the work started in Major Project Part 1.

**BEL860 Bioprocess Analysis and Reactor Design**
3 credits (3-0-0)
Thermodynamic and stoichiometric aspects of microbial processes; Engineering analysis of metabolic pathways; Optimization of fermentation media; Kinetic modelling of enzyme/microbial processes; Mass transfer in biochemical processes; Scale up concepts. Batch, fed batch and continuous microbial reactors; Immobilized enzyme/cell reactors; Non-ideal effects; sensors for monitoring bioprocess parameters; Bioprocess control and computer coupled bioreactors; Growth and product formation by recombinant cells.

**BEL880 Advanced Biochemistry**
4.5 credits (3-0-3)
Protein conformation; Conformational mobility in globular proteins; Protein purification methods; Enzyme catalysis, kinetics and inhibition: Mechanism of Enzyme Action : Regulatory enzymes : Overview of metabolism: Biological membranes; Glycolysis, TCA cycle and oxidative phosphorylation, pentose phosphate pathway and Gluconeogenesis : Metabolism of fatty acids : Regulation of metabolic pathways : Biosynthesis of lipids, Amino acids, Nucleotides and their regulation: Regulatory process control and over-production of primary and secondary metabolites. Regulation of protein synthesis and secretion.

**BEV880 Special Module in Anaerobic Digestion**
1 credits (1-0-0)
The anaerobic trophic food web (digestor, animal, soil and sediment example) Microbes involve in the different type of anaerobic process (psychrophil, mesophile, thermophile) : classical approaches. Microbes involves in the different type of anaerobic process (psychrophil, mesophile, thermophile) : molecular approaches.
The ecological features : richness, diversity, stability and resilience and production AD of industrials waste waters : Technologies, Performances, New applications, Industrial examples.
The Anaerobic Digestion of solid wastes : Pre treatment, technologies, Performances, Post treatment, VFA production coupled with WW treatment plant, Sizing of digesters, Examples of full scales applications. Landfilling, Biogas utilization, Example of full scale applications in Europe Digester technologies in rural zones, Example of full scale applications.
BEL890 General Microbiology
4.5 credits (3-0-3)
Morphological, structural and biochemical characteristics of procaryotes and eucaryotes, Bacterial taxonomy, viruses, Methods in micro- biology, microbial growth and control of micro-organisms, transport of nutrients across cell membrane; Energy transduction mechanisms in microbial cell fermentation, aerobic and anaerobic respiration, microbial photosynthesis, Reproduction in Bacteria-vegetative and sexual (transduction, transformation, conjugation, transfection, sexduction), microbial interactions. Introduction to industrial, agricultural and medical microbiology, viruses.

BED895 Major Project (M.S. Research)
40 credits (0-0-80)
BEL895 Selected Topics
3 credits (3-0-0)
The course will aim at introducing students to some of the areas of current research interests in biochemical engineering and biotechnology while the exact content might vary. Some of the representative topics likely to be covered include: Animal and plant cell culture. Biosensors, bioprocess control and bioreactor designs. Modern microbial biotechnology. Regulation of microbial metabolism, Molecular biology.
CHL101 Introduction to Chemical Engineering Thermodynamics
3 credits (2-1-0)
Overlaps with: CHL21
Simplified mechanical structure of solids, liquids and gases; Origin of intermolecular forces and non-ideal behaviour of gases; Cp, Cv and equations of state; Generalized properties; First law and energy balances as applied to thermochemistry and fluid flow. Work in compression and expansion of fluid flow; Second law, concept of irreversibility; Introduction to phase and chemical equilibria; partial molar properties.

CHL103 Chemical Reactor Analysis and Design
4 credits (3-1-0)
Overlaps with: CHL122
Basic introduction to reaction engineering; Introduction to rate equations, stoichiometry and rate laws for biochemical reactions; Design of batch, plug flow, well mixed and semi-batch biochemical reactors; Introduction to pseudo steady state hypothesis and transition state theory; Michaelis – Menten equation and identification of its parameters; Multiple enzyme and substrate systems; Design equations for bio-reactors; Inhibitors and Propagators for biochemical reactions; Residence time Distribution; Diffusion with chemical reaction in catalyst particles, effectiveness factors; Scale up of bioreactors; Treatment of unsteady state and non-isothermal conditions for catalysed/uncatalysed biochemical reactions.

CHL110 Transport Phenomena
4 credits (3-1-0)
Definition of transport properties, their measurement and estimation. Shell balance approach for developing equations for momentum, heat and mass transport. Solution of problems involving transport in one dimension. Introduction to turbulent flows and expressions for turbulent fluxes. Concept of transfer coefficients. Similarity of momentum, heat and mass transport and various analogies. Application of these concepts to various disciplines in engineering and science.

CHL111 Material and Energy Balance
4 credits (2-2-0)
Mathematical and engineering calculations, Dimensional groups and constants, Behaviour of ideal gases, gaseous mixtures, Vapour pressure, Clausius Clapeyron equation, Cx chart, Duration's plot, Raoults law, Humidity and saturation, humid heat, humid volume, dew point, humidity chart and its use, Crystallisation, dissolution, Material balance; solving material balance problems with and without simultaneous equations; recycle, bypass and purge calculations, Aid of computer in solving material balance problems, Energy balance: heat capacity, calculation of enthalpy changes; energy balances with chemical reaction, Heat of vaporization, heat of formation, laws of thermochemistry, heat of combination, heat of reaction, Solution of sets of equations, Case studies.

CHL112 Chemical Process Technology
4 credits (3-1-0)
The course covers the concept of combination of unit processes and unit operations along with the basic raw materials. Synthesis of steady state flow sheets for the chemical plant. Processing of water for various end uses. Industrial gases and different techniques for air separation systems. Manufacture of Fertilizers including sulfuric acid; ammonia and its allied products like, Urea, Nitric acid and other products. Food processing and agro based products like paper, sugar, oils and soap etc. including the manufacture of ethyl alcohol. Electrochemicals and chloralkali industries. Safety and Hazard in chemical process plant design and environmental constraints. Concept of green technologies.

CHL121 Chemical Engineering Thermodynamics
4 credits (3-1-0)
Overlaps with: CHL101
Simplified mechanical structure of solids, liquids and gases; Origin of intermolecular forces and non-ideal behaviour of gases; Cp, Cv and equations of state; Generalized properties; First law and energy balances as applied to thermochemistry and fluid flow. Work in compression and expansion of fluid flow; Second law, concept of irreversibility; Introduction to phase and chemical equilibria; partial molar properties.

CHL122 Chemical Reaction Engineering – I
4 credits (3-1-0)
Overlaps with: CHL103
Introduction to reaction engineering; Concepts of rate equations, stoichiometry and rate laws; Material balance for CSTR and PFR, their use for kinetic interpretation and design; Comparison of batch reactor, CSTR and PFR; Evaluation of performance properties of the reactors; Analysis of rate data for batch/continuous flow reactors and development of rate equation; Introduction to the concept of yield and selectivity for multiple reactions; Unsteady state reactor design; Concepts of adiabatic and non-isothermal operations (energy balance).

CHL133 Powder Processing and Technology
4 credits (3-1-0)

CHL202 Process Systems Analysis and Control
4 credits (3-1-0)
Pre-requisites: MAL110
Revision of Laplace transform; Dynamic behaviour of first order and second order systems: response of first order systems, response of first order systems in series, second order systems and transportation lag, block diagrams and transfer functions; Feedback Control: P, PI, PID controllers, transient response of control systems: Stability: general concepts, Routh stability criterion, direct substitution method; Frequency response: Bode diagrams, Nyquist diagrams, control system design by frequency response, tuning and troubleshooting; feedforward control, ratio control, cascade control; Introduction to modern control theory.

CHL203 Transport Processes - I
4 credits (3-1-0)
Pre-requisites: CHL110
Overlaps with: CHL231, AML160, AML150, AML170
Revision of momentum transfer principles; flow of incompressible fluids in conduits; fittings and valves; network of pipelines; economic pipe diameter; flow through open channels; compressible fluid flow; transportation and metering of fluids; pumps, fans, blowers and compressors; flow measuring devices; agitation and mixing of fluids; Revision of heat transfer principles; boiling and condensation; heat exchangers; overall heat transfer coefficients; LMTD; analysis of heat exchangers; jacketed vessels; heat exchanger coils; condensers and evaporators; multiple effect evaporation; surface area determination.
CHL204 Transport Processes - II
4 credits (3-1-0)
Pre-requisites: CHL110
Overlaps with: CHL231
Empirical correlations based on analogy between momentum, heat and mass transfer; Mass balance in co-current and counter-current continuous contact equipment; operating line concept; ideal stage and stage efficiency; design of continuous contact equipment; HTU and NTU concept; batch and continuous distillation; absorption; adsorption: applications to chromatography; extraction and leaching operations; equipments and equilibrium diagrams; design procedures and calculations; humidification operations; design of cooling towers; drying of solids; design of batch and continuous dryers.

CHL221 Chemical Reaction Engineering – II
4 credits (3-1-0)
Introduction to Catalysis, classification, preparations, properties; Physical and chemical adsorption, Different types of adsorption isotherms; Kinetics of solid catalyzed gas phase reaction; Laboratory reactors for catalytic gas-solid reactions; Diffusion and chemical reaction in catalysts; Effects of external mass transfer and heat transfer; Effectiveness factors; Fixed bed catalytic reactors; Fixed bed reactor models; Pseudo-Homogeneous and 2-dimensional models concept of heterogeneous models Non-catalytic gas-solid reactions different models reactors; Gas-liquid reaction; Film and penetration theories; Enhancement factor in G-L reactions; Reactor systems for G-L reactions. Laboratory/design activities could also be included.

CHL231 Fluid Mechanics for Chemical Engineers
4 credits (3-1-0)
Pre-requisites: CHL112
Overlaps with: AML160, AML150, AML170, CHL203
Properties of fluids, classification of fluids, forces on fluids, normal forces and shear stresses on fluids, pressure-depth relation for fluids, forces on submerged bodies, rigid body motion, pressure and velocity measurement, kinematics of flow, mass. energy and momentum balances (macroscopic), Fluid friction in pipes, flow in chemical engineering equipment, differential equations of fluid mechanics, solution of viscous flow problems, Laplace’s equation for irrototational flow, stream function, potential flow, description of fluid fields, boundary layer, other unidirectional flow, turbulent flow.

CHL251 Heat and Mass Transfer
4 credits (3-1-0)
Pre-requisites: CHL110
Overlaps with: CHL204

Laboratory/design activities could also be included.

CHL260 Applications of Programming in Chemical Engineering
4 credits (3-0-2)
Pre-requisites: CSL101/CSL102 and CHL110
Solving of linear, non-linear algebraic equations, interpolating polynomials, different ion, integration, ordinary differentiation equations and their applications to Chemical Engineering Design problems. Application of Matlab, various toolboxes, features of symbolic math toolbox.

Use of MATLAB functions for performing integration and differentiation and solving algebraic equations, ordinary and partial differential equations with initial and boundary conditions.

Introduction to ANSI C, character set, keywords, constants, data types, variables, expressions, simple input/output programs, pointers, conversion characters, escape sequence, relational and logical expression and control statements, bit manipulations, introduction to functions with examples, classes of variables, arrays and pointers, Preprocessor and recursive functions, structures, union, field type definition, input/output files.

CHL261 Instrumentation and Process Control
4 credits (3-1-0)
Pre-requisites: MAL110 and CHL122
Overlaps with: MEL312, EEL301, CHL202

CHL275 Safety and Hazards in the Process Industries
4 credits (3-1-0)
Pre-requisites: CHL112
Identification, classification and assessment of various types of hazards, Hazards due to fire, explosion, toxicity and radiation, Protective and preventive measures in hazards control, Industrial hygiene, Reliability and risk analysis, HAZOP and HAZAN, Consequence analysis (vapour cloud modelling), Event probability and failure frequency analysis, Safety Training, Emergency planning and disaster management, Case studies.

CHL277 Materials of Construction
3 credits (3-0-0)
Pre-requisites: CHL112
Types and mechanism of corrosion, factors influencing corrosion, combating corrosion, corrosion testing methods, Metallic materials, Non-metals, High and low temperature materials, Selection of materials of construction for handling different chemicals, Industrial applications and case studies.

CHL291 Introduction to Biochemical Engineering
4 credits (3-1-0)
Pre-requisites: CHL111
Overlaps with: BEL301

CHL296 Nano Engineering of Soft Materials
3 credits (3-0-0)
Pre-requisites: CHL110
The course can be subdivided in three subheadings viz., Soft materials, Intermolecular forces; Surface Instabilities in soft materials.

Soft materials: soft materials and their properties, ways to control and measure the properties of soft materials.

Intermolecular forces: van der Waals, Acid-Base, Double layer and other forces, their decay behavior and measurement, Surface
instabilities: Conditions for onset of surface instability; Morphological changes during evolution of instability. Ways to tune this evolution to result in desired morphology.

**CHP301 Fluid Mechanics and Heat Transfer Laboratory**
1.5 credits (0-0-3)
Pre-requisites: CHL110 + EC60
Overlaps with: CHP304
Selected experiments in fluid mechanics (e.g. Flow Visualisation, Flow through a converging-diverging duct, Free jets through nozzles and orifices, Flow over a notch or weir, Fully developed flow through pipes, Performance characteristics of a centrifugal pump) and heat transfer (e.g. Shell and tube heat exchanger, Double pipe heat exchanger, Thermal conductivity of metal bar, Heat transfer through forced convection and natural convection).

**CHP302 Mass Transfer and Fluid Particle Mechanics Laboratory**
1.5 credits (0-0-3)
Pre-requisites: CHL110 + EC60
Overlaps with: CHP304, CHP305
Selected experiments in (a) mass transfer - batch distillation, diffusion effects, batch drier, absorber, cooling tower performance; and (b) particle mechanics - fluidization, packed bed, particle drag, mill operations, cyclone performance, grinding operations.

**CHP303 Chemical Reaction Engineering and Process Control Laboratory**
1.5 credits (0-0-3)
Pre-requisites: CHL222 & CHL261
Overlaps with: CHP305
Practicals in reaction engineering and process control and instrumentation.

**CHP304 Chemical Engineering Laboratory - I**
1.5 credits (0-0-3)
Pre-requisites: CHL203
Overlaps with: CHP301, CHP302
Experiments in fluid mechanics, fluid-particle mechanics and heat transfer.

**CHP305 Chemical Engineering Laboratory - II**
1.5 credits (0-0-3)
Pre-requisites: CHL103 & CHL204
Overlaps with: CHP302, CHP303
Experiments in mass transfer, thermodynamics and reaction engineering.

**CHD310 Mini Project (CH)**
3 credits (0-0-6)
Pre-requisites: EC 60
Design/fabrication work under the guidance of a faculty member. Prior to registration, a detailed plan of work should be submitted by the student to the Head of Department for approval.

**CHR310 Professional Practices (CH)**
2 credits (0-1-2)
Pre-requisites: EC 60
Lectures on recent developments in chemical engineering by faculty and executives from industry. Visits to industry to observe and study various chemical operations.

**CHS310 Independent Study (CH)**
3 credits (0-3-0)
Pre-requisites: EC 60
Research oriented activities or study of subjects outside regular course offerings under the guidance of a faculty member. Prior to the registration, a detailed plan of work should be submitted by the student to the Head of Department for approval.

**CHP311 Design and Laboratory Practices**
2 credits (0-0-4)
Pre-requisites: CHL110 + EC60
Preparation of fabrication drawings and testing of fabricated laboratory equipment. Piping connections. Study and use of various valves and fittings.

**CHL331 Fluid-particle Mechanics**
4 credits (3-1-0)
Pre-requisites: CHL231
Overlaps with: CHL204

**CHL332 Fluidization Engineering**
4 credits (3-1-0)
Pre-requisites: CHL331
Fluidization, Classification of particles, regimes of fluidization, minimum fluidization velocity, Particulate and aggregative fluidization, bubbling fluidization, bubbling bed models for catalytic reactions, turbulent and fast fluidization, dilute and dense phase transport, cyclones, stand pipes, circulating fluidized beds, spouted beds, three phase fluidization, performance modeling of multiphase systems.

**CHL351 Mass Transfer Operations**
4 credits (3-1-0)
Pre-requisites: CHL251
Pre-requisites: CHL203
Distillation: Raoult's law, ideal solutions, x-y and H-x-y diagrams, flash vaporization and condensation, Differential distillation, steam distillation, Binary distillation: McCabe-Thiele and Ponchon-Savarit Method, Total reflux, minimum and optimum reflux ratios, Design of distillation column with open steam, multiple feeds, side streams and partial condensers, Approximate and plate to plate calculations for multicomponent distillation, Liquid-liquid extraction, Extraction equipment Design, Equilibrium diagram, Choice of solvent, Single stage and multistage counter current extraction with/without reflux, Continuous contact extractors, Leaching equipment and equilibrium, Single stage and multistage cross current and counter-current leaching, Adsorption: adsorption equilibria, adsorption column sizing.

**CHL353 Modern Separation Processes**
4 credits (3-1-0)
Pre-requisites: CHL251
Membrane separation processes, Pressure swing adsorption, Foam separation, Chromatographic techniques: Column chromatography, Gas-liquid chromatography, Ion-exchange chromatography, Separation by thermal diffusion, Electrophoresis, Crystalization. Laboratory/design activities could also be included.

**CHL390 Process Utilities and Pipeline Design**
4 credits (3-0-2)
Pre-requisites: CHL231 & CHL251
Pre-requisites: CHL203
Pre-requisites: CHP304
Pre-requisites: CHL110 + EC60
Pre-requisites: CHL251
Pre-requisites: CHP304
Pre-requisites: CHP305
Pre-requisites: CHL331
Pre-requisites: CHL332
Pre-requisites: CHL351
Pre-requisites: CHL353
Pre-requisites: CHL390

CHL392 Polymer Science and Engineering
4 credits (3-1-0)
Pre-requisites: CHL122 and CHL231
Overlaps with: CYL230
Classification of poly.d application. Polymer based industries.

CHC410 Colloquium (CH)
3 credits (0-3-0)
Pre-requisites: registered for CHT410 and EC 90
One hour lecture by each student on his practical training. Circulation of a ten page notes on his lecture. Some special assignment on his training.

CHT410 Practical Training (CH)
Non credit
Pre-requisites: EC 90 at the end of 5th sem.
Observation of operating chemical plants. Noting down operating procedures, construction details, management procedures. Doing a Project related to the selected industry.

CHD411 Major Project Part 1 (CH)
4 credits (0-0-8)
Pre-requisites: EC 120
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, development of solution techniques and familiarization with relevant software in the case of design or theoretical projects.

CHD412 Major Project Part 2 (CH)
6 credits (0-0-12)
Pre-requisites: CHD411
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 interact data and model the experimental system.

CHL471 Process Equipment Design and Economics
4.5 credits (3-0-3)
Pre-requisites: CHL351
Heat Exchange Equipment: rating of an existing unit and design of a new system of shell and tube heat exchangers; design of multiple-effect evaporator.

Mass Exchange Equipment: design of a sieve-tray tower for distillation; design of a packed tower for gas absorption.

Plant Economics: estimation of various costs to install and run a plant; interest costs and present/future worth of cash flows; straight-line and combination methods for depreciation; discounted cost flow/net present worth methods for profitability analysis.

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.

CHL701 Process Engineering
4 credits (3-0-2)
Pre-requisites: CHL112 & CHL351
Process Synthesis; Hierarchical conceptual design of process; Batch vs. continuous; input-output structure of flowsheet; choice of reactor; choice of separation system; Distillation column sequencing; Heat exchanger network design; Pinch technology; Utility selection; Steam and cooling water circuits.

Process economics: Cost estimation; annuities; perpetuities and present value; Tax and depreciation; Profitability measures; comparison of equipments and projects; NPV and DCFROR, Risk management.

Introductory Optimization: Linear programming and its use in process industry; transportation problems; integer programming (branch and bound method); use of commercial softwares LINDO, CPLEX.

Second Law Analysis: Estimate of inefficiency in equipment/process by finding lost work’ modification of operating conditions/process to improve efficiency.

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 equilibriums, 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  
Selection of a problem, Definition of the problem, Literature Search, Design of an experimental program, Fabrication of necessary equipment, Operation of the equipment, Interpretation of data, report writing and oral defence, Measurements, and interpretation of data.

**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 minimum 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, magnetio 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 vessel, 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:** UG/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 current, eleectrocatalyses – 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 catalysts 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  
Ecology and Environment, Sources of air, water and solid Wastes, Air Pollution: Micromet-eorology and dispersion of pollutants in environment, Fate of pollutants, Air pollution control technologies: centrifugal collectors, electrostatic precipitator, bag filter and wet scrubbers, Design and efficiencies, Combustion generated pollution, vehicles emission control, Case studies, Water Pollution: Water quality modelling for streams, Characterisation of effluents, effluent standards, Treatment methods, Primary methods: settling, pH control, chemical treatment. Secondary method: Biological treatment, Tertiary treatments like ozonisation, disinfection, etc. Solid waste collection, treatment and disposal, Waste recovery system.

**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 catalysts, Reactor modeling, Emphasizes the chemistry and engineering aspects of catalytic processes along with problems arising in industry, Catalyst deactivation kinetics and modeling.
CHL731 Introduction 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, crystallization, 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.

CH740 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

CHC750 Seminar (CC)
1 credit (0-0-2)
Pre-requisites: EC 142

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)

CHC760 Seminar (CP)
1 credit (0-0-2)
Pre-requisites: EC 142

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, polyporphons, Interfacial processes such as crystallization, epitaxy, froth flotation, adsorption, adsorptive 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, Differentering 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.

CHD770 Major Project Part- 1(CHD)
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.

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 hyposthesis, 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 Technology.

CHD780 Major Project Part-2 (CHD)
12 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.

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

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.

**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-L-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  

**CHL851 Major Project Part 1 (CC)**  
6 credits (0-0-12)  
Pre-requisites: EC 165  
Overlaps with: CHD853  
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.

**CHL852 Major Project Part 2 (CC)**  
14 credits (0-0-28)  
Pre-requisites: CHL851  
Overlaps with: CHL854  
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.

**CHL853 Major Project Part 1 (CC)**  
4 credits (0-0-8)  
Pre-requisites: EC 165  
Overlaps with: CHD851  
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.

**CHL854 Major Project Part 2 (CC)**  
16 credits (0-0-32)  
Pre-requisites: CHL853  
Overlaps with: CHD852  
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.

**CHL854 Applications of AI and ANN in Chemical Engineering**  
3 credits (2-0-2)  
Pre-requisites: EEL758  
AI and Chemical Engineering, Expert System and Chemical Engineering-CONPHYDE and OP55, KBS for Process Synthesis and Design, Design problem solving (Exsrep), 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 KBES tools such as KEE, ART, INSIGHT2+, NEXPERT, etc. from the perspective of Chemical Engineers.
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.

**CHD873-Major Project Part 1 (CM)**
4 credits (0-0-8)
Overlaps with CHD871
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.

**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.

**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)
**CYP100 Chemistry Laboratory**
2 credits (0-0-4)
An integrated laboratory course consisting of 12-14 experiments from physical, inorganic and organic chemistry. The course exposes the student to inorganic and organic synthesis as well as basic quantitative and qualitative analysis and is designed to illustrate the underlying principles of chemical and electro-analytical techniques, dynamics and chemical transformations.

Experiments on: Titrimetry, Surface tension and viscosity, Potentiometry, Conductometry, Preparations of metal complexes, Kinetic experiments, Thermo-chemical measurements, Quantitative estimation of organic compounds.

**CYL110 Physical Chemistry: Concepts and Applications**
4 credits (3-1-0)
(i) Chemical thermodynamics – Free energy and entropy changes in chemical processes, Phase rule and phase equilibria, Equilibrium electrochemistry; (ii) Quantum mechanical principles of structure and bonding in molecules and thermodynamic connection. (iii) Chemical dynamics – Reaction rates, Homogeneous and heterogeneous catalysis.

**CYL120 Inorganic and Organic Chemistry: Concepts and Applications**
4 credits (3-1-0)
Inorganic Chemistry:
(i) Transition metal complexes: Crystal field theory, basic concepts, crystal field effects in linear (ML2), tetrahedral, square planar (ML4) and octahedral geometry (ML6), pairing energies, weak field and strong field case, crystal field stabilization energy, factors affecting magnitude of 10Dq, high and low spin complexes, evidences for crystal field stabilization, tetragonal distortions from octahedral geometry, electronic spectra and magnetism.

(ii) Organometallics: EAN rule, metal carbonyls – synthesis, bonding and structure, metalloenes – synthesis and properties, Homogeneous and heterogeneous catalysis.

(iii) Bioinorganic chemistry: Metallorphyrins, metalloproteins, hemoglobin and myoglobin – structure and function.


Organic Chemistry:
(i) Structure and Stereoisomerism: Conjugation and aromaticity, stereoisomerism, structural representation of stereoisomers, IUPAC conventions for optical and geometrical isomers. Conformations and conformational analysis - linear and cyclic compounds. Resolution of racemates - chemical and enzymatic methods.


(iii) Applications: Formation, stability and application of reactive intermediates. Use of reactive intermediates in the design of synthesis of simple organic compounds.

**CYL210 Applied Chemistry: Chemistry at Interfaces**
6 credits (3-1-3)
Pre-requisites: CYP100 & CYL120
Unit processes in organic synthesis. Laboratory vs. industrial synthesis. Role of medium in directing synthetic outcomes, organised media. Natural and synthetic constrained systems (inorganic and organic) for control of reactivity in organic reactions. Phase transfer catalysis, polymer and other supported reagents for control of reactions. Green chemistry. Heterogeneous and homogeneous catalysis, surface chemistry, kinetics of catalysed reactions. Industrial catalysts.

**CYL230 Polymer Chemistry**
3 credits (2-1-0)
Pre-requisites: CYL120

**CYL250 Special Topics in Organic Chemistry**
4 credits (3-1-0)
Pre-requisites: CYL120

**CYL330 Chemistry of High Temperature Materials**
4 credits (3-1-0)
Pre-requisites: CYL120 and EC 60
Synthesis of molecular, non-molecular and composite materials. Physicochemical characterization of materials; structure-property relationship among materials; Application in refractory catalysis, sensors, semiconductors and superconductors.

**CYL340 Supramolecular Chemistry**
4 credits (3-1-0)
Pre-requisites: CYL120 and EC 60
Chemistry beyond the molecule. Supramolecular, chemical and biochemical recognition, biomodels, molecular organization and aggregation, organized media and its use in developing new technologies. Host guest chemistry with cations and anions, clathrates, liquid crystals, use of weak interaction-weak bonds for obtaining new materials and molecular catalysis, membrane mimetic chemistry and technologies, purpose linked molecular design and devices.

**CYL410 Computational Methods and Analysis**
3 credits (3-0-0)
Pre-requisites: CYL110 and EC 90
Structure, dynamics and equilibrium; Monte Carlo method, Brownian dynamics and molecular dynamics. Simple and associated liquids, aqueous solutions; colloids and simple polymers. Electronic Structure Calculations; Matrix methods for many particle Schrodinger equation, combining molecular dynamics methods with electronic structure calculations and quantum Monte Carlo etc. The systems to be considered as molecules, metals and semiconductors. Special methods for macromolecular systems; Energy minimization in multi-dimensions, visualization (exploration of steric and electrostatic complementarities) on systems such as biomolecules (protein and nucleic acids), Complex polymers. Zeolites. Implementation of all the above methods on computers.

**CYL501 Molecular Thermodynamics**
3 credits (3-0-0)
Pre-requisites: CYL110 and EC 90

**CYP501 Physical Chemistry Laboratory I**
2 credits (0-0-4)
Experiments highlighting the principles of thermodynamics, chemical equilibrium, and electrochemistry are included in this course. Examples include thermodynamics of micellization, synthesis, stabilization and spectroscopy of nanoparticles, photoluminescence, electrolyte solutions, thermodynamics of cell reaction etc.
CYP502 Organic Chemistry Laboratory I
2 credits (0-0-4)
Experiments involving basic techniques in organic chemistry will be introduced.

CYP503 Main Group Chemistry and Inorganic Solids
3 credits (3-0-0)

CYP503 Inorganic Chemistry Laboratory I
2 credits (0-0-4)
The laboratory course teaches experimental techniques in synthesis and characterization of metal complexes.

CYP504 Biochemistry I
3 credits (3-0-0)

CYP504 Biochemistry Laboratory I
2 credits (0-0-4)
Quantitative and qualitative estimation/tests of biomolecules. Enzyme assay and studies of their properties.

CYP505 Instrumental Methods of Analysis
3 credits (3-0-0)

CYP506 Quantum Chemistry
3 credits (3-0-0)

CYP506 Physical Chemistry Laboratory II
2 credits (0-0-4)
Experiments are primarily concerned with chemical kinetics and 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.

CYP507 Organic Synthesis
3 credits (3-0-0)

CYP507 Organic Chemistry Laboratory II
2 credits (0-0-4)
Synthesis and characterization of organic molecules will be given in this course.

CYP562 Stereochemistry and Organic Reaction Mechanism
3 credits (3-0-0)
Stereochemistry of acyclic and cyclic compounds including chiral molecules without a chiral centre. Reaction mechanisms (polar and free radical) with stereochemical considerations. Reactive intermediates: generation, structure and reactivity.

CYP563 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 organometalllics and bioinorganic chemistry.

CYP564 Biochemistry II
3 credits (3-0-0)

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

CYP565 Chemical Dynamics and Surface Chemistry
3 credits (3-0-0)

CYP566 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.

CYP600 Group Theory & Spectroscopy
3 credits (3-0-0)

CYP602 Pericyclic Reactions and Photochemistry
3 credits (3-0-0)

CYP603 Basic Organometallic Chemistry
3 credits (3-0-0)

CYP604 Biochemistry III
3 credits (3-0-0)

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

CYP665 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), characterisation 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)

**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 ($^1$H, $^13$C, $^31$P, $^15$N, $^77$As, $^{195}$Pt), 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)

**CYL697 Selected Topics in Biochemistry**
3 credits (3-0-0)

**CYL701 Electroanalytical Chemistry**
5 credits (3-0-4)
Principles of electro-chemical methods, electrochemical reactions, electroanalyticalvoltammetry as applied to analysis and the chemistry of heterogeneous electron transfers, electrochemical instrumentation.
Cyl702 Chemistry 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, AES, 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 modelling, 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.

Cyl706 Spectrochemical Methods
3 credits (3-0-0)
Principles and analytical applications of optical spectroscopic methods including atomic absorption and emission, UV-Visible, IR absorption, NMR (COSY, NOESY, and HSQC) and their use in structure elucidation. NMR properties, one-dimensional spectroscopy (1H, 13C, DEPT, steady state NOE, saturation transfer) and an introduction to two-dimensional NMR (HMQC, 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.

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; Introduction to Surfaces, UHV Instrumentation, Photoelectron Spectroscopy; 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)

Cyl722 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 diffraclometer.

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, spectroscopic, 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, ultracentrifugation, 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 (0-4-0)

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)
Department of Civil Engineering

CEL100 Earth and Earth Processes
3 credits (3-0-0)

CEL110 Basic Concepts in Sustainable Development
4 credits (3-1-0)
Introduction; Basic characteristics of pollution and receiving environment; Concepts in sustainability; Contaminants and fate of contaminants; Noise Pollution, Sustainability and Bioenvironment, ISO 14000 Series.

CEN110 Introduction to Civil Engineering
2 credits (0-0-4)
Introductory lectures, demonstrations, field visits on activities of department and the Civil Engineering Profession.

CEL120 Pollution Prevention and Control
3 credits (3-0-0)
Legislative Framework for Environmental Management; Introduction to pollution: Sources, types, characteristics and impacts. Prevention versus control of pollution: Environmentally sound technology management; Tools for clean production: reuse, recycle, recovery, source reduction, raw material substitution, toxic use reduction and process modifications. Voluntary environmental programs: life cycle analysis; environmental cost accounting; use of a business-friendly, prevention-based approach; and the measurement of environmental performance, EIA.

Urbanization and Sustainability, Environmental consequences of personal choices and examples of social marketing of more environmentally responsible consumption; Public Participation: Structure, Processes and Trends; Conflict Resolution.

CEL140 Environmental Studies
3 credits (3-0-0)
Energy & Environment – basic concepts of energy resources, fossil fuel, geothermal, tidal, nuclear, solar, wind, hydropower & biomas.

Ecology & Ecosystem Dynamics- ecosystem diversity, habitat classification. Type of ecosystems- wetlands, marshlands, swamps, lakes forest ecosystems- Tropical, Himalaya, sub-Himalaya deserts, shelf ecosystem.

Pollutant Sources and Control- air, water, solid waste and noise pollution and their control measures.


CEP200 Design Concepts in Civil Engineering
2 credits (0-0-4)
Pre-requisites: CEN110

CEL121 Environmental Engineering
4 credits (3-0-2)
Pre-requisites: CEN110

CEL222 Engineering Geology and Soil Mechanics
5.5 credits (3-1-3)
Pre-requisites: AML110 & CEN110
Engineering Geology: Introduction; Dynamic Earth; Materials of Earth; Silicate Structures and Symmetry Elements; Formations of Rocks; Characterisation; Weathering Processes; Geological Work – Landforms; Formation of Soils; Geological Time Scale; Structural Features; Tectonics; Stress Distribution; Earthquakes; Geological Maps and Air Photos; Ground Water. Soil Mechanics: Origin and Classification of Soils; Phase Relationships; Effective Stress Principle; Effective Stress Under Hydrostatic and 1D flow; Permeability; Compressibility; Consolidation; Terzaghi’s 1D Consolidation Theory; Shear Strength; Drainage Conditions; Pore Water Pressure; Mohr’s Circle; Failure Envelope and Strength Parameters; Factors Affecting Shear Strength; Laboratory: Geological Mapping – contouring, topo sheets, outcrops, apparent and true dips, three point problems, depth, thickness, joints, faults; Megascopic and Microscopic Identification of Minerals and Rocks. Visual Soil Classification; Water Content; Atterberg Limits; Grain Size Analysis; Specific Gravity; Permeability; Identification to consolidation and strength apparatus; Guided tour through representative geological formations and structures.

CEL231 Structural Analysis – I
5 credits (3-1-2)
Pre-requisites: AML110

CEL232 Concrete Material and Design
6 credits (3-1-4)
Pre-requisites: AML110 / AML120
Chemistry: properties and types of cement; Properties of aggregates and fresh concrete; Concrete Mix Design; Properties of hardened concrete; Reinforcing steel. Design Philosophy: Working stress and limit state design concepts; Design of R.C. beam Sections in flexure, shear, torsion and bond; Design for serviceability; Design of R.C. beams; Design of one way and two way R.C. Slabs; Design of R.C. short and long columns; Design of R.C. footings.

CEL241 Transportation Engineering – I
4 credits (3-0-2)
Pre-requisites: CEN110
Transportation Systems and their classification and description. Role of Roads, Road Transport and Planning in India. Road User and the Vehicle. Geometric Design: Horizontal Alignment, Vertical Alignment,

**CEL251 Hydrology and Hydraulics**
6 credits (3-1-4)
Pre-requisites: CEN110 & AML110


**CEL271 Elements of Surveying**
3 credits (2-0-2)
Pre-requisites: CEN110

**CED310 Mini Project (CE)**
3 credits (0-0-6)
Pre-requisites: EC 80
Design/fabrication/implementation work under the guidance of a faculty member. Prior to registration, a detailed plan of work should be submitted by the student to the Head of the Department for approval.

**CEL311 Advanced Water and Wastewater Engineering**
4 credits (3-0-2)
Pre-requisites: CEL212

**CEL321 Geotechnical Engineering**
5.5 credits (3-1-3)
Pre-requisites: CEL222
Soils of India; Engineering properties of Natural and Compacted Soils; Flow Through Soils – Laplace equation, flownets, seepage; Site Investigations; Foundations – types, selection, design considerations, bearing capacity and settlement of shallow foundations; deep foundations; Slope Stability Analysis; Earth Dams – types and design aspects; Earth Pressures and Retaining Structures; Engineering Properties of Rocks; Rock as Construction Material; Geological Site Criteria for Tunnels and Underground Structures, Dams, Rock Slopes and Landslides. Laboratory: Compaction, consolidation, sample preparation, vane shear test, direct shear test, unconfined compression test, unconsolidated undrained test, consolidated drained test, consolidated undrained test with pore water pressure measurement, direct shear test, drilling and sampling, field density, engineering properties of rocks, refraction and resistivity methods.

**CEL326 Geoenvironmental Engineering**
3 credits (3-0-0)
Pre-requisites: EC 60
Sources of subsurface contamination and their effects; types of waste; integrated management of waste; transportation and disposal of solid waste on land; types of soils, permeability of soils, flow through soils, soil-waste interaction; ground water contamination; Waste containment principles; environmental control over liners, covers, leachate management and gas management; waste disposal in municipal solid waste landfills and in hazardous waste landfills; Waste disposal of coal-ash and mine tailings in ponds and mounds, of very hazardous waste in rocks in rocks; detection and monitoring of subsurface contamination; contaminated site characterization; control and remedial measures for contaminated sites; pollution control regulations.

**CEL331 Structural Analysis – II**
5 credits (3-1-2)
Pre-requisites: CEL231
Development of Slope-Deflection Equations of Equilibrium: Applications to Beams, frames undergoing user support settlement; Development of Moment Distribution Method; Distribution Factors; Application to Beams and Frames without side sway; Application to Frames with side sway; Beams and Frames with uneven loading; Support Settlement; Cases of Symmetry and anti symmetry; Strain energy method of analysis; Introduction to nature methods of analysis; Flexibility Method; Stiffness method; Direct Stiffness Methods for computer Application; Introduction to computer software for Analysis.

**CEL332 Design of Steel Structures**
5 credits (3-1-2)
Pre-requisites: CEL231
Introduction to stability and buckling concepts; Structural steel and properties; Riveted, bolted and welded connections; Working stress and plastic design Methods; Design of tension, compression and flexural members (including built-up members); Column bases; Roof trusses.

**CEL338 Infrastructure Planning and Management**
3 credits (3-0-0)
Pre-requisites: EC 60
Overview of the course, Infrastructure's impact on development of a country, Status of various sectors in Indian Infrastructure, Infrastructure Financing, Private Sector participation in infrastructure models, Basics of infrastructure planning, Problems in Infrastructure Development and Management.

**CEL339 Concrete Technology and Materials**
3 credits (3-0-0)
Pre-requisites: EC 60
Cement Hydration: Cement Types, Paste Micro-structure; Workability; Durability; Factors affecting strength of concrete, Quality control; Concrete mix design; Types of concrete; Concrete production; Tests of concrete in structures; Failure criteria; Fracture mechanics; Hardening plasticity and fatigue; Creep and shrinkage; Fresh concrete modelling; Moisture/tonic diffusion in concrete.

**CEL341 Transportation Engineering – II**
4 credits (3-1-0)
Pre-requisites: CEL241 and EC 60
Design of transportation facilities. (i) Rail Transport: location and route layout, section signals and intersections, earth work and pavement (track, stops, terminals, yard, parking etc.). (ii) Airports: Layout plan, terminal area, interconnection with other modes of transport, runways,
Civil Engineering

circulation patterns, traffic controllers. (iii) Ports and other water transport technology belt conveyor and aerial transport: planning principles, operational requirements, Mekong, Hydrofoil, pipeline, etc. (iv) Transport Structure: FOBs, underground and multistoreyed parking, ramps, escalators, elevators, etc.

**CEL351 Design of Hydraulic Structures**  
3 credits (2-0-2)  
**Pre-requisites:** CEL251  
Input studies, canal layout, regime canal design, design concepts for irrigation structures on permeable foundations, energy dissipation devices, design of diversion works, gravity dam, cross drainage works, canal falls.

**CEL362 Construction Management**  
4 credits (3-1-0)  
**Pre-requisites:** EC 60  
Overview of the to the course, Linear programming, Problems in construction, Formulation, Graphical solution, Simplex method, Dual problem, sensitivity analysis and their application to Civil engineering, Transportation Assignment problems and their applications, Building Specifications, estimation and rate analysis. Project planning and network analysis, Time and cost control, Resource scheduling.

**CEC410 Colloquium (CE)**  
3 credits (0-3-0)  
**Pre-requisites:** registered for CET410  
Presentation by each student on his/her practical training and other topics specified by the course coordinator.

**CET410 Practical Training (CE)**  
Non credit  
**Pre-requisites:** EC 90 at the end of 5th sem.  
Practical Training of 50 working days in an Indian industry or R&D organization.

**CED411 Major Project Part 1 (CE)**  
3 credits (0-0-6)  
**Pre-requisites:** EC 120  
To set the objectives, deliverables, work plan, logistics planning and milestones with discernible outputs and then to demonstrate the feasibility through some initial work.

**CEL411 Industrial Waste Management**  
3 credits (3-0-0)  
**Pre-requisites:** EC 90  
Nature and characteristics of industrial wastes; Control and removal of specific pollutants in industrial wastewaters, i.e., oil and grease, cyanide, fluoride, toxic organics, heavy metals. Recent trends in industrial waste management; Prevention versus control of industrial pollution; Linkage between technology and pollution prevention; Tools for clean production, reuse, recycle, recovery, source reduction, raw material substitution, toxic use reduction and process modifications; Point, and area source: dispersion modeling of industrial air pollutants. Source reduction and control of industrial air pollution; Minimization of industrial solid and hazardous waste; Waste management case studies from various industries.

**CED412 Major Project Part 2 (CE)**  
7 credits (0-0-14)  
**Pre-requisites:** CED411  
Preferably continuation of the topic of CED411.

**CEL412 Environmental Assessment Methodologies**  
3 credits (3-0-0)  
**Pre-requisites:** EC 90  
Environmental issues related to developmental activities: Nature and characteristics of environmental impacts of urban and industrial developments. Linkages between technology, environmental quality, economic gain, and societal goals. Environmental indices and indicators for describing affected environment. Methodologies and environmental systems modeling tools for prediction and assessment of impacts on environmental quality (surface water, ground water, air, soil). Monitoring and control of undesirable environmental implications. Environmental cost benefit analysis. Decision methods for evaluation of environmentally sound alternatives; Environmental health and safety: Basic concepts of environmental risk and definitions; Hazard identification procedures; Consequence analysis and modeling (discharge models, dispersion models, fire and explosion models, effect models etc.); Emerging tools for environmental management: Environmental Management Systems, Environmentally sound technology transfer, emission trading, international resource sharing issues, climate change, international environmental treaties and protocols. Case studies.

**CEL421 Ground Improvement**  
4 credits (3-0-2)  
**Pre-requisites:** CEL321  
Compaction methods used in the laboratory and the field; shallow stabilization with cement, lime, flyash and other chemical admixtures; deep stabilization using vibroflotation, compaction piles, dynamic compaction, blasting, sand drains, stone columns, lime and cement columns; Grouting by permeation, displacement and jet methods; functions and applications of geosynthetics – geotextiles, geogrids, geomembranes; soil reinforcement using strips, bars and geosynthetics; soil nailing and ground anchors; dewatering techniques; Earthmoving machines and earthwork principles; piling and diaphragm wall construction; tunneling methods in soils; hydraulic barriers and containment systems for waste disposal in soils; control and remediation of soil contamination; Laboratory: Lab compaction methods – light, heavy, kneading, vibratory- for soils and soils with admixtures; plasticity and undrained strength behaviour of compacted and stabilized clays; drained strength behaviour of compacted / stabilized sands.

**CEL422 Rock Engineering**  
3 credits (3-0-0)  
**Pre-requisites:** CEL321  
**Overlaps with:** CEL651  
Geological classification, rock and rock mass classification, strength and deformation behaviour of rocks, pore pressures, failure criteria, laboratory and field testing, measurement of in-situ stresses and strains, stability of rock slopes and foundations, design of underground structures, improvement of in situ properties of rock masses and support measures.

**CEL423 Design of Foundations, Earth and Earth Retaining Structures**  
4 credits (3-1-0)  
**Pre-requisites:** CEL321  
**Overlaps with:** CEL610, CEL704, CEL708  

**CEL431 Advanced Structural Analysis**  
3 credits (2-0-2)  
**Pre-requisites:** CEL331  
Introduction to FEM for structural analysis with review of energy methods – 2D plane stress and plane strain elements, beam element, 2D bending element, example problems; elements of structural dynamics- free and forced vibration of SDOF system, treatment of impact and arbitrary loading, frequency and time domain analysis; free vibration mode shapes and frequencies of MDOF systems; normal mode theory for forced vibration analysis of MDOF system; example problems. Elements of plastic analysis; upper and lower bound theorems; method of collapse mechanism; application to beams and multistory frames; example problems.
**CEL432 Design of Prestressed Concrete and Industrial Structures**  
*4 credits (3-0-2)*  
**Pre-requisites:** CEL232 & CEL331  

**CEL433 Advanced Structural Design**  
*4 credits (3-0-2)*  
**Pre-requisites:** CEL232 & CEL332  
Design of Reinforced Cement concrete (RCC) Structures – Building frames, Liquid retaining structures, Earth retaining walls, Flat slabs, Staircases. Design of Steel Structures – Plate girders, gantry girders and steel bridge components.

**CEL442 Traffic and Transportation Planning**  
*3 credits (2-1-0)*  
**Pre-requisites:** CEL241 and EC 90  
Transportation Engineering System, Random utility theory, Supply and demand, Flow estimation and modeling, Planning and engineering evaluation, Transportation engineering management, Traffic flow theory and management, Air and water navigational control, Rehabilitation and satellite area accessibility, Network and graph theory application.

**CEL443 Transportation Safety and Environment**  
*3 credits (3-0-0)*  
**Pre-requisites:** EC 90  
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; 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. 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.

**CEL450 Introduction to Remote Sensing**  
*3 credits (2-0-2)*  
**Pre-requisites:** EC 90  
What is Remote Sensing? Historical development of remote sensing, Remote sensing components, Data collection and transmission, Sensors and satellite imageries, Electromagnetic energy and spectrum, Wavebands, Interactions of electromagnetic energy with atmosphere and earth’s surface, Radiometric quantities, Photogrammetry and aerial photography, Vertical and tilted photographs, Photographic materials, Photo-processes, Stereoscopic viewing, Fly view, Aerial mosaics, Various satellite systems and monitoring programs, Data Products, Satellite data, Data formats, Data acquisition for natural resources management and weather forecast, Random errors and least square adjustment, Coordinate transformation, Photographic interpretation, Image processing, Potential applications of remote sensing in diverse areas and decision making, Integrated use of remote sensing and GIS, Case studies.

**CEL451 Water Power Engineering**  
*4 credits (3-0-2)*  
**Pre-requisites:** CEL251 and EC 90  
Basic principle of hydropower generation, Hydropower Project Planning, Site selection, Hydropower development schemes, Reservoir storage, Assessment of power potential, Hydrologic analysis: Flow duration and power duration curves, Dependable flow, Design flood, Reservoir operation; Hydraulic design of various components of hydropower plants: intakes, hydraulic turbines, centrifugal and axial flow pumps, conduits and water conveyance, Penstocks; Performance characteristics of turbines, Specific and unit quantities, Electrical load on hydro-turbines, Power house dimension and planning, Water hammer and surge analysis, Surge tanks, Small hydro power development, tidal plants, Current scenarios in hydropower development, Project feasibility, Impact of hydropower development on water resources systems, environment, socioeconomic conditions and national economy.

**CEP452 Computational Aspects in Water Resources**  
*3 credits (1-0-4)*  
**Pre-requisites:** CEL251 and EC 90  
Numerical Interpolation and Integration and application of water resource problems. Numerical solution of differential equations in water resources, such as, groundwater flow, pipe flows, open channel flows.

**CEL453 Water Resources Management**  
*4 credits (3-1-0)*  
**Pre-requisites:** CEL251 and EC 90  

**CEL455 Introduction to Geographic Information Systems**  
*3 credits (2-0-2)*  
**Pre-requisites:** EC 90  
Overlaps with: CEL447  
What is GIS. Geographic concepts for GIS. Spatial relationships, topology, spatial patterns, spatial interpolation. Data storage, data structure, non-spatial database models. Populating GIS, digitizing data exchange, data conversion. Spatial data models, Raster and Vector data structures and algorithms. Digital Elevation Models (DEM) and their application. Triangulated Irregular Network (TIN) model. GIS application areas, Spatial analysis, quantifying relationships, spatial statistics, spatial search. Decision making in GIS context.

**CEL459 River Mechanics**  
*3 credits (2-0-2)*  
**Pre-requisites:** CEL251 and EC 90  
Introduction, river morphology, drainage patterns, stream order. Properties of mixture of sediment and water, Incipient motion and quantitative approach to incipient motion, channel degradation and armoring. Bed forms and resistance to flow, various approaches for bed load transport, suspended load profile and suspended load equations, total load transport including total load transport equations. Comparison and evaluation of sediment transport equations. Stable channel design with critical tractive force theory.

**CEL464 Construction Contract and Economics**  
*3 credits (2-1-0)*  
**Pre-requisites:** EC 90  
Overview of the to the course, Engineering economics of the projects, Time value of money, comparison of alternatives, Depreciation and depletion, Quantity surveying, Direct and indirect costs, Professional agreements; Contracts and specification; Disputes, Arbitration and other methods of dispute resolution. Bidding and bidding models.

**CEL466 Construction Equipment and Methods**  
*3 credits (2-1-0)*  
**Pre-requisites:** EC 90  
Overview of the course; Basic principles of construction, selection and economy; General construction equipment – excavation, earthmoving, drilling, blasting, dewatering, shoring, strutting, disposal and underpinning, well sinking and pile driving, heavy lifting. Operations and maintenance of equipment, Productivity estimates, Cycle time, Planning and scheduling of equipment by networks, Formworks and scaffolding, Concrete construction practices. Prefabrication and modular coordination; Steel construction, special constructions such dams, bridges, high rise buildings, offshore platforms.
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 strength 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 - Intermediate and Consolidation; Codel 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 Engineering 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)

CEP702 Geoenvironmental and Geotechnical Engineering Laboratory
3 credits (0-0-6)

CEP703 Site Investigations and Ground Improvement
3 credits (3-0-0)
Site Investigations:
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 – wave and slopes; Codi 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. Codi 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. Codi 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; Codi provisions; Underground Structures in Soils: Pipes; Conduits; Trenchless technology; Tunneling techniques – cut-and-cover method, shield tunnelling.

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

CEL712 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.

CEL714 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 exciting developments in the broad spectrum of Geotechnical and Geoenvironmental Engineering. The course will also focus on new offshoots of Geotechnical and Geoenvironmental Engineering.

CEL715 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.

CEL717 Advanced Structural Analysis
3 credits (3-0-0)

CEL718 Design of Steel Structures
3 credits (2-1-0)

CEL719 Structural Dynamics
3 credits (3-0-0)
Free and forced vibration of single degree of freedom (SDOF) systems, response to harmonic, periodic, impulsive and general dynamic loading,

**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 odes;Superposition and correspondance 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.

**CEL732 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)

**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)

**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 of ground water; Salt water intrusion, Introduction to analog and numerical models to solve ground water problems, Application of finite difference method in ground water.
CEL740 Simulation Laboratory
4 credits (1-0-0)
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, Physical and hydrological characteristics of lakes, Finite 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 earth damns, 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, depreciation, 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 project 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 zones. 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 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 market, Integration of various types of plants, Augmentation of power 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 sizing, Multireservoir systems, Real time operation, Water conflicts, River basin planning, Engineering heuristics, Systems reliability, Case studies.

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 classifications, Rating, Applications. Creep and cyclic loading. Weathered rocks. Flow through intact and fissured rocks. Dynamic properties.

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.


**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)


**CEP757 Field Exploration and In situ Measurements**
3 credits (3-0-0)
Surface and subsurface 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, Coadal 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.

**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.

Safety provisions, localized hazards, fire hazards in highway tunnels, rapid transit tunnels. Tunnel finish, Rehabilitation. Inspection methods, Repairs, Tunnel construction contracting.
**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)  


**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 changes, 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)  

**CEL769 Project Planning and control**  
3 credits (2-1-0)  
Material management- purchases management and inventory control, ABC analysis.  
Human Resource management.

**CEP770 Computation Lab for Construction Management**  
3 credits (0-0-6)  
Programming and use of spreadsheet and software in estimation, quantity survey, Network preparation and computations, scheduling and allocation etc., application of L.P. in construction problem, statistical quality control at site.

**CEL771 Civil Engineering Materials**  
3 credits (3-0-0)  

**CEL772 Quantitative Methods in Construction Management**  
3 credits (2-1-0)  
Introduction and concepts of probability and statistics, Linear programming, Transportation and assignment problems. Dynamic programming, Queuing theory, Decision theory, Games theory. Simulations applied to construction, Modifications and improvement on CPM/PERT techniques.

**CEL773 Management of Quality and Safety in Construction**  
3 credits (2-1-0)  


**CEL774 Construction Engineering Practices**  
3 credits (3-0-0)  
Concrete Construction methods: form work design and scaffolding, slip form and other moving forms, pumping of concrete and grouting, mass concreting (roller compacted concrete), ready mixed concrete, various methods of placing and handling concrete, Accelerated curing, Hot and cold weather concreting, Under water concreting, Prestressing.  
Steel and composites construction methods: Fabrication and erection 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 of techniques, heuristic procedures, formulation of linear and non-linear optimization problems. 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 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, Dewatring, 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. Role of Environment, City structure and fabric. Comparison and evaluation of various models. Simultaneous travel demand models: Parameter Estimation and Validation. Transportation impact study methodologies. Regional analysis and development concepts. Data collection and use of surveys. The role of transportation planning in the overall regional system. Methodology and models for regional transportation system, planning, implementation framework and case studies. Applications to passenger and freight movement in urban and regional contexts. Implications for policy formulations and analysis.

**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)
Design pavement structure. Stresses in rigid and flexible pavements, sub-grade 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. Superelevation, 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, Langelier 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)
Water Demands and Sources, Water quality parameters; Epidemiological and toxic aspects. Physical and chemical interactions due to various forces, suspensions and dispersions. Surface and colloidal chemistry. Settling of particles in water, coagulation and flocculation, flotation, filtration-mechanisms and interpretations, ion exchange and adsorption, Chemical oxidation/reduction processes. Disinfection using chlorine, UV, Ozone. Water stabilization, aeration and gas transfer. Reverse osmosis, Electrodialysis, Desalination. Treatment and sludge management.

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 Structures
3 credits (3-0-0)
Introduction; Rheological modelling of fresh concrete; Constitutive equations; Nonlinear elasticity, plasticity, visco-elasticity and fracture
Civil Engineering

Mechanics of hardened concrete; Confinement and ductility; Moisture diffusion; Drying shrinkage; Solid and structural mechanics of reinforced concrete, Skew bending, modified compression field and unified theories of R.C. beams under bending, shear and torsion; Bond-slip and phenomenon of cracking in reinforced concrete; Statical and dynamical analysis of R.C. Structures; Trends.

**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, global and local techniques, computational aspects of global dynamic techniques, experimental mode 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; Growth and Decay processes; 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 models. Application of optimization methods such as search techniques, linear programming, dynamic programming and integer programming. Integrated management strategies addressing multi-objective planning. Laboratory – Simulation of Environmental Processes, Application of Environmental Databases and Environmental Software Packages, including systems Optimisation.

**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 (0-3-0)  
Comprehensive review of problems and solutions related to air, water, wastewater, and solid waste management. Identification and evaluation of current and emerging local, regional and global environmental, and socio-economic issues.

**CED897 Major Project Part-1 (Environmental Engineering and Management)**  
5 credits (2-0-18)  
Domestic and international experiences; case studies.

**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. Laboratory – Simulation of Environmental Processes, Application of Environmental Databases and Environmental Software Packages, including systems Optimisation.

**CED881 Major Project Part-1 (Environmental Engineering and Management)**  
6 credits (0-0-12)  
Domestic and international experiences; case studies.

**CED882 Major Project Part-2 (Environmental Engineering and Management)**  
6 credits (0-0-12)  
Domestic and international experiences; case studies.
CED895 Major Project (M.S. Research)
40 credits (0-0-80)

CEL895 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.

CEL896 Design of Water and Wastewater Facilities
3 credits (3-0-0)

CEL897 Membrane Processes for Water and Waste Treatment
3 credits (3-0-0)

CEL898 Life Cycle Analysis and Design for Environment
3 credits (3-0-0)

CEL899 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.
CSL101 Introduction to Computers and Programming
4 credits (3-0-2)
Overlaps with: CSL102
Concept of an algorithm: termination and correctness. Algorithms to programs: specification, top-down development and stepwise refinement. Use of high level programming language for the systematic development of programs. Introduction to the design and implementation of correct, efficient and maintainable programs. Introduction to computer architecture: memory, ALU, CPU, I/O devices. Introduction to system software; operating systems, compilers and multi-user environments.

CSL102 Introduction to Computer Science
4 credits (3-0-2)
Overlaps with: CSL101
Design of algorithms; iterative versus recursive style; problem solving using a functional style; correctness issues in programming; efficiency issues in programming; time and space measures; Imperative style of programming; Assertions and loop invariants; programming in an imperative language using advanced features: procedures, functions, list handling using references; file handling; objects and classes.

CSL105 Discrete Mathematical Structures
4 credits (3-1-0)
Overlaps with: MAL180
Fundamental structures: Functions (surjections, injections, inverses, composition); relations (reflexivity, symmetry, transitivity, equivalence relations); sets (Venn diagrams, complements, Cartesian products, power sets); pigeonhole principle; cardinality and countability. Basic logic: Propositional logic; logical connectives; truth tables; normal forms (conjunctive and disjunctive); validity; predicate logic; limitations of predicate logic; universal and existential quantification; modus ponens and modus tollens. Proof techniques: Notions of implication, converse, inverse, contrapositive, negation, and contradiction; the structure of formal proofs; direct proofs; proof by counterexample; proof by contraposition; proof by contradiction; mathematical induction; strong induction; recursive mathematical definitions; well orderings. Basics of counting: Counting arguments; pigeonhole principle; permutations and combinations; inclusion-exclusion, recurrence relations, generating functions.

CSN110 Introduction to Computer Science and Engineering
2 credits (0-0-4)
Overview of the Department's academic/research programmes; state of the computer industry in India and abroad.

CSL201 Data Structures
5 credits (3-0-4)
Pre-requisites: CSL101 / CSL102

CSL211 Computer Architecture
5 credits (3-1-2)
Pre-requisites: (CSL101/CSL102) & (EEL201 & EEP201) (Concurrent registration in EEL201 & EEP201 is acceptable) Overlaps with: EEL308, EEP308
Subsystems of a computer; Instructions and their formats; Assembly programming; Performance metrics; Performance comparison; Information representation; Integer and floating point arithmetic; Processor datapath design; Control unit design; Microprogramming; Performance improvement with pipelining; Memory organization - cache and virtual memory; Input/Output organization; Interrupts and DMA.

CSP301 Design Practices in Computer Science
3 credits (0-1-4)
Pre-requisites: CSL201
Basic design methodology – introduction to the steps involved, Familiarization with software practices, tools and techniques, Software project involving conceptualization, design, analysis, implementation and testing using the tools and techniques learnt.

CSP302 Programming Languages
5 credits (3-0-4)
Pre-requisites: CSL201
Overlaps with: MAL375
Notions of syntax and semantics of programming languages; introduction to operational/natural semantics of functional and imperative languages. Data abstractions and control constructs; block structure and scope, principles of abstraction, qualification and correspondence; parameter passing mechanisms; runtime structure and operating environment; practical and implementation issues in run-time systems and environment; abstract machines; features of functional and imperative languages; the untyped and simply-typed Lambda calculus, type systems for programming languages including simple types and polymorphism; objects, classes and inheritance in object-oriented languages.

CSP303 Logic for Computer Science
4 credits (3-0-2)
Pre-requisites: CSL201
Review of the principle of mathematical induction; the principle of structural induction; review of Boolean algebras; Syntax of propositional formulas; Truth and the semantics of propositional logic; Notions of satisfiability, validity, inconsistency; Deduction systems for propositional logic; Completeness of a deduction system; First order logic; Proof theory for FOL; introduction to model theory; Completeness and compactness theorems; First order theories. Programming exercises will include representation and evaluation; conversion to normal-forms; tautology checking; proof normalization; resolution; unification; Skolemization; conversion to Horn -clauses; binary-decision diagrams.

CSD310 Mini Project (CS)
3 credits (0-0-6)
Pre-requisites: EC 80
Design/fabrication/implementation work under the guidance of a faculty member. Prior to registration, a detailed plan of work should be submitted by the student to the Head of the Department for approval.

CSR310 Professional Practices (CS)
2 credits (0-1-2)
Pre-requisites: EC 60
The course would consist of talks by working professionals from industry, government and research organizations. It may also include site visits to various organizations.

CSS310 Independent Study (CS)
3 credits (0-3-0)
Pre-requisites: EC 60
Research oriented activities or study of subjects outside regular course offerings under the guidance of a faculty member. Prior to registration, a detailed plan of work should be submitted by the student to the Head of the Department for approval.

CSP315 Embedded System Design Laboratory
4 credits (0-1-6)
Basic design methodology – introduction to the steps involved, Familiarization with software practices, tools and techniques, Software project involving conceptualization, design, analysis, implementation and testing using the tools and techniques learnt.

Department of Computer Science and Engineering
CSL316 Digital Hardware Design
5 credits (3-0-4)
Pre-requisites: CSL211 & EEL201 & EEP201
Overlaps with: EEL224
Combinational circuit design using MSI/LSI and programmable logic modules; Iterative and tree networks; Sequential circuit design and implementation; Algorithmic state machine design; Asynchronous and pulse mode circuit design; Hardware description language and synthesis; Microprogrammed control design; Testing of digital systems; Introduction to hardware-software cosynthesis.

CSL332 Introduction to Database Systems
4.5 credits (3-0-3)
Pre-requisites: CSL201
Overlaps with: MAL710

CSL333 Artificial Intelligence
4 credits (3-0-2)
Pre-requisites: CSL201
Overlaps with: EEL758

CSL356 Analysis and Design of Algorithms
4 credits (3-1-0)
Pre-requisites: CSL201
Overlaps with: MAL342

CSL361 Numerical and Scientific Computing
5 credits (3-1-2)
Pre-requisites: CSL101 / CSL102 and EC 60
Overlaps with: MAL230, EPL333
Introduction to Scientific Computing, Review of matrices and linear systems, Linear Least Squares, Eigenvalue Problems, Nonlinear Equations. Optimization, Interpolation, Numerical Integration and Differentiation, Initial and Boundary Value Problems for Ordinary Differential Equations, Partial Differential Equations, Fast Fourier Transform. Throughout the course, implementation of the various methods and their comparisons with professionally written software such as LINPACK, ITPACK, EISPACK, LAPACK, SPARSE PACK will be emphasized with the understanding of various data-structures, storage schemes etc. Existence and uniqueness, sensitivity and condition, convergence and error analysis will be part of every topic.

CSL362 Simulation and Modelling
4 credits (3-0-2)
Pre-requisites: CSL201 & MAL250
Fundamentals of modelling; Classification of simulation models; The simulation process: System investigation; model formulation, validation and translation; Time flow mechanisms; Design of computer simulation experiments; Simulation of complex discrete-event systems with applications in industrial and service organizations. Tactical planning and management aspects; Random variable generation and analysis.

CSL373 Operating Systems
5 credits (3-0-4)
Pre-requisites: CSL201 & CSL211 & CSL302
Overlaps with: CSL633, EEL358, MAL358
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; input-output architecture and device management; file systems; distributed file systems; Case studies of Unix , Windows NT. Design and implementation of small operating systems.

CSL374 Computer Networks
4.5 credits (3-0-3)
Pre-requisites: EEL205 & CSL211 & CSL201
Overlaps with: EEL703
Fundamentals of Digital Communications, including channel capacity, error rates, multiplexing, framing and synchronization. Broadcast network and multi-access protocols, including CSMA/CD. Data link protocols, Network protocols including routing and congestion control, IP protocol. Transport protocol including TCP. Network application services and protocols including email, www, DNS. Network security and management.

CSC410 Colloquium (CS)
3 credits (0-3-0)
Pre-requisites: Registered for CST410
The students will deliver talks on their experience during the 50 working days of practical training, and topics of current interest in the computer science and engineering field. These would include technology, research as well standards issues.

CST410 Practical Training (CS)
Non credit
Pre-requisites: EC 90 at the end of 5th sem.
Expose the students to the actual Industrial environment. Fifty (50) working days or 400 hours of practical training in an industry/research laboratory.

CSD411 Major Project Part 1 (CS)
4 credits (0-0-8)
Pre-requisites: EC 120
This project spans also the course CSD412. Hence it is expected that the problem specification and the milestones to be achieved in solving the problem are clearly specified.

CSD412 Major Project Part 2 (CS)
8 credits (0-0-16)
Pre-requisites: CSD411
The student(s) who work on a project are expected to work towards the goals and milestones set in CSD411. 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.

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; Multicast 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 installation of software, archiving and creation of libraries, version control methods, usage of standard libraries like pthreads, 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).

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

CSD745 Minor Project
4 credits (0-1-5)
Research and development projects based on problems of practical and theoretical interest. Evaluation will be based on periodic presentations, student seminars, written reports, and evaluation of the developed system (if applicable).
CSL750 Foundations of Automatic Verification 4 credits (3-0-2)
Pre-requisites: CSL302 & CSL705
A selection from the following topics, and experiments with the mentioned tools:

- Review of first-order logic, syntax and semantics. Resolution theorem proving, Binary Decision Diagrams (BDDs) and their use in representing systems. (Programming exercises coding and using logic programming frameworks).
- Transition systems, automata and transducers. Buechi and other automata on infinite words; Linear Time Temporal Logic (LTL), and specifying properties of systems in LTL; the relationship between temporal logic and automata on infinite words, LTL Model checking (exercises using Spin or similar tools); Computational Tree Logic (CTL and CTL*); CTL model checking (exercises); Process calculi such as CSP and CCS. Notions of program equivalence — traces, bisimulation and other notions. Hennessy-Milner Logic (HML) and Mu calculus (exercises using tools such as CBW — Concurrency Work Bench). Symbolic model checking, exercises using tools such as SMV.
- Sat-based model checking and Davis-Putnam procedure; (exercises using tools such as nuSMV).
- Possible additional topics include: equational logic frameworks, real-time frameworks, reactive frameworks, pi-calculus (exercises using tools such as the Mobility Workbench), Tree automata and Weak Second-order Logic with k successors (WKS), (exercises using Mona or similar tools).

CSL758 Advanced Algorithms 4 credits (3-0-2)
Pre-requisites: CSL356/CSL630
Overlaps with: MAL760
Topics from some or all of the following areas:

- Graph algorithms: Matching and Flows. Approximation algorithms: Use of Linear programming and primal dual, Local search heuristics. Parallel algorithms: Basic techniques for sorting, searching, merging, list ranking in PRAMs and Interconnection networks.

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, E_1 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 and 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.

CSL771 Database Implementations 4 credits (3-0-2)
Pre-requisites: CSL332 & CSL201
Overlaps with: CSL630
Relational Algebra, Database Language SQL and System Aspects of SQL, Constraints and triggers, Disk Storage, Disk and Memory Organization for Relational Operators, Representing Data Elements, Index Structures, Query Execution, Query Compilation, Query Optimization, Coping with System Failures, Concurrency Control, Transaction Management, Representation of Data.

CSL781 Computer Graphics 4.5 credits (3-0-3)
Pre-requisites: CSL201 and EC 90
Overlaps with: MAL754, EEL754
Graphics pipeline; Graphics hardware: Display devices, Input devices; Raster Graphics: line and circle drawing algorithms; Windowing and 2D/3D clipping; Cohen and Sutherland line clipping, Cyrus Beck clipping method; 2D and 3D Geometrical Transformations: scaling, translation, rotation, reflection; Viewing Transformations: parallel and perspective projection; Curves and Surfaces: cubic splines, Bezier curves, B-splines, Parametric surfaces, Surface of revolution, Sweep surfaces, Fractal curves and surfaces; Hidden line/surface removal methods; Illuminations model; shading: Gouraud, Phong; Introduction to Ray-tracing; Animation; Programming practices with standard graphics libraries like openGL.

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
Introduction to Type theory: The simply-typed lambda-calculus, Intuitionistic type theory. Curry-Howard correspondence. Polymorphism, algorithms for polymorphic type inference, Girard and Reynolds' System F. Applications: type-systems for programming languages; modules and functors; theorem proving, executable specifications.

CSL838 Wireless Networks
3 Credits (3-0-0)
Pre-requisites: CSL774 / 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.

CSL851 Major Project Part 1 (CO)
6 credits (0-0-12)
Pre-requisites: EC 165
Overlaps with: CSD853
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.

CSL852 Approximation Algorithms
3 credits (3-0-0)
Pre-requisites: CSL356 and EC 120
Overlaps with: MAL376

CSL854 Major Project Part 2 (CO)
14 credits (0-0-28)
Pre-requisites: CSD851
Overlaps with: CSL854
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.

CSL855 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, time-space tradeoffs for some fundamental problems. Reductions and completeness, Randomized complexity classes, Boolean circuit complexity. Cryptography and one-way functions. Polynomial hierarchy, P-space completeness. Interactive proofs and Hardness of approximation, Parallel complexity classes.

CSL856 Approximation Algorithms
4 credits (3-0-2)
Pre-requisites: CSL851
Overlaps with: CSL856
Computer Science and Engineering

programming and applications to max-cut, graph coloring. Concept of best possible approximation algorithms, Hardness of approximations.

CSL855 Models of Computation
3 credits (3-0-0)
Pre-requisites: EC 120, CLS 356 / CLS 630

CSL856 Mathematical Programming
3 credits (3-0-0)
Pre-requisites: EC 120, CSL 356 or ( CSL 105 and MAL 124)
Overlaps with: MAL365

CSL857 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.

CSL859 Advanced Computer Graphics
4 credits (3-0-2)
Pre-requisites: CSL781
Rendering: Ray tracing, Radiosity methods, Global illumination models, Shadow generation, Mapping, Anti-aliasing, Volume rendering, Geometrical Modeling: Parametric surfaces, Implicit surfaces, Meshes, Animation: spline driven, quaternions, articulated structures (forward and inverse kinematics), deformation — purely geometric, physically-based, Other advanced topics selected from research papers.

CSL860 Special Topics in Parallel Computation
4 credits (3-0-2)
Pre-requisites: CSL201, CSL373 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.

CSL861 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.

CSL862 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.

CSL863 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.

CSL864 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.

CSL865 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.

CSL866 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.

CSL867 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.

CSL868 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**
6 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)
EEL101 Fundamentals of Electrical Engineering
4 credits (3-0-2)
Overlaps with: EEL102

EEL102 Principles of Electrical Engineering
4 credits (3-0-2)
Overlaps with: EEL101

EEN110 Introduction to Electrical Engineering
2 credits (0-0-4)
Discussion with faculty about different aspects of Electrical Engineering; practical sessions on Electrical Components, Circuit drawing, PCB design, Winding of transformer, assembly of a motor, disassembly of a computer, assembly of electronic circuits like audio amplifier, radio receiver/transmitter, etc.

EEN120 Introduction to Electrical Engineering (Power)
2 credits (0-0-4)
Discussions with faculty about different aspects of Electrical Power Engineering, practical sessions on electrical components, circuit drawing, PCB design, winding of a transformer, assembly of a motor, etc.

EEL201 Digital Electronic Circuits
4 credits (3-1-0)
Pre-requisites: EEL101 / EEL102
Review of Boolean Algebra, Karnaugh Map and Logic Gates; Designing combinational Circuits using gates and/or Multiplexers; Introduction to logic families: TTL, ECL, CMOS, PLAs and FPGAs; Sequential Circuits: Flip Flops, Counters and Registers; Design of Sequential Circuits: STD and applications; Pipelining and Timing issues; Memories.

EEP201 Electronics Laboratory - I
1.5 credits (0-0-3)
Pre-requisites: EEL101 / EEL102
The laboratory is divided into two parts. In the first part, the student is required to perform some set experiments to familiarize himself/herself with basic digital electronic techniques. In the second half of the semester, the student is required to design and fabricate a digital module. A formal presentation of the design is required at the end of the semester.

EEL202 Circuit Theory
4 credits (3-1-0)
Pre-requisites: EEL101 / EEL102

EEL203 Electromechanics
4 credits (3-1-0)
Pre-requisites: EEL101 / EEL102
Review of 1-phase, 3-phase circuits and magnetic circuits, transformers-1-phase and 3-phase, special multiphase transformers and their applications, Electro mechanical Energy conversion principles and rotating machines, DC machines- construction, characteristics, commutation, armature reaction, speed control of DC motors and applications in drives; Synchronous machine-construction, characteristics, regulation, V-curves, parallel operation; Induction machines- 3-phase and 1-phase- construction, characteristics, starting, braking and speed control, Induction generators and applications-Fractional kW motors, special machines- PM machines, SRM, stepper motors and their applications.

EEP203 Electromechanics Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL203
Experiments on Transformers, DC and AC machines.

EEL204 Digital Electronic Circuits
4 credits (3-1-0)
Pre-requisites: EEL101 / EEL102
Review of working of BJT, JFET and MOSFET and their small signal equivalent Circuit; Biasing of BJT, JFET and MOSFET circuits; Analysis and Design of various single stage amplifier configurations; Multi Stage Amplifiers; Differential Amplifier and Operational Amplifier; Feedback Amplifiers; Tuned Amplifiers; Oscillators.

EEP204 Electronics Laboratory - II
1.5 credits (0-0-3)
Pre-requisites: EEL101 / EEL102
To design and test single stage and multi stage amplifiers, power amplifiers and oscillators on bread board. The students will be given the specification and the design to be verified before wiring up the circuit. The students are encouraged to trouble shoot with hints from the instructor and TAs.

EEL205 Signals and Systems
4 credits (3-1-0)
Pre-requisites: EEL101 / EEL102 / MAL110 / MAL111 / MAL115
Classification of signals and systems, various system representation techniques, differential, difference and state-space representations, Fourier transforms and series, application to analysis of systems, Laplace transform, its properties, and its application to system analysis, Z-transforms, its properties and applications, Random variables and random process, characterization of random variables and random process, linear systems and random signals.

EEL207 Engineering Electromagnetics
4 credits (3-1-0)
Pre-requisites: PHL110

EEL209 Power Electronics Devices and Circuits
4 credits (3-1-0)
Pre-requisites: EEL101 / EEL102
Basic features of semiconductor junctions, the BJT operations at high currents, switching features of the BJT and MOS transistors. The thyristor operation, distributed gates, IGBT operation, principles and ratings. Boost and buck converters using BJT and IGBT circuits-problems, design and operation. Snubber designs and protection. Firing circuits. Thyristor and BJT based converters-design, phase control, effects on power
factor and harmonics, firing circuits and their designs. Inverter circuits operation. Designs using BJT's and MOS devices. Base and gate drive circuits, snubbers, operational problems. The basic concept of PWM control and advantages against phase control. AC voltage controllers, choppers and cycloconverters.

EEP209 Power Electronics Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL209
Experiments on measurement of turn on and off characteristics of various devices on storage CRO computation of losses. Assembly and testing of converters and inverters on resistive and inductive loads. Fabrication and testing of firing circuits, base and gate drives. Study of turn on and turn off characteristics of junction and MOS devices Performance of low rating boost and buck converters Design and Testing of firing circuits for: (a) Thyristorised boost/buck converters. (b) BJT/IGBT based boost/buck converters Phase controlled operation of a six pulse thyristorised converter, and harmonics analysis of performance. Performance study of a commercial, low rating, BJT PWM inverter, and harmonics analysis of performance

EEP211 Design (EE)
2 credits (0-0-4)
Pre-requisites: EEL101 / EEL102
Design activities related to various aspects and applications of electrical engineering.

EEL212 Measurements and Instrumentation
3 credits (3-0-0)
Pre-requisites: EEL101 / EEL102
Principles of Measurement, bridge measurements, oscilloscope, measurements of analog waveforms, Q-meter, Spectrum Analysis, Special transducers, A/D and D/A, Telemetering, Data recording and display, Computer-aided Measurement systems.

EEL218 Physical Electronics
3 credits (3-0-0)
Pre-requisites: EEL101 / EEL102
Overlaps with: EPL213, EPL439
Band model of solids, electrons and holes in semiconductors, carrier statistics, current flow in semiconductors, Junction devices, Metal-oxide-semiconductor devices, Schottky and optoelectronic devices.

EEP221 Design (EP)
2 credits (0-0-4)
Pre-requisites: EEL101 / EEL102
Design activities related to various aspects and applications of electrical power engineering.

EEL301 Control Engineering - I
4 credits (3-1-0)
Pre-requisites: EEL205
Overlaps with: MEL312, CHL261

EEP301 Control Engineering Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL301

EEP303 Power Engineering - I
4 credits (3-1-0)
Pre-requisites: EEL203
Energy resources, power generation: Thermal, hydro and nuclear power plants. Transmission lines, line parameters, corona, interference of power lines with communication circuits, line insulators. Cables, per unit system, symmetrical components, fault analysis, switching surges. Integrated operation of power systems, basic concepts of load flow, economic operation, stability, protection, HVDC transmission. Load management and tariffs.

EEP303 Power Engineering Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL303
Experiments related to EEL303 Power Engineering - I

EEP305 Electric Drives
4 credits (3-1-0)
Pre-requisites: EEL203
Requirements, components and benchmarks of electric drives. Review of induction motor theory, distinction between wound rotor and cage rotor, cases of multiple cages, energy efficient motors, synchronous motor theory-equivalent circuit, extensions as reluctance motors, and permanent magnet motors. Stepper motor features and operation. Speed control of induction motor-basic issues, the ac power controller, and slip energy recovery schemes. VSI and CSI fed induction motors. Speed control of synchronous motors and associated machines. Organisation of micro-controllers, key issues like actuation and signal sensing, interrupt handling, timing, and priority of tasks in a microcomputer controlled drives.

EEP305 Drives Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL305
Experiments related to course EEL305 Electric Drives.

EEP306 Communication Engineering
4 credits (3-1-0)
Pre-requisites: EEL205

EEP306 Communication Engineering Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL306
Laboratory experiments on analog, pulse, and basic digital modulation and demodulation techniques.

EEP307 Electromagnetics Laboratory
1.5 credits (0-0-3)
Pre-requisites: EEL207
Laboratory experiments on different transmission lines, antennas, microwave sources and passive devices.

EEP308 Computer Architecture
4 credits (3-1-0)
Pre-requisites: EEL201
Overlaps with: CSL211
Organizing the areas of Computer: von Neumann and Harvard architecture; Instruction Set Architecture: RISC and CISC processors; Computer Arithmetic: fixed point and floating point arithmetic; Design of ALU: hardware algorithms for addition, multiplication and division of fixed point and floating point numbers; Processor design: Data Path and Control Design, Microprogramming, Exception Processing, Pipelining; Memory Organisation: memory hierarchy, cache organization, virtual memory; System Design: bus structure, bus transactions; Input-output Systems: programmed I/O, DMA and interrupt driven I/O. Illustrations with examples of CISC processors from Intel and RISC processors like MIPS and ARM.

**EEL308 Computer Technology Laboratory**
1.5 credits (0-0-3)
Pre-requisites: EEL201 & EEP201
Overlaps with: CSL211
Laboratory Experiments will be on: (a) Use of ALU; (b) Design and implementation of special purpose hardware for application specific computation, like HCF; (c) Design and implementation of interfacing hardware, eg. Serial I/O; (d) Assembly Language programming and interfacing experiment with microprocessor/microcontroller kit; (e) Use of Hardware Description Language like VHDL; (f) Controller synthesis on FPGA.

**EED310 Mini Project (EE)**
3 credits (0-0-6)
Pre-requisites: EC 80
Project activity of one semester duration emphasizing design activity in any area of electrical engineering, under the guidance of a faculty member. Prior to registration for the course, a proposal will have to be prepared and approval obtained from the department.

**EES310 Independent Study (EE)**
3 credits (0-3-0)
Pre-requisites: EC 80
Study of subjects in electrical engineering outside course offerings or research-oriented activities under the guidance of a faculty member. A proposal detailing the envisaged activities will have to be submitted to the department for approval and prior permission obtained to register for the course.

**EEL311 Graph Theory and its Application to Electrical Engineering**
3 credits (3-0-0)
Pre-requisites: CSL376, MAL468
Overlaps with: MAL376, MAL468
Basic of graph theory: trees, f-circuits, f-cutsets, connected and separable graphs etc. Matrices of a graph and relations between them. Generation of network functions of one and two-port networks using spanning tree and directed tree algorithms. Graph searches like BFS and DFS. Path problems like shortest paths, all paths between a pair of nodes etc. Generation of directed graphs and their use in the determination of transfer functions of networks. Applications of graph algorithms in routing, assignment and other problems in VLSI design.

**EEL315 Analog Integrated Circuits**
3 credits (3-0-0)
Pre-requisites: EEL 204 & EEL 202

**EEL316 Digital Communications**
4 credits (3-0-2)
Pre-requisites: EEL306

**EEL319 Digital Signal Processing**
4 credits (3-0-2)
Pre-requisites: EEL205
Overlap with: EEL731

**EED320 Mini Project (EP)**
3 credits (0-0-6)
Pre-requisites: EC 80
Project activity of one semester duration emphasizing design activity in electrical power engineering, under the guidance of a faculty member. Prior to registration for the course, a proposal will have to be prepared and approved obtained from the department.

**EES320 Independent Study (EP)**
3 credits (0-3-0)
Pre-requisites: EC 80
Study of subjects in electrical power engineering outside course offerings or research-oriented activities under the guidance of a faculty member. A proposal detailing the envisaged activities will have to be submitted to the department for approval and prior permission obtained to register for the course.

**EEP321 Measurements and Instrumentation Laboratory**
1.5 credits (0-0-3)
Pre-requisites: EEL212
The laboratory is divided into two parts. In the first part, the student is required to perform some set experiments to familiarize himself with basic electronic techniques. In the second half of the semester, the student is required to design and produce a demonstrable instrument, together with its operating and maintenance manual.

**EEL322 Integrated Circuits Technology**
3 credits (3-0-0)
Pre-requisites: EEL204
Fabrication of active and passive devices and integrated circuits. Basic technological steps – pattern definition, impurity introduction, layer deposition, etching. Simplified process sequences for bipolar, NMOS and CMOS.

**EEL324 Digital Hardware Design**
3 credits (3-0-0)
Pre-requisites: EEL201
Overlaps with: CSL316
Review of combinational and sequential logic; Finite state machines and optimization of finite state machines; Hardware Description Languages (HDL), HDL based design; Introduction to data path and control path synthesis; Asynchronous state machine based design; Considerations of technology: testability and fault-tolerance in design.

**EEL325 Control Engineering - II**
3 credits (3-0-0)
Pre-requisites: EEL301
Introduction to digital control systems: Principles of signal conversion, sampling and reconstruction. Principle of discretization. Impulse and step invariance. Finite difference approximation. Bilinear transformation, Mathematical models discrete time signals and systems. Transfer function and system response. Stability on the z-
EEL326 Micromotors and their Applications
3 credits (3-0-0)
Pre-requisites: EEL203
Micromotors: dc micromotors: PCB motors, voice coil motors, ultrasonic wave motors, coreless motors, PM motors, disc motors, servo motors, brushless motors, step motors, ac servo motors, synchronous motors, induction motors, universal motors axial field motors. Applications to information technology equipments, Computers FDD, HDD, printers and plotters, instruments, Consumers products such as cameras, camcorders, timers, clock, VCR, VCP Wipers, fax machines, cassette recorders, copiers etc.

EEL327 Fault Diagnosis of Digital Circuits
3 credits (3-0-0)
Pre-requisites: EEL201
Concepts of faults and fault models; test generation, test selection, and fault dictionaries. Test generation for fault detection, fault location, and fault correction. Some basic reliability-enhancing design techniques for digital circuits and systems.

EEL329 VLSI Technology and Design
4 credits (3-0-2)
Pre-requisites: EEL201
Overlaps with: EEL734

EEL330 Selected Topics in Communication Engineering - I
3 credits (3-0-0)
Pre-requisites: EEL306
Topics of recent interest in the area of Communication Engineering.

EEL331 Electromagnetics and Advanced Electromechanics
3 credits (3-0-0)
Pre-requisites: EEL203

EEL338 Antennas and Propagation
3 credits (3-0-0)
Pre-requisites: EEL207

EEL339 Power Conditioning
3 credits (3-0-0)
Pre-requisites: EEL209
Concepts of nonlinear loads and electric power conditioning unity power factor rectifier STATCON, (Static condenser) SMPS: analysis, design and control. UPS on-line and off-line, power supplies in telecommunication systems. High frequency induction heating, dielectric heating Power supplies in automobiles. Passive filters, active filters for harmonic and reactive power compensation in two wire, three wire and four wire ac systems. Harmonic standards, power quality, surge suppressors, compensation of arc furnace and traction loads. Microwave ovens, light and temperature controllers. Power supplies for appliances such as camera, X-ray equipment. Case studies on microcomputer and DSP control in active filters and power supplies.

EEL340 Selected Topics in Power and Machines
3 credits (3-0-0)
Pre-requisites: EEL203
Topics of interest in the relevant areas.

EEL341 Selected Topics in Power Electronics and Drives - I
3 credits (3-0-0)
Pre-requisites: EEL203 & EEL209
Topics of special interest in power electronics and drives.

EEL342 DSP based Control of Electric Drive
3 credits (3-0-0)
Pre-requisites: EEL203
Features of a DSP in comparison to those of ordinary processors, computational advantage handicaps regarding analog and digital interface. Communication advantages. Harmonic analysis in real time using a DSP specific assembly language features for a DSP. On chip RAM and external RAM I/O interface. PWM and firing pulse generation through a typical DSP, look-up tables and real-time computation. Interfacing and actuation circuits for DSP based controllers. Realization of computationally intensive algorithms like variable structure, adaptive and neural network schemes for drive systems.

EEL344 Electric Transportation
3 credits (3-0-0)
Pre-requisites: EEL203
Battery powered vehicles: electric cars, pallet truck, fork lift trucks, electric bus, solar powered electric vehicles and boats etc. drives used in electric vehicles, d.c. drives, vector controlled ac motor drives, PMBL motor drives, switched reluctance motor drives, Electric traction, trains, trams and trolleys, nature of reactive loads, supply systems, power factor and harmonics, traction motors and drives, Diesel electric traction, a.c. induction motor drives, marine propulsion systems and aircraft system.

EEL346 Electrical Machines and Industrial Drives
3 credits (3-0-0)
Pre-requisites: EEL203
EEL349 Advanced Electrical Machines
3 credits (3-0-0)
Pre-requisites: EEL203
Details of PWM inverter fed ac drives with different forms of feedback control, bang-bang and sliding mode structures, realisation on microcomputer based systems. Vector control of ac motor; flux estimators and their shortcomings, hardware realisation, start up control of induction motors with PWM and flux vector structures. Present day shortcomings of inverter fed induction motor drives-bearing erosion, shaft fracture and efficiency problems involvement of soft switching inverters and impact on ac drive performance SR motors and PM motors drive control. Design of power electronic modules and microprocessor controllers.

EEL358 Operating Systems
3 credits (3-0-0)
Pre-requisites: EEL308
Overlaps with: CSL373, MAL358, EEL602
Introduction to OS; Process and Thread management; Scheduling; Concurrent threads and processes: mutual exclusion, synchronization, inter-process communication; Memory management: Cache and Virtual Memory management; Resource management: deadlock and its prevention; File management; I/O management; Introduction to real time systems; Elements of distributed operating systems.

EEL359 Electric Machine Design and CAD of Electric Machines
3 credits (3-0-0)
Pre-requisites: EEL203 & EEP203

EEL360 Selected Topics in Control Engineering - I
3 credits (3-0-0)
Pre-requisites: EEL301
Select topics in control engineering; details will be decided by the instructor.

EEL361 Selected Topics in Power Systems - I
3 credits (3-0-0)
Pre-requisites: EEL303
Topics of interest in power systems; will be decided by the instructor.

EEL365 Intelligent Control
3 credits (3-0-0)
Pre-requisites: EEL301

EEL370 Selected Topics in Computers - I
3 credits (3-0-0)
Pre-requisites: CSL201
Topics of current interest in computers; details will be decided by the instructor.

EEL375 Embedded Systems
5 credits (3-0-4)
Pre-requisites: EEL308
Overlaps with: CSP413, MEL432, EEL705
Overview of Embedded Systems; Embedded System Architecture: processor examples - ARM, PIC, etc.; features of digital signal processor; SOC, memory sub-system, bus structure (PC-104, I2C etc.), interfacing protocols (USB, IrDA etc.), testing and debugging, power management; Embedded System Software: Program Optimization, Concurrent Programming, Real-time Scheduling and I/O management; Networked Embedded Systems: special networking protocols (CAN, Bluetooth); Applications.

EEL380 Selected Topics in Electronics - I
3 credits (3-0-0)
Pre-requisites: EEL202 and EC 60
Topics of interest in areas of electronics; details will be provided by the instructor.

EEL388 Stepper Motors
3 credits (3-0-0)
Pre-requisites: EEL203
Discretisation of angular position by stepper structures, stepping angle and frequency of excitation. VR and PM rotor structures and their torque production, torque angle characteristics. The hybrid structure and torque production by permanent magnet and excitation fluxes. Power electronic converters for stepper motors, control by load angle. Hardware and software based control. Trajectory and motion definition in angle and angular speed. Transfer function of stepper motors, and control of damping by one-step and one-and-a-half step excitation.

EEL389 Computer Aided Testing of Electric Machines
3 credits (2-0-2)
Pre-requisites: EEL202
Data acquisition system, sensors, transducers such as speed torque, temperature, noise, voltage, current, power, power factor, harmonics, crest factor etc. Digital signal processing and instrumentation. Recorders, computer interface. Case Studies of Computer Aided testing of different electric machines.

EEL390 Selected Topics in Information and Communication Technology – I
3 credits (3-0-0)
Pre-requisites: CSL201 & EEL205 and EC 60
Topics in the emerging areas of information and communication technology and the interface between the two.

EEL394 Permanent Magnet Motors
3 credits (3-0-0)
Pre-requisites: EEL203
Permanent magnet materials and circuits; Characteristics, parameters, properties, classification and calculations, Permanent magnet motors, D.C. brushed motors, design analysis and control and applications, PM synchronous motors, rotor construction such as surface mounted PM, buried PM, inset type PM and interior type PM rotor and cageless rotor motors, line start and inverter fed control and applications. PM brushless dc motor, theory, operation, control and applications, axial field disc construction, PM step motors, hybrid step motors, sensorless control, reduction of torque pulsations; Case studies such electric vehicles, marine propulsion, spindle drives, commercial and industrial drives, PV fed water pumping.

EEL398 Machines and Drives Dynamics
3 credits (3-0-0)
Pre-requisites: EEL203
EEV401 Special Module in Communication Engineering
1 credit (1-0-0)
Pre-requisites: EEL306 and EC 90
Details will be decided by the course coordinator.

EEV402 Special Module in Power Systems, Machines and Power Electronics
1 credit (1-0-0)
Pre-requisites: EEL203 & EEL303 & EEL209 and EC 90
Details will be decided by the course coordinator.

EEV403 Special Module in Electrical Machines
1 credit (1-0-0)
Pre-requisites: EEL203 and EC 90
Details will be decided by the course coordinator.

EEL404 Flexible AC Transmission System
3 credits (3-0-0)
Pre-requisites: EEL303
Overlap with: EE894
Concepts of reactive power support and voltage stability. Compensation at a bus and over a line. The synchronous condenser, static var compensation, static phase shifter, thyristor controlled switched capacitor, STATCON’s and DVR’s, unified power flow controller, interphase power controller. Reactive power balance over a network and optimisation.

EEV404 Special Module in Control Engineering
1 credit (1-0-0)
Pre-requisites: EEL301 and EC 90
Details will be decided by the course coordinator.

EEL405 Power Engineering Instrumentation
3 credits (3-0-0)
Pre-requisites: EEL303
The concepts of accuracy and precision, Log errors and sources of measurement errors. Non idealities involved in Power instrumentation. Instrument transformers, structures of PT’s and CT’s ratio and phase errors. Current probes and their efficiency. DC current measurements by Hall devices, saturable reactor set, UPS. Electromechanical meters for dc and ac measurements-moving coil and moving magnet structures. Analog circuits for power instrumentation, voltage followers, buffers, differential amplifiers, specific analog circuits for peak detection, rms detection, and average computation, common mode operation and noise analysis of OPAMP based circuits. Filter designs and concepts of operating bandwidth. Digital instrumentation in power application, A/D and D/A circuits and their operation, errors Basic concepts of digital filtering storage and related circuit design. Microprocessors in power instrumentation, configuration and software flowcharts for basic power measurement involving filtering, arithmetic operations and storage.

EEV405 Special Module in Electronics
1 credit (1-0-0)
Pre-requisites: EEL202 and EC 90
Details will be decided by the course coordinator.

EEV406 Special Module in Power Electronics and Drives
1 credit (1-0-0)
Pre-requisites: EEL209 and EC 90
Details will be decided by the course coordinator.

EEL407 Distribution System Planning and Automation
3 credits (3-0-0)
Pre-requisites: EEL303
Configuration of distribution systems load characteristics, distribution transformers, distribution substation design, feeder design, voltage regulation, protection in distribution systems, SCADA, distribution automation.

EEV407 Special Module in Power Systems
1 credit (1-0-0)
Pre-requisites: EEL303 and EC 90
Details will be decided by the course coordinator.

ECC410 Colloquium (EE)
3 credits (0-3-0)
Pre-requisites: registered for EET410
Students will deliver talks about their experience during practical training, and on topics of current interest.

EET410 Practical Training (EE)
Non credit
Pre-requisites: EC 90 at the end of 5th sem.
Fifty (50) working days or 400 hours of practical training in an industry.

EED411 Major Project Part 1 (EE)
3 credits (0-0-6)
Pre-requisites: EC 120
Formation of project team (up to two students and two faculty guides); formulation of work plan; completion of targeted work for the semester; and presentation of progress for award of grade. Topic could be from any area of electrical engineering. Completion of about a third of the total work for assessment and grading.

EED412 Major Project Part 2 (EE)
7 credits (0-0-14)
Pre-requisites: EED411
Continuation of planned tasks started in Project Part 1 to completion, thesis writing and presentation of complete work for award of grade. Completion of the planned work for assessment and grading.

EED412 Selected Topics in Power Electronics - II
3 credits (3-0-0)
Pre-requisites: EEL202 and EC90
Topics in electronics; details will be decided by the instructor.

EEC410 Colloquium (EE)
3 credits (0-3-0)
Pre-requisites: registered for EET410
Students will deliver talks about their experience during practical training.

EET410 Practical Training (EE)
Non credit
Pre-requisites: EC 90 at the end of 5th sem.
Fifty (50) working days or 400 hours of practical training in an industry.

EED421 Major Project Part 1 (EP)
3 credits (0-0-6)
Pre-requisites: EC 120
Formation of project team (up to two students and two faculty guides); formulation of work plan; completion of targeted work for the semester; and presentation of progress for award of grade. Topic should be in the area of electrical power. Completion of about a third of the total work for assessment and grading.

EED422 Major Project Part 2 (EP)
7 credits (0-0-14)
Pre-requisites: EED421
Continuation of planned tasks started in Project Part 1 to completion, thesis writing and presentation of complete work for award of grade. Completion of the planned work for assessment and grading.

**EEL422 Computers in Biomedicine**  
3 credits (3-0-0)  
Pre-requisites: EEL303  
Introduction to computer simulation in biological sciences. Simulation of normal and pathological states. Artificial intelligence and expert systems for medical applications. Algorithms for automated analysis of bioelectrical signals such as ECG and EEG. Pattern identification and tissue and cell typing. Fractal and chaotic dynamics in biological systems, 3D Medical Imaging, Telemedicine and Virtual reality, Computers in medical therapeutics; Drug Delivery System, Smart sensors and actuators, Bio-informatics.

**EEL423 Demand Side Management**  
3 credits (3-0-0)  
Pre-requisites: EEL306  
The concepts of demand-side management (DSM) for electric utilities, DSM alternative and goals. End use equipment and control, utility equipment control, energy storage, dispersed generation, customer DSM promotions, performance improvement equipment and system benefit/cost analysis of DSM alternatives; issue in forecasting DSM program impacts. Implementation of DSM program; pricing and incentives.

**EEL424 Nuclear Power Generation**  
3 credits (3-0-0)  
Pre-requisites: EEL303  
Basics of nuclear fission, and characteristics of heavy isotopes. The concepts of beta-decay line, and suitability of nuclear fuels. Fission by fast and slow neutrons, criticality, and moderation. Types and basic structures of common reactor designs-BWR, HWR and PHWR, power output, size and radiation considerations, operation and control by solid and liquid moderators, neutron density and reactivity control. Point form differential equations for common nuclear reactors core models, moderator dynamics, and thermal circuits. Reactor - poisoning by Xenon and strontium, control of performance to avoid poisoning. Special features of alternators and boilers in nuclear plants. Control and safety standards of nuclear units.

**EEL428 Substation Design**  
3 credits (3-0-0)  
Pre-requisites: EEL303  
Types of substations layout and bus bar arrangements Grounding; design and Practices, substation auxiliaries, Cable routing, data acquisition, substation Control, load shedding, implementation.

**EEL430 Selected Topics in Communication Engineering - II**  
3 credits (3-0-0)  
Pre-requisites: EEL306 and EC 90  
Selected topics in communication engineering; details will be decided by the instructor.

**EEL432 Satellite Communication**  
3 credits (3-0-0)  
Pre-requisites: EEL306  
Satellite systems basics, satellite channel, earth station and satellite equipment, different modulation and access techniques, examples of different satellite systems.

**EEL433 Communication Engineering - II**  
3 credits (3-0-0)  
Pre-requisites: EEL316  

**EEL435 Optical Communication**  
3 credits (3-0-0)  
Pre-requisites: EEL306  
Overlaps with: EEL712  
Introduction to optical communication, review of optical sources, fiber and detector, optical signaling schemes viz., IM, PL, PCM, PCM/PL, digital PPM, PFM, PAM. Various receiver configurations - direct detection, homodyne and heterodyne receivers, Noise sources in optical communication - modal noise, speckle noise, shot noise, phase noise, thermal noise, Integrated and transimpedance amplifiers, optical line coding, performance evaluation of optical receivers for various modulation and demodulation schemes and their comparative study. Diversity receivers-phase and polarization diversities. Optical fiber link design, fiber optics networks, introduction to optical space communication.

**EEL437 Selected Topics in Power Systems - II**  
3 credits (3-0-0)  
Pre-requisites: EEL303 and EC 90  
Topics will be decided by the instructor from among current areas of power systems.

**EEL440 Selected Topics in Power, Machines and Power Electronics - II**  
3 credits (3-0-0)  
Pre-requisites: EEL303, EEL209 and EC 90  
Topics in power, machines and power electronics; details will be decided by the instructor.

**EEL441 Industrial Electronics**  
4 credits (3-0-2)  
Pre-requisites: EEL101 / EEL102 and EC 90  
Power electronic components- thyristors, triacs, GTOs, MOSFETs and other bipolar devices and their switching properties. Introduction to thyristorised phase controlled rectifiers and dual converters. AC controllers and timers, dimmers, heating. SMPS and UPS systems. Introduction to AC controllers, inverters, choppers, cycloconverters. Introduction to converter fed AC and DC drives-their performance. Other applications of power electronics.

**EEP443 FEM Analysis of Machines Laboratory**  
1.5 credits (0-0-3)  
Pre-requisites: EEL203 and EC 90  

**EEP446 Electrical Machines and Industrial Drives Laboratory**  
1.5 credits (0-0-3)  
Pre-requisites: EEL203 and EC 90  
Experiments related to the course EEL446.

**EEL450 Switchgear and Transients**  
3 credits (3-0-0)  
Pre-requisites: EEL303  
Switchgear; fault clearing processes and arcing phenomena, thermodynamic aspects of arc interruption, electrical aspects of arc interruption; recovery and restricting voltage. Types of circuit breakers; testing of circuit breakers.

**EEL451 Power Systems Protection**  
3 credits (3-0-0)  
Pre-requisites: EEL303  
Basic concepts of power system protection, types
of relays, protection of generators, transformers, bus bars and transmission lines, distance and carrier current protection. Computer relaying. Induction motor protection. Theory of arc interruption, types of circuit breakers (air, air blast, oil, vacuum and SF6), circuit breaker rating and testing of circuit breakers.

**EEL452 HVDC Transmission**  
3 credits (3-0-0)  
**Pre-requisites:** EEL303  
Comparison of HVAC and HVDC transmission, HVDC transmission schemes, Component description, converter: principles, characteristics, control circuits, HVDC system control, Protection, Harmonics and filters, AC-DC system interaction, AC-DC load flow.

**EEP452 Machine Modelling and Simulation Laboratory**  
1.5 credits (0-0-3)  
**Pre-requisites:** EEL203 and EC 90  
Experiments related to modelling and analysis of electrical machines.

**EEL453 Power System Dynamics and Control**  
3 credits (3-0-0)  
**Pre-requisites:** EEL303  
Introduction to power system stability problems, Models of: synchronous machines, excitation systems, prime mover and governor, loads, Transmission stability analysis, Dynamic stability analysis, Dynamic Equivalents, Stabilizers, Levels of power system control, AGC, SCADA and Computer control.

**EEL455 Power System Planning**  
3 credits (3-0-0)  
**Pre-requisites:** EEL303  
Load forecasting, generation system reliability, transmission system reliability and distribution system reliability. Generation system expansion planning, Transmission system expansion planning and distribution system expansion planning, Reactive power planning, Integrated power system planning.

**EEL456 Power Engineering - II**  
4 credits (3-0-2)  
**Pre-requisites:** EEL303  
Integrated operation of power systems, advanced load flow modeling, advanced fault analysis, stability analysis, security analysis, optimal power flow, power system control.

**EEL458 Power Systems Optimization**  
3 credits (3-0-0)  
**Pre-requisites:** EEL303  
Characteristics of generation units, economic dispatch of thermal plants, unit commitment hydro thermal coordination maintenance scheduling, emission minimization, optimal power flow, security constrained optimization.

**EEL460 Selected Topics in Control Engineering-II**  
3 credits (3-0-0)  
**Pre-requisites:** EEL301 and EC 90  
Topics in control engineering; details will be decided by the instructor.

**EEL462 Identification and Adaptive Control**  
3 credits (3-0-0)  
**Pre-requisites:** EEL301  

**EEP467 Computer Control Laboratory**  
1.5 credits (0-0-3)  
**Pre-requisites:** EEL301  
Familiarisation with programmable logic controllers, Testing and debugging of PLC programming, Microcontroller based interfacing. Computer control of inverted pendulum, Exposure of software for mathematical modeling and analysis.

**EEL470 Selected Topics in Computers - II**  
3 credits (3-0-0)  
**Pre-requisites:** CSL201 and EC 90  
Topics of current interest in the area of Computer Technology; details will be provided by the instructor.

**EEL472 Parallel and Distributed Processing**  
3 credits (3-0-0)  
**Pre-requisites:** EEL308  
Overlaps with: CSL830, CSL847, MAL311, MAL465  

**EEL473 Computer Communication**  
3 credits (3-0-0)  
**Pre-requisites:** EEL306  
Overlaps with: CSL 374  
Introduction; Mathematical theory of Networks : birth-death processes, M/M/m, M/G/1, simulation techniques for LANs; Local Area Networks, Metropolitan Area Networks, Access Techniques, Wide Area Network, Routing algorithms. Case studies in network design.

**EEL481 Testing and Commissioning of Electrical Equipment**  
3 credits (3-0-0)  
**Pre-requisites:** EEL303  
Testing of Transformers, dc machines, Induction machines synchronous machines and other Electric apparatus. Study of testing standard (BIS and EMC) etc. on electrical equipment Type tests and routine tests. Tests before commissioning and after commissioning of electrical equipments. Various testing standards.

**EEL482 Mechatronics**  
3 credits (3-0-0)  
**Pre-requisites:** EEL201 & EEL203 & EEL301  
Overlaps with: MEL411, MEL432  
Mechatronics: definitions and terminology, its elements such as mechanics, electronics, microelectronics, power electronics and information technology. Mechanical elements with integrated electronics suspension systems, vibration dampers, clutches, bearing mechanical or magnetic, gears etc. Machines with integrated electronics, electric drives, pneumatic and hydraulic drives, water steam or gas turbines, combustion engines, etc. Generators, pumps, compressors, machines tools, robots, printing machines, vehicles: automobiles, ships and aircraft. Precision machines with integrated electronics devices for telecommunication, consumer electronics, data processing devices, sensors, actuators, optical devices and medical devices, Power electronics converters.

**EEL483 Hydro Power Generation**  
3 credits (3-0-0)  
**Pre-requisites:** EEL303  
Types of Hydro plants subsystems of hydro plant, turbines, hydro alternates hydro plant. Auxiliaries, control of hydro power, micro hydel systems, special problems in hydro plants.
centralized and distributed routing procedures, congestion control.
Local Area Networks: LAN topologies and protocols, IEEE 802.x protocols,
implementation and performance issues. High speed LANs. Transport
layer. Quality of service transport classes. Design issues, buffer
management, synchronization. Session and presentation layer,
Synchronization issues, formatting, data compression, data security.

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
Basic component of Robotic systems. Kinematics of manipulators,
Selection of Coordinate frames, Transformations. Solution of kinematics
and manipulator dynamics. Newton-Euler dynamic formulations. Path
planning, Position, velocity and force control, Computed Torque control.
Linear and Nonlinear controller design of robot. Introduction to robot
vision. Application of computer controlled robot in manufacturing and
programmable automation.

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
Introduction to embedded system : Single purpose hardware and
Component Interfacing : Interrupt, DMA, I/O Bus Structure, I/O devices.
Software for Embedded Systems : Program Design and Optimisation
techniques, O.S for Embedded Systems, Real-time Issues. Designing
Embedded Systems : Design Issues, Hardware-Software Co-design,
Use of UML. Embedded Control Applications : Open Loop and Closed
Loop Control, Software Coding of PID Controller, applications – washing
machine, automobiles. Networking Embedded Systems : Distributed
Embedded Architectures, Protocol Design issues, wireless network.
Embedded Multimedia and Telecommunication Applications: Digital
Camera, Digital TV, Set-top Box, Voice and Video telephony.

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, Inference 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
Multimedia Data Types: Image, audio, video, animation; Compression
Technology, System Design: Architecture and Operating Systems,
Multimedia Delivery, Content management and retrieval.

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 Rician;
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;
correlation 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, time budget and maximum link length calculation, hybrid
fiber co-axial/microwave links, fiber-in-the-loop (FTL)- FTT/HFBB,
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
Review of EM theory: Maxwell’s equations, plane waves in dielectric
and conducting media, energy and power.Transmission lines and
waveguides: closed and dielectric guides, planar transmission lines
and optical fibre.Network analysis: scattering matrix, other parameters,
signal flow graphs and network representation. Impedance matching and tuning.Analysis of planar transmission
lines.Analysis of design of passive components.

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,
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
Electrical Engineering

state equations of linear time-invariant and time-varying systems.

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)
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.

EEP717 Communication Laboratory I
2 credits (0-0-4)
Experiments related to Communication.

EEP718 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, eigenanalysis, 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.

EEP719 Communication Laboratory II
2 credits (0-0-4)
Experiments related to Microwaves.

EEP719 Communication Engineering Laboratory - II
1.5 credits (0-0-3)
Pre-requisites: EEL713
Experiments on microwave measurement techniques, antennas and design of microwave circuits.

EES720 Independent Study (Control & Auomation)
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: Organisation, 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)
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
Basic principles of bio medical, instrumentation and techniques. Problems of interfacing biomedical, electrical and electronic equipments with living systems, measuring instruments for bio-signals e.g. ECG,

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 reswitching 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)

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-linearties, 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.

EED750 Minor Project (EI)
3 credits (0-0-6)
Pre-requisites: EC 120
A semester-long project usually involving design and implementation under the guidance of a faculty member.

EEP752 Software Laboratory
2 credits (0-0-4)
Pre-requisites: CSL201
Exercises on system and application software development. Emphasis on issues involved in object oriented design and development (UML tools), Compiler design and middleware based distributed applications development.

EEP753...
EEL754 Computer Graphics
4 credits (3-0-2)
Pre-requisites: CSL201
Overlaps with: MAL754, CSL781
Elements of a Graphics System; Computer Graphics Hardware; Geometric primitive generation algorithms; Modelling and Viewing transformations; Curve and surface generation: Hermite, Bezier, B-splines; Solid-modelling techniques; Colour Spaces; Rendering: hidden surface removal, ray tracing, texture mapping, radiosity; Image based rendering.

EEEP757 Embedded Telecommunication Systems Laboratory
3 credits (0-1-4)
Real-time operation systems, object-oriented design for embedded systems-UML, Petrinet based program development, real-time protocol stackdesign, real-time programming, lightweight wireless protocols/Bluetooth.

EEL758 Intelligent and Knowledge Based Systems
3 credits (3-0-0)
Pre-requisites: CSL201
Overlaps with: CSL333

EEL760 Antenna Theory and Techniques
3 credits (3-0-0)

EEL761 Electronics & Instrumentation
3 credits (3-0-0)
Review of RC coupled amplifier, principles of feedback, feedback amplifiers and oscillators.
Operational amplifier and its characteristics, inverting and non-inverting amplifiers, instrumentation amplifier, active filters - low pass, high pass, band pass and all pass, universal active filter, oscillators, analog multiplexer, sample and hold circuit, Schmitt trigger, window detector. A to D and D to A converters, data acquisition systems, 555 timer and its applications, phase lock loops, Lock-in-amplifiers.
Transducers and recorders in instrumentation.

EEL762 Digital Communications
3 credits (3-0-0)


EEL763 Monolithic Microwave Integrated Circuits & Technology
3 credits (3-0-0)
Amplifiers (Narrow band/Broad band) Oscillators, Misers, Active & Passive Phase shifters. Monolithic Microwave Integrated circuit process. Optical Control of MMIC's.

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)
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 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, attenuation, 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)  
Review of Fourier Transforms, Random Processes, Probability density function, Gaussian, density function, Rayleigh probability density, Correlation between random variables, Autocorrelation, Power spectral density of random sequences, Noise, Some sources of noise, Frequency-domain representation of noise, Spectral Components of noise, Noise bandwidth, Quadrature components of noise, Representation of noise using orthonormal components, Sampling Theorem, Quantization, Pulse Code Modulation, Digital Modulation Schemes, PSK, QPSK, FSK, QASK, MPSK, Noise Performance Analysis of the digital modulation schemes. Information Theory, Concept of information, Entropy, information rate, Coding to increase average information per bit, Shannon's theorem, Capacity of Gaussian 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  
Maximization of functionals of a single and several functions using calculus of variations, Constrained extremals, Necessary conditions for optimal control, Linear regulator problems, Pontryagin's minimum principles and state inequality constraints, Minimum time problems, Minimum control effort problems, Singular intervals in optimal control problems, The principle of optimality, Application of the principle of optimality to decision making, Dynamic programming applied to routing problems, Computational steps for solving optimal control problems using dynamic programming, Discrete linear regulator problem, Hamilton-Jacobi-Bellman Equation, Numerical Techniques to determine optimal trajectories, Optimal control of distributed parameter systems.

EEL774 Parameter Estimation and System Identification  
3 credits (3-0-0)  

EEP773 Telecommunication Software Laboratory  
3 credits (0-1-4)  
CASE tools, object-oriented program development, use of Telecommunication network simulator, implementation using C/C++/Java, network management software design, VS test and simulation.

EEL777 Parameter Estimation and System Identification  
3 credits (3-0-0)  

EEP775 Telecommunication Networks Lab-1  
3 credits (0-1-4)  
Use of laboratory and Tele-communication field test instruments such as: oscilloscopes, oscillators, RMS meters, transmission impairment measuring systems, return loss meters, etc. Enables students to study voice and data switching functions and to measure transmission and traffic characteristics on models of the major business communication systems and carrier transmission facilities (controlled LAN environments, Ethernet, E1, T1/T3, Frame Relay lines). Experimental procedures include the use of frequency and time division multiplex systems and the modulation techniques employed by in such systems and the observation of noise and distortion effects.

EEP776 Wireless Communication Laboratory  
3 credits (0-1-4)  

EEL781 Neural Networks  
3 credits (3-0-0)  
Pre-requisites: EEL205  
Overlaps with: MAL720  
Introduction to Biological Neural Networks; Basic anatomy and physiology of a nerve cell; mathematical models of a biological neuron; networks of neurons; a simple model of a neuron and its application to a classification problem; linear separability and linear dichotomies; nonlinearly separable problems; learning with layered networks; backpropagation; recurrent neural networks; the Hopfield network; application to optimization tasks; unsupervised learning -- both co-operative and competitive; Oja and Sanger's rules; Principal Component Analysis; Kohonen's Self Organizing Feature Map; applications of unsupervised learning; Reinforcement Learning; Support Vector Machines; Hardware Realization of Neural Systems; Current Trends and Future Directions.

EEL782 Analog ICs  
3 credits (3-0-0)  

EEL783 Filter Design  
3 credits (3-0-0)  
Approximation theory of magnitude and/or delay. Practical design considerations. Use of computers in filter design. Active filter design using op-amps; various design methods; effect of op-amp non-idealities. Elements of switched capacitor, CCD and SAW filters.

EEL784 I.C. Technology  
3 credits (3-0-0)  

EEP785 I.E.C. Laboratory II  
3 credits (0-0-6)  
Introduction to processing of ICs.

EEL786 Mixed Signal Circuit Design  
3 credits (3-0-0)  
EEL787 Memory Design and Testing
3 credits (3-0-0)

EEP788 IC Processing Lab
3 credits (0-0-6)

EEL789 Optoelectronic Instrumentation
3 credits (3-0-0)
Introduction to test and measuring instruments, instrumentation amplifier, analog signal processing: active filter, A/D, D/A converters, sample & hold, multiplexer, peak detector, zero crossing detector etc., digital design: PALs, FPGA, signal analyser: superheterodyne spectrum analyzer, DFT and FFT analyzer, digital filters and computer interface, microcontrollers: introduction to microcontroller and applications such as 8031, Optoelectronic circuits : circuit design for LD transmitter and PIN receiver, OTDR, optical spectrum analyzer, sensors : fiber optic and radiation sensors, their noise and error analysis, applications in physical sensors, chopper stabilised amplifier.

EED790 Minor Project
3 credits (0-0-6)

EEL790 Selected Topics in Information and Communication Technology - II
3 credits (3-0-0)
Pre-requisites: CSL201 & EEL205 and EC 90
Topics of interest and recent developments in information and communication technology.

EEP790 Advanced Electrical Laboratory
3 credits (0-1-4)

EEL791 Power System Analysis
3 credits (3-0-0)

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

EEL792 Power System Protection
3 credits (3-0-0)
Basic Principles - CTs, PTs. Static relays. Modern circuit breakers Protection of power transformers, alternators, transmission lines, cables, reactors and capacitors. Protection of motors, rectifiers and thyristors. HVDC protection. Relay Coordination, Numerical relaying algorithms, Traveling wave relays, adaptive relaying.

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

EEP796 Power System Control and Instrumentation
3 credits (3-0-0)

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

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

EEP799 Power System Reliability
2 credits (0-0-4)

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)

EEEL802 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, Pseudocode; 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)
Analysis of basic transmission lines for millimetre wave frequencies.

**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, V5.x standards, service provisioning and inter-networking.

**EEL818 Telecommunication Technologies**
3 credits (0-1-4)
Data Networks, ISDN, STS, Access-WILL/RILL, 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

**EEL832 Millimetre Wave Integrated Circuits**
3 credits (3-0-0)
Introduction to millimetre wave devices: couplers, power dividers, filters, oscillators, mixers, switches, phase shifters and amplifiers.

**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.

**EEL833 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.


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.

EES837 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) Conn. 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, Inger 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.

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

EEP858 Telecom Networks Laboratory-II
3 credits (0-1-4)
Specification and implementation of the alternating-bit protocol in SDL ATH-Signaling Protocols Hand-over in GSM radio 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)
Pre-requisites: EEL703

EED861 Major Project Part-1 (Communications Engineering)
6 credits (0-0-12)
Pre-requisites: EEL703
Topics of current interest in communication engineering; details will be provided by the instructor.

EEL862 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.

EEL863 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.

EEL864 Modern Antennas and Arrays
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.

EEL865 Microwave Propagation and Systems
3 credits (3-0-0)
Pre-requisites: EEL306 and EC 120
Frequency bands and allocations. Earth and its effects on propagation. Atmospheric and its effects on propagation. Attenuation of millimetre waves. Line-of-sight communication links: system configuration, multiplexing, link design. Troposcatter propagation and links: fading and diversity reception, path profile and path loss, link design, signal design for fading channels.

EEL866 Microwave Solid State Devices and Circuits
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.

EEL867 Digital Logic Design
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.

EEL868 Computer Networks and Internet Applications
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.

EEL869 Computer Networks and Internet Applications
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.

EEL870 Computer Networks and Internet Applications
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.
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  
**3 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- RAY-net, WDM networks- LAMBDA-net, 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)**  

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. Co-ordination of FACTS devices with HVDC links. The FACTS optimisation problem Transient and dynamic stability enhancement using FACTS components. Advanced FACTS devices-the STATCON and the unified power flow controller.

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)  
Department of Humanities and Social Sciences

HUN100 Introduction to Humanities and Social Sciences
2 credits (0-0-4)
This introductory course will expose students to the basic concepts, debates, issues, ideas, and the problems of methodology in the different disciplines of Humanities and Social Sciences like Economics, English, Philosophy, Psychology, and Sociology. An objective of the course will be to improve English language proficiency of the students.

HUL101 English in Practice
3 credits (2-0-2)
Verb structures and patterns, avoiding common errors, vocabulary building, spelling patterns, developing writing skills (composition, letter writing) etc. developing listening skills.

HUP102 Psychology Laboratory
1 credit (0-0-2)
To familiarize students with psychological concepts through practical training in a laboratory through experiments pertaining to cognitive psychology, environmental psychology and physiological psychology.

HUL211 Introduction to Economics
4 credits (3-1-0)
Pre-requisites: HUN100

HUL212 Microeconomics
4 credits (3-1-0)
Pre-requisites: HUN100

HUL213 Macroeconomics
4 credits (3-1-0)
Pre-requisites: HUN100

HUL214 International Economics
4 credits (3-1-0)
Pre-requisites: HUN100

HUL215 Econometric Methods
4 credits (3-1-0)
Pre-requisites: HUN100

HUL216 Indian Economic Problems and Policies
3 credits (2-1-0)
Pre-requisites: HUN100

HUL217 An Introduction to Literature
4 credits (3-1-0)
Pre-requisites: HUN100
What is literature? This is the central question that the course will address through representational readings from different genres. The focus will be less on any given genre and more on how it becomes possible for the student to reconstruct something called 'literature' through the variety of genres to which he or she is exposed. The course does not presuppose any knowledge of literature. Students will be expected to have a strong command of the English language. The actual texts chosen to illustrate the different forms of literature will not be restricted to any particular culture but will be open ended to include any text that will help the class to answer the question of what constitutes the essence of literary representation.

HUL232 Modern Indian Fiction in Translation
4 credits (3-1-0)
Pre-requisites: HUN100
To study the need, the scope and the processes of literary translation, with particular reference to the multilingual nature of Indian society and the predicaments of the bilingual writers in India. Students will be encouraged to work with at least some texts of their own choice and to present their work in an acceptable format. A preliminary list of the possible texts will be circulated. This list will be open-ended as it will grow and evolve according to the preferences and the inclinations of the people who are actually doing the course.

HUL233 American Literature
4 credits (3-1-0)
Pre-requisites: HUN100
This course aims to acquaint students with a broad spectrum of issues in the culture of the United States that are reflected in its literature. It will include texts written by both white and colored peoples of the United States including slavery and immigration narratives. Selections of texts include those pertaining to the culture of New England Puritanism, The American Renaissance, Modernism, Postmodernism, etc. It will also look at the relationship between the categories of
race, class and gender as critical tools and examine how these tools force us to reevaluate the relationship between culture and literature. It will also address the perennial question of the American Dream and the representation questions that this notion gave rise to.

**HUL234 Language and Communication**  
4 credits (3-1-0)  
Pre-requisites: HUN100  
This course builds the skill sets needed to understand the basics of both language and communication. It is also interested in exploring the relationship between the two categories (language and communication) in order to work out how they relate to each other. It will include introductory concepts in semantics, semiotics, syntax, lexicography, and discourse analysis. It will also include an analysis of philosophical problems of reference, representation, rhetoric, sense, speech acts, and textualuality. Students will have to submit a term paper and make an oral presentation on any aspect of language and/or communication that they wish to explore at length. Workshops are also included to help students internalize the concepts of communication to which they have been introduced.

**HUL235 Technical Communication**  
4 credits (3-1-0)  
Pre-requisites: HUN100  
This course is designed to sensitize students of technology to the importance of communication. The topics covered include the basic principles and models of communication, stylistic considerations in technical writing, types and formats of technical documents, the process of writing technical reports, graphical representation of technical data, technical presentations including the use of media to support technical presentations and collaborative writing. Students will be expected to prepare a technical report and make a short oral presentation.

**HUL236 An Introduction to Drama**  
4 credits (3-1-0)  
Pre-requisites: HUN100  
This course will introduce students to problems of both dramatic and theatrical representation. It will include readings from both ancient and modern drama and engage with some of the leading theorists of drama from Aristotle to Brecht. Students will be exposed to the generic differences between the different forms of drama like tragedy, comedy, melodrama, farce, etc. Students will be encouraged to stage scenes from well-known plays as a part of their assessment.

**HUL237 Contemporary Fiction**  
3 credits (2-1-0)  
Pre-requisites: HUN100  
This course aims to acquaint students with fiction written after the modernist era. Much of this fiction is an attempt to shake off the excessive sense of despair that characterized the modernists. It is also preoccupied with the aftermath of World War II, the cold war, the great ideological debates between capitalism and communism, and the return to realist modes of narration despite the persistence of modernist aesthetics. Representative texts will be examined at length to understand and work through the issues listed above.

**HUL238 Modern Fiction**  
4 credits (3-1-0)  
Pre-requisites: HUN100  
This course is quite demanding in that it expects students to have not only an excellent command of the English language but a preoccupation with the nature of language per se. Since the very essence of modernist aesthetics is based upon a preoccupation with the combinatorial possibilities of language as opposed to referential or instrumental forms of linguistic expression, only students with an excessive capacity for both existential and linguistic self-reflexivity will enjoy the study of modern fiction. Amongst the writers who will be read include Hardy, Joyce, Lawrence and Nabokov though others may also be included if time permits.

**HUL239 Indian Writing in English**  
4 credits (3-1-0)  
Pre-requisites: HUN100  
This course aims to introduce the students to the problems of identity as they emerge in Indian English literature during the nation's struggle for freedom and thereafter. The breakdown of the joint family in the wake of independence and its far-reaching consequences. The age-old conflict between arranged marriages/monogamy and romantic love as a major preoccupation of the Indian writer. The problem of guilt in man torn between a sense of duty toward family and his need to break away from it for self-fulfillment. The impact of the West on Indian society and mind, and its various manifestations in Indian fiction in English as it exists now in courses of study.

**HUL240 Indian English Poetry**  
4 credits (3-1-0)  
Pre-requisites: HUN100  
The aim of this course will be to read the poems of Indian English Writers (pre and post Independence), with specific reference to the articulation of their identity. Some of the perspectives from which the poems will be discussed include the notion of home (childhood, family and ancestors); land (history, geography, community and contemporary politics); language (the dialogue between the different languages in the creative repertoire of the poets); and culture (ritual, traditions, legends and myths). The course will also look at the differences between the resident and expatriate poets vis-a-vis the conflicts and resolutions as expressed in their poems. An attempt will be made to make this list as culturally and linguistically representative as possible. Students will be expected to choose one poet and make a presentation and write an assignment.

**HUL241 Workshop in Creative Writing**  
4 credits (3-1-0)  
Pre-requisites: HUN100  
Introduces the concept of creative writing through an analysis of the techniques of writing and stylistics along with explorations in the problem of literary creativity. It also introduces contemporary writing that is relevant to the areas being discussed in the workshop. Students are invited to write in a genre of their choice. Selected readings in the theory and practice of creative writing will be used to brainstorm on what is involved in acquiring a style of writing.

**HUL251 Introduction to Logic**  
4 credits (3-1-0)  
Pre-requisites: HUN100  
Informal logic: The student is acquainted with the fundamentals of informal logic needed in verbal analysis. Fallacious reasoning and its forms are analyzed and the student comes to recognize the many informal fallacies that are due to the equivocation of language or to a lack of relevance between premises and the conclusion of an argument. Logical systems: Students conceptualize the difference between inductive and deductive argument forms and systems and perform inductive and deductive inferences. They study the formal rules and principles demonstrated in the deductive system of Aristotelian logic. Symbolic logic: The ability to translate ordinary language into symbolic form is acquired and the student constructs arguments in symbolic expression. Philosophy of logic and the role of logic in science: The procedure of scientific explanation is investigated and its methodologies examined.

**HUL252 Introduction to Classical Indian Philosophy**  
4 credits (3-1-0)  
Pre-requisites: HUN100  
There is no one system, which can be called Indian philosophy. Diversity and healthy dialogue between even antagonistic systems characterizes the classical philosophical scene in India. The course will begin by exploring the worldview implicit in the Vedas, the Upanishads, and the orthodox systems and then move on to the rejection of this entire system in Buddhism and materialism. Instead of presenting the course material in a historical fashion, the focus will be on analyzing the fundamental questions of classical Indian philosophy.

**HUL253 Moral Literacy and Moral Choices**  
4 credits (3-1-0)  
Pre-requisites: HUN100  
This is primarily a course in applied ethics. It will focus primarily on questions like: What is the meaning of right action? Can ethical assertions be true or false? Is morality relative to society? Or can we say that acts have universal moral content? The course discussions will help to
demonstrate that morality is not always self-evident and that rational morality must come in place of taboo based morality.

HUL254 Art and Technology
4 credits (3-1-0)
Pre-requisites: HUN100
This course will study the nature of the art object comprising both the cognitive and the aesthetic. It will be an attempt to work out a relation between truth, morality and beauty and differentiate between the beautiful and the sublime. It will also focus on the element of creativity in art, science and technology by examining the differences between the genius and the expert. It will examine the aesthetics of engineering design and the effect of mechanical and electronic reproduction on the nature of the work of art. Finally, it will consider the relationship between media entertainment and information technology by differentiating between media as message and mass deception. Critical strategies to understand the role of power and ideology in information societies will be examined.

HUL255 History of Natural Science: Copernicus to Einstein
4 credits (3-1-0)
Pre-requisites: HUN100
This course will discuss the history of science in the period from the sixteenth century to the twentieth century. The primary focus will be on astronomy, physics, chemistry, and cosmology. Among the issues that are relevant include the non-scientific or metaphysical basis in the construction and maintenance of any scientific paradigm. There will also be discussions on changes in scientific methodology over this period. The major goals of this course are to get a good understanding of some of the topics in the history of science, and to improve our skills in reading, thinking, speaking and writing critically about topics in the history of science.

HUL256 Critical Thinking
3 credits (2-1-0)
Pre-requisites: HUN100
This course is an introduction to Philosophy. It will discuss the fundamental questions involved in the study of logic, metaphysics and ethics. It comprises a study of the different theories of truth, the problem of God’s existence, the debate between determinism etc.

HUL257 Introduction to Philosophy of Science
4 credits (3-1-0)
Pre-requisites: HUN100
The logical nature and reconstruction of scientific explanation and the laws of nature. The nature of scientific evidence. The differences between verification and falsification as forms of scientific validation. The influence of society on the nature of scientific work.

HUL261 Psychological Basis of Behavior
4 credits (3-1-0)
Pre-requisites: HUN100

HUL262 Environmental Psychology
4 credits (3-1-0)
Pre-requisites: HUN100

HUL263 Organizational Psychology
4 credits (3-1-0)
Pre-requisites: HUN100
Introduction to organizational psychology, its field, methods of study, organizational psychology as an applied behavioral science. Group behavior and individual adjustment. Levels of communication. Types of organizations. Theories of leadership. Motivation and productivity. Tests for selection. Training for employee’s growth and development. Effective organizations.

HUL264 Managerial Behavior: Psycho-social Dimensions
4 credits (3-1-0)
Pre-requisites: HUN100

HUL265 Personality and Society
3 credits (2-1-0)
Pre-requisites: HUN100
Coping with stress. Approaches to the study of personality. Freud’s psychoanalytic theory. Jung’s analytic theory. Adler’s individual psychology, Roger’s person centered approach, Lewin’s field theory, and Skinner’s operant reinforcement theory. Models of healthy personality, the notion of the mature person, the self-actualizing person, etc. Yoga and personality. The problem and value of psychological growth. Psychotherapeutic techniques and Eastern psychology.

HUL266 Industrial Safety: Psychological Dimensions
4 credits (3-1-0)
Pre-requisites: HUN100

HUL267 Positive Psychology
4 credits (3-1-0)
Pre-requisites: HUN100
Positive Psychology: Introduction and Historical Overview, Positive Prevention and Positive Therapy; Identifying Strengths: Positive Directions in Diagnosis and Intervention; Emotion focused Approaches: Subjective well-being, The concept of flow, Self-esteem, Positive affectivity, Emotional intelligence and Emotional creativity; Cognitive focused Approaches: The role of Personal Control in Adaptive functioning, Well-being, Optimism and Wisdom; Self-based Approaches: Authenticity, Uniqueness seeking; Interpersonal Approaches: Empathy, Altruism, Moral Motivation and Forgiveness; Biological Approaches: Role of Neuro-Psychology and Biopsychology in Positive Psychology; Specific Coping Approaches: Meditation, Yoga and Spirituality.

HUL271 Sociology: The Science of Praxis
4 credits (3-1-0)
Pre-requisites: HUN100
The rational organization of knowledge and the emergence of sociology as a scientific discipline. Industrial society in Western Europe. Industrialism and its scientific programme. Key thinkers and key perspectives. Science, reform and revolutionary social change. The critics of modernity. Implications of these thinkers for social science and society today.

HUL272 Introduction to the Sociology of India
4 credits (3-1-0)
Pre-requisites: HUN100
This course focuses on understanding the various constructions of Indian society from colonial to contemporary times. The structural and cultural dimensions of Indian society are explored through the study of village, region nation and civilization. Castes and tribes, kinship and family systems, the diversity of religious traditions and organizational forms are explored together with contemporary issues of secularism communalism, religious conversions and caste-based affirmative action. Institutions such as ‘purdah’ and ‘down’ allow the understanding of the social construction of gender in Indian society.

HUL273 Science, Technology and Society
4 credits (3-1-0)
Pre-requisites: HUN100


HUL274 Re-thinking the Indian Tradition
4 credits (3-1-0)
Pre-requisites: HUN100

The examination of sources, the structure, the texts and exemplars of the Indian tradition provide the theoretical framework for the discussion of contemporary political and social issues. These are economic development and social justice religion and the nation, communalism and secularism, caste class and gender equity and so on. The political misuse of tradition in programs of reform and revival both in the past and in modern times will be highlighted to underline the need for rethinking tradition in an academically serious manner.

HUL275 Environment, Development and Society
4 credits (3-1-0)
Pre-requisites: HUN100


HUL276 Sociology of Knowledge
4 credits (3-1-0)
Pre-requisites: HUN100

The de-mystification of science as a privileged form of knowledge since Copernicus. Re-examining the laboratory, the factory and the nation-state, structures linked to the West-European model of science. Examining systems deemed ethno-science or folklore, to set up a dialogue with institutionalized science. Comparing science with religion as forms of knowledge having competing power over human belief and action. Examining Traditional Knowledge (TK) systems and their relevance for global economy.

HUL281 Mind, Machines and Language
4 credits (3-1-0)
Pre-requisites: HUN100

What is the role of language in the cognitive sciences? What are the implications of conceiving the mind as a machine (computer)? Can theories about language acquisition help us to understand the ways in which humans perceive the world? Finally, how are the three categories (mind, machine and language) related to each other? These are a few of the fundamental questions that will be posed in this course. It will benefit any student who wishes to think systematically the cognitive structures that he or she inhabits but otherwise takes for granted.

HUL282 System and Structure: An Introduction to Communication Theory
4 credits (3-1-0)
Pre-requisites: HUN100

This course is an introduction to theories of communication for which there is not sufficient time in the other communication courses, which are mainly applied in their orientation. This is an interdisciplinary course. It will examine how the notion of communication is used in different disciplines in the humanities and the social sciences. It will intersect with problems of organizational structure, linguistic structure, interpersonal structure and the problem of what is involved in changing a structure. This course will include no components of remedial English, business correspondence or skill building activities. Only those really interested in theoretical questions should enroll.

HUL283 Industrial Organizations
4 credits (3-1-0)
Pre-requisites: HUN100


HUL284 Participative Management
4 credits (3-1-0)
Pre-requisites: HUN100


HUL285 Social Responsibilities of Scientists and Technologists
4 credits (3-1-0)
Pre-requisites: HUN100

The concept of social responsibilities and its relevance. The development of the field. The systems approach and multidisciplinary nature of the issue systems, methodology and planning for social responsibilities. The social sub-system and science and technology. The human sub-system and science and technology. Other methodological aspects. Ethics issues in science and technology.

HUL286 Social Science Approaches to Development
3 credits (2-1-0)
Pre-requisites: HUN100

Historical genesis and theories of development and underdevelopment. Comparative paths of development. Soviet Union, Japan, China. India’s path of planning and socialism: development experience in the post independence period. Explanations of the poor achievements of India’s economy in meeting basic needs for several decades after independence. Social indicators of development, problems of poverty and inequality. Economic reforms and liberalization. Panchayati Raj and decentralization. Role of religion, caste and family in development. Interrogation of the accepted paradigm of development from the point of view of gender, environment and poverty issues. Appropriate technology and development.

HUL287 Industry and Work Culture under Globalization
4 credits (3-1-0)
Pre-requisites: HUN100

The course will focus on the sociological dimensions of industry under globalization. Changing nature of industrial organization (changes in
production processes-horizontal and vertical integration), emergence of new industries, changing rhythms and forms of work, the work culture and the decline of organized industry; the growing importance of the informal sector and the implication of these changes for family and society will be discussed. The transnational nature of much of contemporary industry-new phenomena such as out sourcing, call centers etc. Industry and global governance (WTO) the new international division of labor. Education and industry linkages, rise of the consumer society and its sociological implications for industry.

HUL 288 Science and Humanism: Towards a Unified World View
4 credits (3-1-0)
Pre-requisites: HUN 100
Introduction and orientation to the development of science up to the 19th century and the concomitant worldview. Traditional conflict between science and religion - its causes and consequences. Role of science as a promoter of human values. Humanism and its true basis. New paradigm emerging from the 20th century Developments in science and the implications of the complementarity of science and humanism— the need for inner development. Education, development, and planning with the new unified worldview.

HUL 289 Macro Perspective on Science, Technology and Human Development
4 credits (3-1-0)
Pre-requisites: HUN 100
The dynamics of scientific discovery, technological innovation and its application to the human scene. Case histories of some recent developments in physical and biological sciences and their impact on communications, health care, education and defence, interlinking issues such as protection of the environment and avoidance of potential catastrophes arising out of side effects, techniques of conflict analysis and resolutions of Indian thinkers to the development and application of these techniques, the respective roles of the individual and the social organizations in anticipating and solving problems as well as in optimizing the application of science and technology towards human development.

HUL 290 Technology and Culture
4 credits (3-1-0)
Pre-requisites: HUN 100
To examine the relationship between technology and culture through a consideration of modern/current developments in various specific areas: e.g. Biotechnology and Medicine, IT, AI & Robotics, Fashion Technology, Magic Technology, Communications, Defense and Space Research.

To focus on the roles played by the IITs themselves in creating ‘knowledge societies’ - that is, in influencing, formulating and envisioning the links between technological ‘solutions’ and socio-cultural ‘problems’ especially in the Indian context. Here we will discuss, for example: Patent Laws, Gender Issues, Environmental Ethics, Design(er) and Person(al) Technological Aesthetics, Technologies for the Disabled, Educational Technologies.

HUL 291 Electronic Governance
4 credits (3-1-0)
Pre-requisites: HUN 100
Information and communication technology for development; historical evolution; theoretical assumptions or foundations; criticisms – policy rhetoric; implementation – telecenters, public-private partnership; critical success factors; barriers – legislature, technology, people; evaluation; India specific case studies.

HUL 301 The Sociology of Religion
4 credits (3-1-0)
Pre-requisites: HUL 271
This course will introduce students to sociological approaches to the study of religion in contemporary society. Religion will be understood in terms of its social and cultural structure; in addition the course will also encourage a critical perspective on religion and society – its interface with society, polity and the economy. Religious conflict and change, syncretism, popular religion, revivalism and fundamentalism will also be considered.

HUL 307 Fantasy Literature
4 credits (3-1-0)
Pre-requisites: HUL 231
Major Themes of Fantasy: Archetypes and Myths; Motifs – journeys, theology, devices and aides; creation of alternate worlds; treatment of time and space; close reading of individual texts.

HUL 308 Theatre of the Absurd
4 credits (3-1-0)
Pre-requisites: HUL 231
Socio-political background of the theatre of the Absurd, its basis in Existentialist philosophy. The reactions against the conventions of realist theater that dominated this theatre. The pre-occupations of major playwrights with issues of language and the difficulty of communication, the isolation that human beings tend to feel from each other and themes of violence.

HUL 317 Applied Positive Psychology
4 credits (3-1-0)
Pre-requisites: HUL 267/HUL 261
Meaning and goals of applied positive psychology; Relevant research methods of the field; Introduction to intervention programmes including internet based intervention; Researches that support intervention strategies: Psychological well-being and its intervention programmes; Emotional intelligence and its intervention programmes; Strategies for achieving well-being; Mindfulness and in its intervention programmes; Intervention module on stress and time management; Character strength; their role in well-being; How psychosocial resources enhance health and well-being; Intervention researches in Indian socio-cultural context; Current issues and future direction in this area.

HUL 401 Political Ecology of Water
4 credits (3-1-0)
Pre-requisites: HUL 271 and HUL 272/HUL 273/HUL 274/HUL 275/HUL 276/HUL 286/HUL 287/HUL 301
Understanding Political Ecology: Water as resource and as in integral part of Indian culture; Indigenous water conservation strategies; Pollution of groundwater; Water related natural disasters and their management; Dams and Hydroelectric Project related controversies in India; Environmental Movements in India – case studies; Community Control of Water; local and state level disputes; and Water Policy (India).

HUL 701 Sociological Theory Developments and Trends
3 credits (2-1-0)
Pre-requisites: HUL 274, HUL 275, HUL 276
Understanding Sociological Theory: Development and Trends in the field; Introduction to research methods and theoretical perspectives whereby he may develop a better understanding of both his social environment and theoretical understanding.

HUL 706 Language, Society and Culture
3 credits (2-1-0)
Pre-requisites: HUL 274, HUL 275, HUL 276
Psycho-linguistics and sociolinguistics; culture and identity studies; studies in expressive culture: idea-systems, myths and archetypes.

HUL 707 Social Psychology
3 credits (2-1-0)
Pre-requisites: HUL 274, HUL 275, HUL 276
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 one of the courses.)

HUL736 Planning and Economic Development
3 credits (0-0-6)

HUL738 International Economics
3 credits (2-1-0)

HUL745 Psychological Factors in Work Design
3 credits (2-1-0)
Approaches to work design. Historical perspective. Human information processing, Natural and man-made environment effect, psychology of work. The living environments, physical features, psychological dimensions of work. Job enrichment, quality of working life. Future of work designs.

HUL748 Community Psychology
3 credits (2-1-0)
Concept of community and their implications for community psychology. Community processes and orientations toward change. Examinations of the models; the mental health model; the organizational model; the social action model; the ecological model. Implications for a psychology of the community: the study of community life, interaction strategies; implications for manpower and training; family therapy and the community; crisis intervention; advocacy and community psychology.

HUL754 Science, Technology and Society
3 credits (2-1-0)
An interdisciplinary exploration of the mutual interaction of science, technology and society, with insights drawn from sociology of sciences, history of science and technology, and the changing formations of the modern society.

HUL755 Econometrics and Economic Forecasting
3 credits (2-1-0)

HUL759 Urban Social Systems
3 credits (2-1-0)
This course intends to impart a comprehensive and systematic understanding of urban social systems. Students completing this course will have a detailed knowledge of urban-growth and urban behaviour analysis, and urban-planning through a feedback analysis approach. Following will be the main course contents:

Nature, types and growth of cities, Some important aspects of urban-systems: migration; neighbourhood; social groups; and voluntary associations. Trend of urbanisation. Urban influences on rural areas. A profile of urban India and its problems. Solution of the problems through various approaches. Urban planning.

HUL760 Industry and Society
3 credits (2-1-0)
The basic aim of this course is to introduce students from various backgrounds scientists, technologists to the study and understanding of modern industrial societies. the course material will focus on the following topics:


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)
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 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/falsity, denotative/connotative, meaning/use, analytic/synthetic, argument/predicate, intention/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 Gricean 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, Amheim, 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 culture of knowledge which surrounds it. The nature of scientific knowledge and the general characteristics of scientific research which make such knowledge possible. Whether present framework of organizing knowledge is itself an object of sociological investigation? Comparison of methods of acquiring and of validating knowledge claims across cultures. Investigation through case studies of the various cognitive frameworks. Transfer of scientific and other expertise to wider sub-culture. Nature of scientific community, and of communication within a community and inter-community through networking.

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. Tests 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 Austin and Searle; 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, Drieser, Edith Wherton, Willa Cather, Henry James, and 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, and John Updike.

**HUV886 Special Module in Cognitive Psychology**  
*2 credits (1-0-2)*  
The course will focus on current relevant and emerging issues, and experiments in the field of cognitive psychology.

**HUL888 Applied Linguistics**  
*3 credits (3-0-0)*  
Notions of applied linguistics; psycholinguistics; socio-linguistics; language learning; language teaching; contrastive analysis; error analysis; pedagogic grammars; applied lexicology; communicative teaching; discourse analysis; stylistic and literature.

**HUL889 British Fiction – A Stylistics Approach**  
*3 credits (3-0-0)*  
Language in prose and poetry; stylistics; deviance; prominence, foregrounding; literary relevance; stylistic variants; language and the fictional world; the rhetoric of text; discourse situation; conversation, speech and thought.

**HUL891 Globalization and Transnationalism**  
*3 credits (2-1-0)*  

**HUL893 Literature and the City**
SML100 Introduction to Entrepreneurial Ventures  
4 credits (3-1-0)  
Choice of Technology.  
The need, scope and approaches for project formulation, biography of Indian entrepreneurs.  
Achievement motivation. Creativity - coping with uncertainties. Attitude towards wealth and work. Smaller-medium-large scale enterprise linkage.  

SML101 Management Concepts and Techniques - An Introduction  
4 credits (3-1-0)  
Organizing: Basic departmentation. Line and staff authority relationships. Functions of leadership, Nature of leadership, Control: The system and process of control, Control techniques, Control of overall performance.  
Introduction to functional areas of management: Operation management, Financial management, Marketing management, Human resources management and organization management.  

SML301 Entrepreneurial Operations  
4 credits (3-1-0)  
Pre-requisites: EC 60  
Entrepreneurship in India; The operating cycle; Market Segmentation; Market research; Test marketing; Essentials of costing & pricing; Working capital management; Break even analysis; Product development; Production planning and control; Materials management; Selection and recruitment; Group dynamics; Delegation; Industrial policy; Project identification; Techno-economic feasibility report.  

SML302 Entrepreneurship Management  
4 credits (3-1-0)  
Pre-requisites: EC 60  

SML303 Cost Analysis and Control  
4 credits (3-1-0)  
Pre-requisites: EC 60  
Meaning, nature and managerial need of cost analysis. Cost concepts and cost classification relating to income determination, profit planning, control and decision-making.  
Elements of costs-material, labour and overheads. Allocation, absorption and apportionment of overheads; methods of allocation of overheads.  

SML304 Introduction to Marketing Management  
4 credits (3-1-0)  
Pre-requisites: EC 60  
Marketing orientation; Consumer Behaviour; Segmentation; Forecasting; Product life cycle; Product decision; Pricing decision; Promotion; Distribution; Sales management; Marketing Information Systems; Market Planning and Control; Market research; Cases and exercises.  

SML305 Organization of Engineering Systems and Human Resources Management  
4 credits (3-1-0)  
Pre-requisites: EC 60  

SML306 Manufacturing Systems Management  
4 credits (3-1-0)  
Pre-requisites: EC 60  
Overlaps with: MEL421, MEL322  
Essentials of manufacturing management, Manufacturing systems classification, Operations capacity planning; Facilities design-location, Layout & materials handling; Assembly line balancing; Organizing conversion system; Productivity improvement techniques; Scheduling production & service. Systems, production planning & Inventory control, Material requirements planning; Quality management; Advanced manufacturing system-introduction to FMS, JIT; CIM, WCM; Maintenance management, Applications of operations research techniques to manufacturing systems management. Case studies.  

SML307 Information Systems for Managerial Decision-making  
4 credits (3-1-0)  
Pre-requisites: EC 60  
Role of information in managerial decision-making; Information needs for various levels of managerial decision makers; Computer based Information systems-office automation systems; Transaction processing systems; Functional information systems; Information systems planning, design & implementation; Structured Systems Analysis & Design; Object oriented design; Evaluation of an information system; Introduction to decision support systems; User involvement & end user computing. Case studies.  

SML401 Managerial Accounting and Financial Management  
4 credits (3-1-0)  
Pre-requisites: EC 90  
Overlaps with: SML303, SML770  

SML402 Industrial Marketing Management  
4 credits (3-1-0)  
Pre-requisites: EC 90  
Fundamentals of Industrial Marketing: Industrial buyer behaviour models; Decision-making units; Technology and Marketing; System selling; Role of service; Intangibles in Industrial Marketing, Derived demand methodologies; globalization; Contract review; Selling;
**SML700 Fundamentals of Management of Technology**
3 credits (3-0-0)
*Pre-requisites: SML305 and SML401


**Module II:** Technology forecasting and assessment. Technology flow and diffusion. Evaluating technology, technology planning and strategy, Strategic potential of new technology. Factors promoting technology acquisition. Flexibility in Technology Management. Technology transfer and absorption, Modes of global technology transfer. Technological Entrepreneurship.


**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, technologic change, sources of technology, Technology Information. Criticality of technology for growth, core competencies, R&D productivity, Resource Leverage. World Class Organisation.

**Module II:** Corporate technology strategy, Generic competitive technology strategies. Corporate R&D, Strategic technology management process, relationship between technology strategy and corporate strategy. Strategic shifts and resource commitments, technology vision and goals, technology leadership. SWOT analysis for technology, Matching Business Portfolio and Technology Portfolio, Technology- Market matrix. Innovation and entry strategy, Flexibility in Technology strategy.


**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, licsence 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)
*Pre-requisites: SML305

**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)
*Pre-requisites: SML305

**Module I:** Structure of managerial problems. Open and close ended problems, convergent and divergent thinking. The creativity process, Individual and group creativity, Idea generation methods: Brain storming, Nominal Group Technique, Idea Engineering, Check list, Attribute listing, Morphological analysis, Synectics, Mental Imaging, Critical Questioning. Total System Intervention, Flexible Systems Methodology.

**Module II:** Idea Structuring: Graphic tools, Programme Planning Linkages, Interpretive Structural Modelling, Relationship Analysis, Flexible Systems Management, SAP-LAP Analysis, Flexibility Influence Diagrams, Collaboration Digrams. Scenario Building: Harva method, Structural Analysis, Options Field/Profile Methodology.


**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 I: Organisational systems vix. a vis, the environment. The dialectics of agency and structure - extent of environmental and organizational control. External control of organization. Organizations and the new institutionalism. Systems for managing chaos and conflict.

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 organisational 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 (3-0-0)
*Pre-requisites: SML305 and SML401


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 Yourdon techniques). Traditional workflow methods.


SML720 Business Environment and Corporate Strategy
3 credits (2-0-2)
*Pre-requisites: SML305


SML 723 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 telecommunications, 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 structure of industry; evolution and role of international institutions; global trends in liberalization and de-regulations, Patterns of Transaction in international telecom management; managing the market growth; developing, operating and monitoring regulation issues.

**Module II**: Role of telecommunications in socio-economic development; ICT & Social change, new technologies and services for international telecommunications; data services and business applications, Telecom prospectus of WTO & other international bodies.

**Module III**: Current issues and organisational growth; telecom implications for the industry; value added services and market drives; regional 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; mechanisation, automation and computerisation; Organizational interdependence and organizational evaluation.

**SML731 Human Resources Management**
3 credits (3-0-0)
*Pre-requisites: SML401, Overlap with: SML305


**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)
*Pre-requisites: SML305


**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.


**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 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; Cost analysis and its managerial Project appraisal techniques. Social cost benefit analysis; Investment decisions under risk and uncertainty.


**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.

**SMN794 Communication Skills**

1.5 credits (1-0-1)

Pre-requisites: SML305 and SML401


**SMN795 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, Analysis 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.

**SML 804 Technical Entrepreneurship**

3 credits (3-0-0)

**Module I:** Basis and challenges of entrepreneurship Technological entrepreneurship, Innovation and entrepreneurship in technology based organisations, High tech. entrepreneurship. Entrepreneurial characteristics. Concept of new ventures. Technology absorption, Appropriate technology. Networking with industries and institutions.

**Module II:** Starting a new technological venture and developing the business: Business idea, Business plan, Marketing plan, Financial plan, Organisational plan. Financing a new Venture: Sources of Capital, Venture Capital, Going public. Entrepreneurship & liberalization.

**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

**Module I:** Nature of Management Control Systems: planning and control


SML812 Flexible Systems Management
3 credits (2-0-2)


SML813 Systems Methodology for Management
3 credits (2-0-2)

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 (2-0-2)
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 (2-0-2)
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 (2-0-2)
Pre-requisites: SML715 and SML720


SML818 Industrial Waste Management
3 credits (2-0-2)
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, aluminum, power, automobile, transport and other service industries. Economic analysis and system models of industrial waste management systems. Analytical and Creative techniques to waste control.

SML819 Business Process Reengineering
3 credits (2-0-2)
Pre-requisites: SML720 and SML745
Module I: Nature, significance and rationale of Business Process
Reengineering, Reengineering scenarios in major countries. Problems issues, scope and trends in BPR. Implementing BPR: Methodology and steps. IT enabled reengineering, mediation and collaboration.

**Module II: The paradigm of Mass customization, managing organisational change. Transforming/ Reinventing the enterprise, Team building. Case studies of success as well as failure.

**Module III: People view, empowering people, reengineering management. Issues of purpose, culture, process and performance, and people.**

**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 merges. 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 organization, 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, Enhancing Competitiveness, Competitiveness Processes & Initiatives, Leadership Dimension, Cases.

Module III: Practitioners 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


SML831 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.


SML832 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/spare) 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.


SML844 Systems Reliability, Safety and Maintenance Management
3 credits (3-0-0)
Pre-requisites: SML745


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. Environmental impact analysis of a project.

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)
Pre-requisites: SMV793; or MAL140
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, 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 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 DBCG 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, Digitals 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, Designing 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, online commerce solutions.

Types of e-commerce: web store, auctions, discounting, advertising and promotions (case studies) etc., risks in internet commerce, jobs in cyberspace.

Business Models for e-commerce, on-line commerce options: customer choices and merchant choices, Advertising and marketing on internet.


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, Mapping 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- co-ordinating 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 I: International marketing-its scope and tasks- world economy prospects and Challenges; India’s external trade. Analysis of export performance. Why all organisations cannot go global Shipping terms

Module III: Product Decisions.

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 credit (3-0-0)
Pre-requisites: SML770
Module I: Investment Environment.

Module II: Valuation of Securities.

Module III: Portfolio Management.

SML874 Indian Financial System
3 credits (3-0-0)
Pre-requisites: SML770
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.

SML875 International Financial Management
3 credits (3-0-0)
Pre-requisites: SML770


SML879 Current and Emerging Issues in Finance
3 credits (3-0-0)
Pre-requisites: SML720
(Relevant current and Emerging Issues)

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.

SML 889 Current and Emerging Issues in Public Sector Management
3 credits (3-0-0)
Pre-requisites: SML881
(Relevant current and Emerging Issues)

SMN895 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.

SMN896 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


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 relation-ship, 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.
Department of Mathematics

MAL110 Mathematics - I
4 credits (3-1-0)
Overlaps with: MAL111, MAL115
Taylor's theorem and infinite series. Fundamental theorem of integral calculus. Applications of definite integral to area, arc length, surface area and volume. Differential calculus of functions of several variables with applications; Maxima and minima; Ordinary differential equations of first and higher order; Series solution for Legendre and Bessel equations. Laplace transform.

Rank and inverse of a matrix, consistency of linear system of equations; Eigen values, Eigen vectors and their applications to system of ordinary differential equations; Cayley-Hamilton theorem; Diagonalization of matrices.

MAL111 Introduction to Analysis and Differential Equations
4 credits (3-1-0)
Overlaps with: MAL110, MAL115
Product of sets; mappings and their compositions; denumerable sets' upper and lower bounds, supremum, infimum.


Solution of dy/dx = f(x, y); linear differential operator L, higher order ordinary differential equation with constant coefficients; Wronskian, solution space; Euler's equation; boundary value problem; initial value problem – existence and uniqueness theorem.

MAL115 Multivariable Calculus and Matrix Theory
4 credits (3-1-0)
Overlaps with: MAL110, MAL111
The Riemann integral definition and properties. The fundamental theorem of integral calculus, applications and improper integrals; Gamma function. Existence properties, Sequence and series of functions, Power series. Properties of functions represented by power series, Fourier series.

Scalar and vector valued functions of several variables: limits, continuity, partial derivatives, differentiability, Jacobian, Implicit differentiation, gradient and directional derivative, Taylor's theorem in one and several variables, maxima and minima, constrained extrema and Lagrange multipliers.

Multiple integrals: definitions, properties, evaluation and applications of double integrals (in Cartesian and polar coordinates) and triple integrals (Cartesian, cylindrical and spherical coordinates), line integrals, Green's theorem; Proof, first and second forms, Applications, Surface integrals, Gauss theorem; proof and extensions; Volume integrals, Stokes' theorem; Proof and applications.

Row reduced Echelon matrices, rank of a matrix, systems of linear algebraic equations, Eigen values and Eigen vectors. Diagonalization of matrices, Hermetian, Unitary and Normal matrices, Bilinear and Quadratic forms.

MAL120 Mathematics - II
4 credits (3-1-0)
Overlaps with: MAL122, MAL124
Vector Field Theory: Vector calculus, arc length, directional derivative, gradient, curl, divergence, line and double integral, Green's theorem, surface integral, triple integral, Gauss and Stokes' theorems with applications.

Complex analysis: Limit and derivative of a function, analytic function, Cauchy-Riemann equations, elementary functions, line integral, Cauchy's integral theorem, Cauchy's integral formula, derivatives of analytic function, convergence of sequence and series, power series, Taylor series, Laurent series, zeros and singularities, residues and residue theorem, evaluation of real integrals, Conformal mapping, Linear fractional transformations, mapping by elementary functions.

Fourier series, Fourier integrals and Fourier transforms.

MAL122 Real and Complex Analysis
4 credits (3-1-0)
Overlaps with: MAL120, MAL124
Metric spaces: Definition and examples, open and closed and bounded sets; closure, interior and boundary, completeness; Bolzano-Weierstass theorem, completeness of R. Continuity and uniform continuity, connectedness, compactness and separability.


MAL124 Introduction to Algebra and Matrix Analysis
4 credits (3-1-0)
Overlaps with: MAL120, MAL122
Group theory: Groups, subgroups, Normal subgroups, Factor subgroups, Lagrange theorem, Homomorphism and Isomorphism theorems, Permutation groups, Matrix groups, Abelian groups.

Rings and Fields, Ideals, Homomorphism, Euclidean domains, Finite and Infinite fields, Polynomial rings Matrix rings.

Linear Algebra and Matrix Theory: Vector spaces, subspaces, direct sums, bases and dimension, Linear transformation, Matrix of the linear transformation, Change of basis, Eigen values and Eigen vectors, The Characteristic and Minimal polynomials, Diagonalization.


MAL140 Probability and Statistics
4 credits (3-1-0)
Overlaps with: MAL220, MAL250
Probability, Conditional probability, random variables, expected value, Specific discrete and continuous distributions, e.g. binomial, Poisson, geometric, Pascal, hypergeometric, Uniform, exponential and normal, Poisson process, Multidimensional random variables, Multinomial and bivariate normal distributions, moment generating function, Law of large numbers and central limit theorem, Sampling distributions, Point and interval estimation, Testing of hypothesis, Goodness of fit and contingency tables. Linear regression.

MAL145 Number Theory
4 credits (3-1-0)
Congruences, Arithmetical functions, Theory of partitions, Diophantine approximations, Binary quadratic forms, diophantine equations, Distributions of primes.

MAL146 Combinatorics
4 credits (3-1-0)
Overlaps with: MAL147
Dikworth's theorem and extremal set theory, partitions, latin squares, Hadamard matrices and Reed-Muller codes, (0,1) matrices and min-max theorems, codes and designs, projective and combinatorial geometries, Polya's theory of counting.

MAL147 Combinatorial Mathematics
4 credits (3-1-0)
Overlaps with: MAL146
Elementary counting; Recursions and generating functions; Principle of
Inclusion and Exclusion; Inversion formula; Cayley's Tree theorem; Colourings of graphs; Ramsey's theorem; Basics of Ramsey numbers; Turan's theorem and external graph theory; system of distinct representatives and Hall's marriage theorem; Harere's and tournaments.

**MAN150 Introduction to Mathematics and Computing**  
2 credits (0-0-4)  
Lecture-demonstrations to introduce the art of reasoning in the discrete world and illustrate the complexities of mathematical software development; hands-on experience with various mathematical and statistical software; interactive sessions with professionals from industry and R&D institutions.

**MAL180 Discrete Mathematical Structures**  
4 credits (3-1-0)  
Overlaps with: CSL105  
Propositional Logic: Language of Propositional logic, truth table, natural deduction, Predicate logic: language of predicate logic, Logical inference with Quantifiers. Proof Techniques; Combinatorics: Counting techniques: recurrence relation and its application to analysis of algorithm; Basic Discrete Probability, probabilistic counting. Graph theory: Graph as a discrete structure, Modeling applications using Graphs, Hamiltonian graphs, Planar graphs, Graph coloring, Network flows, Matching. Algebra: Groups and Examples, Cosets and Normal subgroups, Lagrange theorem, cyclic groups, permutation groups, Finite Abelian groups, Homomorphisms, Matrix groups. Rings, Ideals, Fielrds, Finite fields, Polynomial rings, Unique Factorization. Introduction to lattices and Boolean algebra.

**MAL210 Optimization Methods and Applications**  
4 credits (3-1-0)  
Pre-requisites: MAL110/ MAL111/ MAL115  

**MAL220 Basic Probability and Statistical Inference**  
4 credits (3-1-0)  
Pre-requisites: MAL110/ MAL111/ MAL120  
Overlaps with: MAL140/MAL250  
Probability space, Conditional probability, Random variable, distribution function, pmf and pdf, Standard probability distributions, multidimensional random variables, marginal and conditional probability distribution, independence of random variables, bivariate normal and multinomial distributions, functions of one and more random variables, Expectation, moments, and moment generating functions, correlation, moment inequalities, Markov and Chebychev inequality, conditional expectation and regression, random sums, convergence in probability, Weak Law of Large Numbers, Central Limit Theorem, Sampling Distributions, unbiased and consistent estimators, moment and maximum likelihood estimators, interval estimation, simple and composite statistical hypotheses, power of statistical test, standard statistical tests for population means, variances and proportions, Tests of goodness of fit and linearity of regression.

**MAL230 Numerical Methods and Computation**  
4 credits (3-1-0)  
Pre-requisites: MAL110/ MAL111/ MAL115  

**MAL240 Algebra**  
4 credits (3-1-0)  
Pre-requisites: MAL110/ MAL111/ MAL115/ MAL124  
Definition and examples of group, rings and fields; Subgroups. Normal subgroups and factor groups, Isomorphism theorems. Sylow theorems of finite groups and applications, Fundamental theorem for finitely generated Abelian groups. Nilpotent and solvable groups. Commutative rings, Prime ideals, Maximal ideals, Polynomial rings in several variables. Algebraic field extensions, Splitting fields, Finite separable and normal extensions, Fundamental theorem of Galois theory.

**MAL245 Topology and Functional Analysis**  
4 credits (3-1-0)  
Pre-requisites: MAL122  

**MAL250 Introduction to Probability Theory and Stochastic Processes**  
4 credits (3-1-0)  
Pre-requisites: MAL110/ MAL111/ MAL115/ MAL120/ MAL122/ MAL124  
Overlaps with: MAL140/MAL220  
Axioms of probability, Probability space, conditional probability, independence, Baye's rule, Repeated trials, Bernoulli trials, Random variables: discrete r.v., probability mass functions, c.d.f., common distributions, continuous r.v., probability density and distributions of r.v., joint distributions, order statistics, expectation; moments, transforms, conditional expectations, stochastic processes, Markov chains and Markov processes (birth, death, etc.), Queuing models.

**MAL255 Linear Algebra**  
4 credits (3-1-0)  
Pre-requisites: MAL110/ MAL115  
Overlaps with: EPL333, MAL124  

**MAL256 Modern Algebra**  
4 credits (3-1-0)  
Pre-requisites: MAL110/ MAL115/ MAL111  
Overlaps with: MAL124  
**MAL260 Boundary Value Problems**
4 credits (3-1-0)
Pre-requisites: (MAL110/ MAL111/ MAL115) & (MAL120/ MAL122/ MAL124)

Boundary Value Problems, existence and uniqueness of solution, shooting method, finite difference method, orthogonal set of functions, regular and singular Strum Liouville problems, Eigen function expansions, Green's functions, equivalent integral equations and numerical methods for their solution, analytic and numerical solution of BVPs in PDEs, Ritz Galerkin and Collocation Methods.

**MAL270 Measure, Integral and Probability**
4 credits (3-1-0)
Pre-requisites: (MAL110/ MAL111/ MAL115)


**MAP290 System Design Laboratory**
2 credits (0-0-4)
Pre-requisites: CSL101

Laboratory assignments on various topics covered in MA754 and MA715.

**MAL311 Parallel Algorithms**
4 credits (3-0-2)
Pre-requisites: MAL230


**MAL335 Differential Equations: Theory and Numerical Methods**
4 credits (3-1-0)
Pre-requisites: (MAL115/ MAL110/ MAL111) & (MAL120/ MAL122 & MAL230)

Overlaps with: EPL333


**MAL341 File Structures and Information Systems Design**
4 credits (3-0-2)
Pre-requisites: CSL201

Secondary storage media, blocking, buffering, External sorting techniques, Concept of a file, primary key and secondary key, sequential, Indexed and relative file organizations. Update of indexed sequential and random access files, Creation and Update of relative files, dynamic hashing techniques, list structure, multiring and inverted files, grid files, etc. Introduction to concurrent operations on the structures.

**MAL342 Analysis and Design of Algorithms**
4 credits (3-1-0)
Pre-requisites: CSL201

Overlaps with: CSL356

Algorithms Fundamentals: space and time complexities, asymptotic notations, randomized algorithms; Basic Algorithms for Different Data Structures: linear, non-linear, priority queues, graphs and their analysis; Divide and Conquer Algorithms - Master theorem; Sorting Algorithms - lower bound, sorting in linear time; Greedy Methods - knapsack, minimum cost spanning trees, single source shortest paths, Huffman coding; Dynamic Programming - matrix multiplication, Travelling salesman, 0/1 knapsack; Search Techniques - depth-first, breadth first, heuristic search algorithms, backtracking and bounding; NP- completeness.

**MAD350 Mini Project (MT)**
3 credits (0-0-6)
Pre-requisites: EC 80

Design/fabrication/implementation work under the guidance of a faculty member. Prior to registration, a detailed plan of work should be submitted by the student to the Head of the Department for approval.

**MAL353 Algebraic Methods in Computer Science**
4 credits (3-1-0)
Pre-requisites: MAL124 / MAL180

Universal Algebra: Basic constructions, equationally defined classes of algebras, implicationally defined classes of algebras. Algebraic specifications of abstract data types, algebraic semantics of recursive programme schemes, applications of universal algebra to structural aspects such as syntax and semantics, data abstraction, etc. Group theoretical methods in computer science in general and in image processing, image understanding and computer vision in particular. Representation Theory of the classical groups SO(2), SO(3), and SU(2), and applications. Algebraic and projective invariants in computer vision.

**MAL355 Partial Differential Equations: Theory and Computation**
4 credits (3-1-0)
Pre-requisites: (MAL115/ MAL120 /MAL111) & (MAL230)

Theory : First order equations, Cauchy Kovalewski theorem.

Classification of second order equations. Characteristics, uniqueness theorems for hyperbolic equations with initial and boundary conditions, elliptic equations, Dirichlet and Neumann problems, Maximum and minimum theorem, Poisson's integral, Green's and Neumann's functions. heat equations.


**MAL358 Operating Systems**
4 credits (3-0-2)
Pre-requisites: EEL308

Overlaps with: MAL708/EEL358/CSL373

Operating System components, process creation, management and scheduling in a multiprogramming, multiprocessing, and multitasking system; inter-process communication mechanisms, virtual storage; interactive and batch processing; file management facilities; distributed operating system design issues; load distribution in distributed operating systems; network file system management.
MAL365 Mathematical Programming Techniques
4 credits (3-1-0)
Pre-requisites: EC 60
Overlaps with: CSL856
Fourier transform of square integrable functions, Riesz Fischer theorem, Integral wavelet transform, orthogonal bases of wavelets, multi resolution analysis, compactly supported wavelets, cardinal spline wavelets, fast wavelet transform, numerical algorithms, recent developments and applications.

MAL373 Wavelet and Applications
4 credits (3-1-0)
Pre-requisites: EC 60
Overlaps with: CSL705

MAL375 Programming Languages
4 credits (3-0-2)
Pre-requisites: CSL201
Overlaps with: CSL302
Language Definition and Processing - syntax, semantics, translation issues; Data abstraction - encapsulation, storage management, inheritance; Control constructs - sequence control, subprocess control, parameter passing, runtime structures and operating environments; Issues of Language Design - Chomsky hierarchy, features of imperative and functional languages, features of object - based languages; Untyped and simply-typed Lambda calculus, Study of a functional language; Meta languages and SML, Logic Programming languages and Prolog.

MAL376 Graph Algorithms
4 credits (3-1-0)
Pre-requisites: CSL201
Overlaps with: CSL851, MAL468
Introduction to Graphs: Definition and basic concepts, Efficient representations of Graphs; Graph Searching: DFS and BFS; Application of Graph Searching: finding connected components, bi-connected components, testing for bipartite graphs, finding cycle in graph; Trees: Different MST algorithms, enumeration of all spanning trees of a graph; Paths and Distance in Graphs: Single source shortest path problem, All pairs shortest path problem, center and median of a graph, activity digraph and critical path; Hamiltonian Graphs: sufficient conditions for Hamiltonian graphs, traveling Salesmen problem; Eulerian Graphs: characterization of Eulerian graphs, construction of Eulerian tour, The Chinese Postman problem; Planar Graphs: properties of planar graphs, a planarity testing algorithms; Graph Coloring: vertex coloring, chromatic polynomials, edge coloring, planar graph coloring; Matching: maximum matching in bipartite graphs, maximum matching in general graphs; Networks: The Max-flow min-cut theorem, max-flow algorithm; NP-Complete Graph problems; Approximation algorithms for some NP-Hard graph problems; Algorithms for some NP-Hard graph problems on special graph classes.

MAL380 Numerical Linear Algebra
4 credits (3-1-0)
Pre-requisites: MAL230 & MAL255
Introduction to Parallel Computing: Need, Scope, issues and motivation; Models of Parallel Computation: Taxonomy of Parallel Architectures- SIMD, MIMD; PRAM model of computation; Interconnection Networks: Tree, Hypercube, Mesh, etc, dynamic Interconnection Network; Routing and communication mechanisms for static interconnection networks; elementary Parallel algorithms: Parallel reduction, Parallel prefix sums, List ranking, preorder Tree traversal, Merging. Basic Communication Operations: point to point message transfer, broadcasting, all to all broadcasting, one to all and all to all personalized communication. Parallel programming Paradigm: Explicit versus implicit, shared address space versus Message Passing, data parallelism versus Control Parallelism; Introduction to Message passing Interface (MPI); Parallel Programming Using MPI; Performance and Scalability of Parallel Systems, Basic design techniques; Parallel Algorithms for matrix computation, sorting, graph algorithms, Mapping and scheduling.

MAL465 Parallel Computing
4 credits (3-1-0)
Pre-requisites: MAL342
Introduction to Parallel Computing: Need, Scope, issues and motivation; Models of Parallel Computation: Taxonomy of Parallel Architectures- SIMD, MIMD; PRAM model of computation; Interconnection Networks: Tree, Hypercube, Mesh, etc, dynamic Interconnection Network; Routing and communication mechanisms for static interconnection networks; elementary Parallel algorithms: Parallel reduction, Parallel prefix sums, List ranking, preorder Tree traversal, Merging. Basic Communication Operations: point to point message transfer, broadcasting, all to all broadcasting, one to all and all to all personalized communication. Parallel programming Paradigm: Explicit versus implicit, shared address space versus Message Passing, data parallelism versus Control Parallelism; Introduction to Message passing Interface (MPI); Parallel Programming Using MPI; Performance and Scalability of Parallel Systems, Basic design techniques; Parallel Algorithms for matrix computation, sorting, graph algorithms, Mapping and scheduling.

MAL466 Multivariate Statistical Methods
4 credits (3-1-0)
Pre-requisites: MAL390
Multivariate Normal Distribution and sampling from it, Hotelling’s T2 and Mahalanobis D2 statistics, Multivariate analysis of variance, Multivariate regression model, Discriminant function and classification problems, Canonical correlation, Analysis of covariance structures, Principal Component Analysis, Factor analysis, cluster analysis, pattern recognition.

MAL468 Graph Theory
4 credits (3-1-0)
Pre-requisites: EC 90
Overlaps with: EEL311, MAL376, CSL851
Students will present seminars on topics of their interest including one on the training taken in the previous summer.
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 digraph and critical path; Hamiltonian Graphs: sufficient conditions for Hamiltonian graphs, traveling Salesman problem; Eulerian Graphs: 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 representations; Graph searching: BFS, DFS. Basic Graph Algorithms: MST, shortest paths, biconnectivity, strong connectivity, etc.

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.


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, Sturms 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, Sturms-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.


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)
Mathematics of statistical estimation and testing, inferences about population characteristics.


MAL524 Numerical Analysis
4 credits (3-1-0)
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) Enrolled (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, Godels 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 algorithms; 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.

MAL614 Advanced Matrix Theory
4 credits (3-1-0)
To provide indepth 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 of 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 & SDRs; Extremal set theory, Steiner Triple systems, Ramsey's Theorem.

MAL621 Computational Methods for Ordinary Differential Equations
4 credits (3-1-0)

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 digraph 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 Factorization; 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 import 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)

MAP701 Computing Laboratory
2 credits (0-0-4)
The objectives of the course are to (i) familiarize the students with the working of mathematical software like MATHEMATICA, STATISTICA, MATLAB, UNIX Commands and other IDEs and (ii) provide hands on experience with programming on/matrix computation (Laboratory/ design activities could also be included) Programming Assignments using MATHEMATICA, STATISTICA, MATLAB And UNIX Commands Computing assignments to be chosen from the following topic Matrix Computation: Matrix multiplication; traditional matrix multiplication Algorithm, Strassen’s algorithm; solving systems of linear equations; inverting Matrices; symmetric positive definite matrices and least squares approximation.

Non-singular Varieties, Tangent Spaces, Jacobian Criterion. Elliptic Curves Zariski’s Main Theorem and related topics.

MAL702 File System and Data Management
3 credits (3-0-0)

MAP702 Computing Laboratory
2 credits (0-0-4)
To develop in depth knowledge in mathematical software like MATHEMATICA, STATISTICA, MATLAB, UNIX and continue the work done in MAP 701.

MAD703 Project Part 1
4 credits (3-1-0)
To encourage the students to do some innovative work in one of the areas of Mathematics, viz. Pure Mathematics, Applied Mathematics, Statistics, Operations Research, and Computer Science.

MAL703 Numerical Algorithms for Parallel Computing
3 credits (3-0-0)
Current trends in the development and analysis of software in parallel computing. Parallel algorithms in computational linear algebra, large sparse systems, finding roots of polynomials, two-point boundary-value problems, partial differential equations, etc.

MAL704 Numerical Optimization
3 credits (3-0-2)

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)

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. Queuing 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/1-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
opimization, 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 functors, 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, Itô'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, surfaces in three dimensions, First fundamental form, curvature of surfaces, Geodesics, Gauss’s Theorem.

MAL740 Queueing 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.
Erlang 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, AES, 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

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)

MAL809 Numerical Software
3 credits (3-0-0)

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, inaccuracy, 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)
MAL843 Mathematical Modeling of Credit Risk
3 credits (3-0-0)

MAD851 Major Project Part 1 (MT)
6 credits (0-0-12)
Pre-requisites: EC 165
A student 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.

MAL853 Applied Numerical Analysis
3 credits (3-0-0)

Numerical differentiation and integration: Newton-Cotes and Gaussian type quadrature methods.

MAD854 Interpolation and Approximation
3 credits (3-0-0)


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)

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)

MAL883 Physical Fluid Mechanics
3 credits (3-0-0)
Description of principles of flow phenomena: pipe and channel flows, laminar and turbulent; flow past an object; boundary layer, wake, separation, vortices, drag, convection in horizontal layers, transition from periodic to chaotic behaviour; equations of motion; dynamical scaling, sample viscous flows; inviscid flows. Flow in rotating fluids; hydrodynamic stability.

MAL888 Boundary Elements Methods with Computer Implementation
3 credits (3-0-0)
Distributions and Sobolev spaces of fractional order. Elliptic boundary value problems on unbounded domains in IR^n (n=2,3).

MAL890 Wavelet Analysis and Applications
3 credits (3-0-0)

MAL899 Selected Topics (Self-study)
3 credits (3-0-0)
tool life and tool wear aspects. Theoretical models of shear angle solution, Basic concepts of cost and economics of metal cutting operations, Tool nomenclature, chip control and design for machining, Electrical discharge Machining, Electrochemical Machining, Ultrasonic machining, Abrasive Jet Machining, Laser Beam Machining, Water Jet and Electron Beam machining. Construction of Machine tools, alignment, metrology and inspection.

MEL234 Metal Forming and Machining
5 credits (3-1-2)
Pre-requisites: MEL120
Overlaps with: MEL233
Mechanical behaviour of metals in elastic and plastic deformation, stress-strain relationships, Yield criteria, Application to tensile testing, Concept of flow stress by true stress-strain curves, Fundamentals of metalworking, Strain rate and temperature in metal working, Hot deformation, Cold working and annealing, Analysis of bulk forming processes like forging, rolling, extrusion, wire drawing by slab method, Technology and practice of these processes, Sheet metal forming processes, High Energy rate forming processes, Fundamentals of metal cutting and common machining operations, Mechanics of metal cutting, Heat generation in metal cutting, Tool wear and tool life, Nomenclature of cutting tools and cutting tool materials, Cutting fluids, Abrasive machining, Surface finish, Economics of machining, Non-conventional machining processes.

MEL235 Metrology and Quality Assurance
4 credits (3-0-2)
Pre-requisites: MEL120
Introduction to Metrology and its relevance, Standardization, dimensional measurement, limits, fits and tolerances, limit gauging, linear and angular measurements and their applications, surface roughness-quantification and measurement, alignment testing of machine tools, feature inspection and online inspection. Introduction to quality assurance and quality control, Various elements in Quality Assurance program, On-line and Off-line quality control, Statistical concepts in quality, Central limit theorem, Quality Characteristics, QC Tools, 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, Remedial / Corrective actions, Special purpose control charts, Reject limits, Variables inspection and attributes Inspection, Control charts for attributes, Defects classification, Sensitivity of control charts. Sampling inspection for product acceptance.

MEL241 Energy Conversion
4 credits (3-0-2)
Pre-requisites: MEL140

MEL242 Heat and Mass Transfer
4 credits (3-1-0)
Pre-requisites: AML160

MED310 Mini Project (ME)
4 credits (0-0-8)
Pre-requisites: EC 80
Team formation. Formulating work plan, learning objectives and deliverables. Need identification, assessment of alternative approaches, defining design and performance specifications. Defining testing and/or validation procedure(s). Detailed work including preparation of engineering drawings, fabrication and procuring parts. Assembly and testing. Performing experiments. Model development, writing code, its validation, and user’s and programmers manuals. Display of outcome at an Open House. Documentation and coding of entire work and knowledge gained.

MEL310 Concurrent Engineering
4 credits (3-1-0)
Pre-requisites: EC 60

Integrating concurrent approaches with those of conventional. Implementation of concurrent engineering in industrial environment especially those of IT and high speed computation.

MEL311 Machine Element Design
5 credits (3-1-2)
Pre-requisites: MEL211 & AML140 & MEP201 & MEP202
Mechanical Engineering Design vis-à-vis Solid Mechanics, factor of safety, standards and design equations. Selection of materials and processes. Standard numbering system including BIS designations of materials. Application of theories of failure to design. Design procedure and its application to static strength. Design of elements subjected to simple loading: screws including power screws, bolted joints including eccentrically loaded joints, axles, and coupling, clutches and brakes. Introduction to design for fatigue strength. Endurance and modifying factors. Surface strength. Review of design procedure of fatigue failure with application to the design of bolts and springs subjected to fatigue loading. Design of shafts, spur, helical, bevel and worm gears, journal and rolling contact bearings, belts and chains. Introduction to CAD. Design exercises of systems like those of mechanical drives which may also involve the assistance of a computer.

MEP311 Mechanisms Laboratory
1 credit (0-0-2)
Pre-requisites: MEL211
A set of 10 experiments based on Reuleaux basic mechanical devices, Graashoff mechanisms, Linkages, gear and gear trains, gear tooth profile, cams, belts, brakes, clutches, bearings and lubrication, friction, Coriolis acceleration, gyroscopic couple, balancing of rotating and reciprocating masses, free and forced vibrations, transmission system of automobile vehicles, etc.

MEL312 Control Theory and Applications
5 credits (3-1-2)
Pre-requisites: MAL110 & AML110 & (EEL101 / EEL102) and EC 60
Overlaps with: EEL301/CHL261/MEL334

Practicals include studies on hydraulic, pneumatics, electronic controller. Control of various parameters such as speed, temperature, level, pressure, etc. Tutorials for control problems in these areas using MATLAB.

MEL314 Noise Engineering
4 credits (3-0-2)
Pre-requisites: MAL110 / MAL120 and EC 60
Overlaps with: ITL760


MEL316 Mechanical Vibrations
4 credits (3-0-2)
Pre-requisites: MEL211


MED320 Mini Project (PE)
4 credits (0-0-8)
Pre-requisites: EC 80

Team formation. Formulating and executing the work plan on a topic related to production engineering or industrial engineering. Nature of work could be either hardware based, theoretical or computer simulation type. Display of outcome at an Open House and making a presentation. Documentation and coding of entire work and knowledge gained.

MEL321 Ergonomics
4 credits (3-0-2)
Pre-requisites: MEL221

Introduction to Ergonomics: Definition and importance of ergonomics, History of Ergonomics; Introduction to Human-machine systems; Human-machine systems – Interfaces; Ergonomics at the Workplace: Anthropometrics principles; Work-related Musculoskeletal Disorders; Workplace Design; Environmental Factors at Work; visual environment; thermal environment; auditory environment; Vibration; Ergonomic Workplace Analysis: Introduction to workplace analysis; Ergonomics workplace analysis; Ergonomic awareness checklist; Legal and safety issues, Various case studies.

MEL322 Operations Planning and Control
4 credits (3-0-2)
Pre-requisites: MEL221


MEL323 Investment Planning
4 credits (3-0-2)
Pre-requisites: MEL221/MAL250


MEL324 Value Engineering
4 credits (3-0-2)
Pre-requisites: MEL221


Creative thinking and creative judgement, False material, labor and overhead saving, System Reliability, Reliability elements in series and parallel, Decision matrix, Estimation of weights and efficiencies, Sensitivity analysis, Utility functions, Fast diagramming, Critical path of functions, DARSIRI method of value analysis, Purchase price analysis.

MEL331 Machine Tools and CNC Manufacturing
4 credits (3-0-2)
Pre-requisites: MEL231

This course exposes the student to conventional machine tools and classification, machining operations, work and tool holding devices, drive systems, structures and guidelines, mechanisms, NC systems, controls, programming, industrial robots and applications, measurement techniques on machine tools.

Familiarization and identification of various machine tools, study of structural features of machine tools, study of various mechanisms and their assembly, study of machine tool to identify the existing limitations and to suggest changes.

MEP331 Process Engineering and Tool Design Project
3 credits (1-0-4)
Pre-requisites: MEP331 & MEP334 & MEP335

Introduction to process planning, part print analysis, make-or-buy decision, product drawing analysis, establishing the sequence of processes, economic processing considerations, machine selection, payback comparison, tooling costs, process documentation, routing, operation sheets, tolerance charting, computing dimensions and tolerances and computer aided process planning.

MEL332 Design and Manufacturing of Composites
4 credits (3-0-2)
Pre-requisites: MEL120 & AML140 and EC 60

FRP Composites, fiber types, fiber forms and properties, matrices type
Mechanical Engineering

and properties, lamina, laminate, orthotropy, anisotropy, composites - macro and micro-mechanical analysis and properties, Failure theories - Tsai-Hill, Tsai-Wu, Primary and Secondary Manufacturing - Lay-up, Autoclave Molding Filament Winding, Pultrusion, Compression Molding, RTM, RIM, SIRIM, Machining, drill-ing, routing etc., design, structural and testing, applications. Metal Matrix Composites and Ceramic Matrix composites - Manufacturing routes and applications.

**MEL333 Metrology**
4 credits (3-0-2)
Pre-requisites: MEL233
Introduction to Metrology and its relevance, standardization, dimensional measurement, limits, fits and tolerances, limit gauging, linear and angular measurements and their applications, surface roughness quantification and measurement, alignment testing of machine tools, feature inspection and Computer Aided inspection.

**MEL334 Low Cost Automation**
4 credits (3-0-2)
Pre-requisites: MEL233 / MEL234
Overlaps with: MEL312/EEL301/CHL261
Introduction, Types of systems - mechanical, electrical, electronics, fluidics; Hydraulics: Systems and components; Pneumatic Systems Control; Sequence operation of more than two cylinders and motors; Applications of relays/switches; Measuring systems, Transducers; Feed back control systems; Programmable controllers; Small components feeders; Automatic orientation and assembly; Design of components for assembly. Cost considerations and case studies. Laboratory work will be hands-on design and operation of automatic systems.

**MEL335 Advances in Metal Forming**
4 credits (3-1-0)
Pre-requisites: MEL234

**MEL336 Advances in Welding**
4 credits (3-0-2)
Pre-requisites: MEL231
This course introduces the concept of welding technology involving metallurgy, designing, automation, welding of high specialty alloys and materials and inspection procedures. Familiarization and identification of various processes, equipment, power sources, consumables, correlations between various responses and welding parameters and under water welding.

**MEL341 Gas Dynamics and Propulsion**
4 credits (3-0-2)
Pre-requisites: MEL241

**MEP341 Thermal Engineering Laboratory**
1.5 credits (0-0-3)
Pre-requisites: MEL242 & MEL241
Experiments related to courses MEL242 Energy Conversion and MEL243 Heat and Mass Transfer courses. Application of uncertainty analyses. Experiments will be conducted in a group of two students. A professional report is to be prepared for each experiment.

**MEL342 Power Plant Technologies**
4 credits (3-0-2)
Pre-requisites: MEL241 & AML160

**MEL343 Fuels, Combustion and Pollution**
4 credits (3-0-2)
Pre-requisites: MEL241

**MEL344 Refrigeration and Air-Conditioning**
4 credits (3-0-2)
Pre-requisites: MEL140 and EC 60

**MEL345 Internal Combustion Engines**
4 credits (3-0-2)
Pre-requisites: MEL140 and EC 60
Thermodynamics of fuel-air cycles, real cycles; Unburned and burned gas mixture charts; Ignition, normal and abnormal combustion in SI and CI engines; Conventional and alternative fuels for engines; Conventional and electronic fuel management systems for SI and CI engines; Design of combustion chamber for SI and CI engines; Engine emissions; Lubrication; Cooling; Supercharging and Turbocharging; Modern developments in IC engines.

**MEL346 Turbo-machinery**
4 credits (3-0-2)
Pre-requisites: MEL140 & AML160 and EC 60

MEC410 Colloquium (ME) 3 credits (0-3-0)
Pre-requisites: Registered for MET410
Introduction to planning, preparing and making presentations – preparation of slides, time management, communication aspects, etc. Making a presentation on practical training with response sheet for testing audience. Reading an assigned project report, making a presentation with audience response sheet and a critique on writing style, completeness and editorial get-up. Performing patent searches on an allotted product and making a presentation using diagrams/figures only. Preparing posters on practical training and presenting these at a poster session.

MEL410 Creativity in Engineering 4 credits (3-1-0)
Pre-requisites: EC 90

MET410 Practical Training (ME) Non credit
Pre-requisites: EC 90 at the end of 5th sem.
Prior to training, students and faculty identify industries where training that will meet the course objectives, in particular, linkages to the core mechanical engineering curriculum. An evaluation and monitoring plan is drawn up. Students spend at least 50 working days in the industry and submit regular progress reports to training coordinator. Training activities comprise study and participation in various aspects of a manufacturing enterprise and impacts on humans/society and environment. Before returning, each student submits a comprehensive training report, report(s) on projects, posters, presentation, response sheet and self-assessment. Training in academic institutions, software industry, laboratories, and organizations with narrow specialization is not permitted.

MED411 Major Project Part 1 (ME) 3 credits (0-0-6)
Pre-requisites: EC 120
Team formation for designing, manufacturing and operating a selected product, formulating project management procedures. Need identification, assessment of alternative designs, selection of design for development, defining design and performance specifications, and testing procedure. Detailed mechanical, thermal and manufacturing-related design of systems, assemblies, sub-assemblies and components culminating in engineering drawings and material specifications; preparing bill of materials and identification of standard components and bought-out parts.

MEL411 Mechatronics 4 credits (3-0-2)
Pre-requisites: MEL312 & (EEL101 / EEL102)
Overlaps with: MEL433/MEL749/EEL482
Introduction to mechatronic systems and components. Principle of basic electronics. Microprocessors and their applications, integrated circuits, sensors, actuators, and other electrical/electronic hardware in mechatronic systems. Principles of electronic/system communication. Interfacing, DA and AD converters, software and hardware principles and tools to build mechatronic systems. Selection of mechatronic systems, namely, sensors like encoders and resolvers. Stepper and servomotors; Solenoid like actuators; Transmission elements like Ball screw; and Controllers. Analysis and synthesis of mechatronic systems with applications to robotics, CNC systems, and others.

MED412 Major Project Part 2 (ME) 7 credits (0-0-14)
Pre-requisites: MEL411
The same student team continues working as per work plan of Part-1. MED411, and facilitators. Using engineering drawings, the process sheets are developed based on available materials, machine tools and other fabrication facilities. Materials and standard components are procured and manufacturing is carried out. After inspection, parts are accepted. Assembly procedure is finalized and the machine is assembled. Acceptance tests are carried out vis-à-vis specifications from Part-1. Functioning product is displayed at an Open House. Professional quality documentation of all designs, data, drawings, and results, change history, overall assessment, etc. is mandatory, along with a final presentation.

MEL412 Advanced Mechanical Design 4 credits (3-0-2)
Pre-requisites: MEL311
Concepts of fatigue and creep design. Production considerations in design. Advanced concepts for design of spur, bevel, worm and other types of gear drives, bearings, rotating discs, pressure vessels, etc. Optimization in design and computer aided design methods.

MEL413 Design of Mechanisms 4 credits (3-1-0)
Pre-requisites: MEL211 and EC 90

MEL414 Computer Aided Mechanical Design 4 credits (3-0-2)
Overlaps with: AML710

MEL415 Vibrations Engineering Design 4 credits (3-0-2)
Pre-requisites: MEL312
Overview. Need of vibration engineering design for mechanical equipment. Theoretical and Experimental routes to dynamic design., Modelling and simulation to predict vibration behavior of mechanical
systems and products. Techniques for vibration control including designing for reduced vibration, choice of materials and configurations, isolation, passive and active techniques etc. Finite Element model updating. Vibration engineering design

Using techniques of modal testing, Finite element model updating, system identification and structural dynamic modification. Integration of dynamic design in mechanical engineering design. Some case studies of actual systems like machine tools, pumps, compressors, turbines, transportation systems, etc.

MEL416 Robotics Engineering
4 credits (3-1-0)
Pre-requisites: MEL311 & (EEL101 / EEL102) and EC 90

MEL417 Lubrication
4 credits (3-0-2)
Pre-requisites: MEL311

MEL420 Total Quality Management
4 credits (3-0-2)
Pre-requisites: Completion of Practical Training in any program (xxt4y0)
Evolution of quality paradigms, Customer-orientation, Quality philosophies, TQM in manufacturing and services. Tools and improvement cycle (PDCA). Life cycle approach to quality costs; Prevention; Appraisal and Failure costs.


MEC420 Colloquium (PE)
3 credits (0-3-0)
Pre-requisites: Registered for MET420
Introduction to planning, preparing and making presentations – preparation of slides, time management, communication aspects, etc.

Making a presentation on practical training with response sheet for testing audience. Reading an assigned project report, making a presentation with audience response sheet and a critique on writing style, completeness and editorial get-up. Performing patent searches on a production or industrial engineering process/product and making a presentation. Preparing posters on practical training and presenting these at a poster session.

MET420 Practical Training (PE)
Non credit
Pre-requisites: EC 90 at the end of 5th sem.
In the year prior to training, students and faculty identify industries where training will meet the course objectives, in particular, linkages to the core production and industrial engineering curriculum. An evaluation and monitoring plan is drawn up. Student spends at least 50 working days in the industry and submits regular progress reports to program's training coordinator. Before returning, each student submits a comprehensive training report, report(s) on projects executed, posters, presentation, an audience response sheet and self-assessment of training. The work will focus on production and/or industrial engineering.

MED421 Major Project Part 1 (PE)
3 credits (0-0-6)
Pre-requisites: EC 120
Team formation and problem identification. Preparing work plan for Parts 1 and 2, and project management procedure. Identification of milestones, deliverables and final outcome. Literature review, revision of basic courses. Formulating a detailed problem statement, knowledge base and completing about 30% of the total work.

MED421 Production Management
4 credits (3-0-2)
Pre-requisites: MET410

MED422 Major Project Part 2 (PE)
7 credits (0-0-14)
Pre-requisites: MED421
The same student team continues working as per the work plan developed in Part-1, MED421, with same guide. Work is continued until all stated objectives and deliverables are met. The project outcome is displayed at an Open House. Professional quality documentation of the entire project is mandatory single, double, multiple and 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; Problems and illustrations in quality assurance.

MED422 Project Management
4 credits (3-0-2)
Pre-requisites: MET410 / MET420
The nature of projects, the project as a non-repetitive unit production system, the project as an agent of change. Project Identification considering objectives and SWOT analysis, Screening of Project Ideas, Technical, Market, Financial, Socio-economic and Ecological Appraisal of a project. Work break down structure and network development. Basic Scheduling, Critical Path and four kinds of floats. Scheduling under probabilistic durations, Time Cost tradeoffs, Project Monitoring with PERT/Cost, Organizational aspects, Computer packages and Project Completion.

MED423 Computers in Manufacturing Enterprises
4 credits (3-0-2)
Pre-requisites: MET420

MED424 Knowledge Management for Competitiveness
4 credits (3-0-2)
Pre-requisites: MET420 & MET421
Knowledge Management (KM) Introduction, Definitions, Industrial
MEL425 Flexible Manufacturing Systems
4 credits (3-0-2)
Flexible Manufacturing Systems: Introduction, Definitions, Industrial Relevance, Need for FMS, Problems of conventional batch manufacturing systems, Role of Information Technology, Overview of Multi model and mixed model flexible lines, Understanding Flexibility, Types of Flexibility in FMS, Flexible and Dynamic Manufacturing Systems, IT facilitated flexibility, integration and automation, Role of Integrated and automated material handling systems, Typical FMS operation, IT based Tools: Computer simulation and AI for FMS, Group technology, Decision Support Systems, Design, Planning, Scheduling and Control Issues in FMS, Real time control strategies, Various FMS configurations, Computer configurations, FMS as mini-CIM, Benefits and Justification for FMS, Future challenges and research issues etc.

MEL426 Materials Management
4 credits (3-0-2)
Pre-requisites: MET420 & MEL221
Introduction, Relevance of Materials Management, Need for Integrated approach, Deterministic models: EOQ, EPQ, Discount, backlogging, multi-item models etc., sensitivity analysis, basic systems of inventory management, inventory costing. Aggregate inventory models, Stochastic inventory models, service level, single period model, etc., Role of uncertainty, Selective Inventory control. Material planning, forecasting, Warehousing, Storage etc., documentation for purchasing etc. MRP- concepts, logic, computerized models, implementation issues, case studies. JIT-Philosophy, logic, applications, implementation, Vendor selection, and evaluation, Vendor relations, consolidation of vendor base, single sourcing. Information systems for Materials, Documentation, e-procurement and internet based purchasing, e-commerce and materials management. Organizational issues, and evaluation of materials function.

MEL427 Manufacturing Economics and Analysis
4 credits (3-0-2)
Pre-requisites: MET420 & MEL221
Basics of Engineering economic analysis, concepts of various types of costs, Decision making: Investment in a new machine, Replacement of the existing machine, Make-or-buy, break-even point, Decision about the product mix, Justifying the investment in advanced manufacturing technology, Various economic measure: NPW, IRR, Pay-back period etc.
Concept and various methods of depreciation, tax considerations, Stochasticity analysis.
Multi-attribute decision-making framework, concept of utility. The traditional accounting system (standard costing) and contemporary costing systems such as Activity Based Costing (ABC), Target Costing, and Information system required for analysis.

MEL431 CNC Machines and Programming
4 credits (3-0-2)
Pre-requisites: MEL331 / MEL233
An overview of CNC machines - need, benefits and limitations, classification of CNC machines, Constructural features of CNC machines, CNC part programming - Preparatory and Miscellaneous codes, transformations, subroutines, canned cycles for CNC lathe and milling, CNC program verification tools, CNC program generation from CAD, CNC controller and motion control in CNC system, Applications of CNC and recent advances in CNC machines.

MEL432 Microprocessor Applications in Manufacturing
4 credits (3-0-2)
Pre-requisites: (MET410 / MET420) & (EEL101 / EEL102)
Overlaps with: MEL411/EEL375/CSP413
Review of manufacturing and need and integration of microprocessor applications. Digital electronics review: number system, gates, flip-flops, counters, registers, tri-state concept, TTL and CMOS circuits, memories, op-amps, comparators, etc.
Microprocessors: Microprocessor architecture and computer systems, timing diagrams and machine cycles, interrupts, instruction set, memory and I/O interfacing, programming techniques, PPI, Timer/Counters, Serial Interfacing and communications, Interfacing to keyboards and displays, Standard busses. Microcontrollers and their applications. 8051 architecture and instruction set.
Microprocessor based measurement and control: D/A and A/D conversion, data acquisition systems, optical interrupters and couplers, incremental encoders, interfacing of motors and transducers, open loop and closed loop systems, PID control, motion control and robotics.
Case studies of applications in process and discrete manufacturing.

MEL433 Micro- and Nano-Manufacturing
4 credits (3-0-2)
Pre-requisites: MEL120 and EC 90
An overview of micro and nano mechanical systems and their applications in Mechanical Engineering, MEMS Microfabrication methods, Silicon Micromachining methods, Laser Micromachining methods, Mechanical Micromachining techniques, Nanomanufacturing methods, CAD/CAM Tools for Micro- and Nanomanufacturing processes.

MEL434 Design for Manufacturing and Assembly
4 credits (3-0-2)
Pre-requisites: MEL331 / MEL233 and EC 90
An overview of three stages of product design, generating and evaluating conceptual alternatives from manufacturability point of view, selection of materials and processes, Evaluating part configurations for manufacturability, Evaluating parametric designs for manufacturability, DFM analysis for various manufacturing processes, Product design for manual assembly, product design for high-speed automatic assembly and product design for robot assembly.

MEL435 Geometric Modelling for Manufacturing
4 credits (3-0-2)
Pre-requisites: MEP201 and EC 90
Geometric representation of curves, surfaces and solids, Machining of free-form surfaces from geometric models, geometric modeling for die/mold design, geometric model driven process simulation and process planning, use of geometric models in inspection of curved geometries and reverse engineering, realization of free-form solids by layered manufacturing, computational geometry for manufacturing and inspection.

MEL436 Injection Molding and Mould Design
4 credits (2-0-4)
Pre-requisites: MEL311
Nature of engineering plastics, visco-elasticiy, design methods and grade selection
Principles of Injection Molding, Injection molding machine and types, capacity and clamping tonnage, mold size, plasticating extruder concepts, molding properties and control parameters, molding cycle.
Injection Molds for thermoplastics, cavity and core- integer and 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 thermosets molding.

Exercises on CAD/CAM of molds, mold flow analysis, molding of articles, process control and defect identification.

**MEL441 Modeling and Experiments in Heat Transfer**
4 credits (2-0-4)
Pre-requisites: MEP241 & MEL242

**MEL442 Thermal Analysis of Bio-systems**
4 credits (3-0-2)
Pre-requisites: MEL242 and EC 90

**MEC601 Mechanical Engineering Seminars**
(Non-credit Audit) 1 credit (0-1-0)
The seminar series will be a mix of talks by faculty, students (Ph.D. and M.Tech.) and guest speakers from industry and academia on contemporary topics broadly related to thermal engineering. In their 4th semester every second year M.Tech. (Thermal Engg.) student will make a presentation. Each session will comprise about 40-45 minutes of presentation followed by an interactive session. There will be one seminar per week throughout the semester. A faculty member will coordinate the series. Each student will register for this course every semester. Pass/Fail will be on the basis of attendance.

**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)


**MEP667 Long Range Planning**
3 credits (3-0-0)

**MEP671 Value Engineering**
3 credits (2-0-2)

Elements of product cost and cost classification. Investment criteria in value analysis. Case studies in value engineering.

**MEP674 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.


Signal 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 Advanced 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 mid-term 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)
Review of various ideal cycles—Rankine and Brayton—and fuel-air cycles. Thermodynamics optimization of design parameters. Real cycle effects—internal and external irreversibilities, pressure drops, heat loss, condenser air leakage, fouling of heat transfer surfaces, combustion losses—and their impact on the thermodynamic cycle. Optimization of

**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)

**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.

**MEL717 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.

**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 heat 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)

**MEL730 Hydroelectric Power Plants**
3 credits (3-0-0)

**MEL731 Design of Mechanisms and Manipulators**
4 credits (3-0-2)
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; Structural analysis and synthesis of mechanisms; Forward kinematics of robot manipulators with examples; Inverse kinematics; Jacobian and singularity; Alternative design solutions of mechanisms and manipulators; Evaluation and selection of optimum mechanism; Type and number synthesis, Design of mechanisms; Indexes of merit; Graphical, Algebraic and Optimization techniques; Design of function, path, and motion generators; Dynamic considerations, Rigid body dynamics, Newton-Euler formulation, Equations of motion; Methodologies for inverse and forward dynamics. Practical will include numerical problem solutions; Basic practices in MATLAB, ADAMS and ULTRAGRIP software; Analysis and Synthesis using software.
MEL733 Vibration Engineering
4 credits (3-0-2)


MEL734 Noise Engineering
4 credits (3-0-2)


MEL735 Computer Methods in Mechanical Design
4 credits (3-0-2)
Introduction and overview. Need and Scope of Computer Aided Machine Design. Role of Geometric Modelling, FE and Optimization; Principles of interactive computer graphics, and overview of hardware available for use in CAD; Geometric transformations and 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 modeling; Introduction to the Finite Element Method, principle of potential energy; 1D elements, Derivation of Stiffness and Mass matrices for a bar, a beam and a shaft, Comparison with Analytical results; Solution of static problems and case studies in stress analysis of mechanical components; FEA using 2D and 3D elements; Plain strain and plain stress problems, FE using plates / shell elements; Importance of Finite element mesh, Automatic meshing techniques; Interfacing with CAD software, Case studies using FEM for Design of simple element geometries such as a tapered bar, a plate with a hole and a sparner;

Introduction to Dynamic analysis; Limitations of FEM, Introduction to Non-linear problems and FEA for plastic materials.

Practicals: Practice of transformation. Use of CAD Package for developing typical objects using Boolean, and sweep operations on primitives, use of CAD models for other applications. Development of FEM models for Static / Dynamic analysis of a bar, beam and a shaft. Practice in using an FEM Software on other real life problems like spanners, connecting rods etc.

MEL736 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.

MEL737 Advanced Mechanical Engineering Design
4 credits (3-0-2)

MEL738 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.

MEL739 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.

MEL740 Instrumentation and Automatic Control Systems
4 credits (3-0-2)

Mechanical Engineering

Practicals: Static and dynamic Behaviour of some important transducers, calibration procedure, Development of Computer aided experimentation systems. Experimental studies on Hydraulic, Pneumatic, Electrical controller, Electromechanical actuators.

MEL741 Blade and Disc Dynamics
4 credits (3-0-2)

MEL742 Optimum Design of Mechanical Systems
4 credits (3-0-2)
Introduction to Optimum design of Mechanical Systems. Need of optimization of preliminary design by identification of design requirements and by use of appropriate design strategy. Introduction to detail design optimization by simulation, prototyping and optimum selection of configuration, materials and processes.
Mechanical System Design problem-economic political environment, issues of human safety & welfare, and professional ethics.
Optimum mechanical design concepts. Overview and application of optimisation methods to machine elements and mechanical system design. Prototyping, simulation, and use of standards for detail design optimization. Optimum selection of material & processes in mechanical design using material selection 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.

MEL743 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.

MEL744 Design for Manufacture and Assembly
4 credits (3-0-2)

MEL746 Design for 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 - Rubber, Fluid Film Journal and Thrust, Dynamically Loaded, Rolling Element; Lube 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)
Introduction to mechatronic systems and components. Principles of basic electronics. Microprocessors and their applications, integrated circuits, sensors, actuators, and other electrical/electronic hardware in mechatronic systems. Principles of electronic/system communication. 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)

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 scheduling 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.

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.

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 Q-ting, 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.

MEL766 Quality Management: A Systems Perspective 3 credits (2-0-2)
Mechanical Engineering

Improvement, QFD, Taguchi Methods, 7 QC tools, Statistical Process Control, Acceptance Sampling, Service Quality, Tools and Techniques of Service Quality Improvement, Quality Costs,


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 passes 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 and analysis, Properties for selection of materials. Characteristic properties and behaviour of commonly used materials, Effect of alloying materials, Heat flow in welds, 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, Joining metallurgy and microstructures, Joint preparation weld symbols, Weld joint designs for strength and quality, Automation in welding, Cost analysis.
measurements, automatic gauging, automatic measuring machines for inspecting multiple workpiece dimensions, measurement with coordinate measuring machines.

**MEL787 Welding and Allied Processes**
4 credits (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, Thermit welding, Electro-slag and electro-gas welding, Solid-state and radiant energy welding processes such as EBW; LBW; USW, Explosive Thermit welding, Electro-slag and electro-gas welding, Solid-state and radiant energy welding processes such as EBW; LBW; USW, Explosive Thermit welding; Friction welding etc, Welding of plastics, Advances, challenges and bottlenecks in welding.

**MEP790 Process Engineering**
4 credits (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 3js and fixture design and manufacture, Group technology & CAPP.

**MEL791 Composite Materials and Processing**
4 credits (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–days, whiskers, fibers, mixing, mass processing techniques, applications.

**MEL792 Injection Molding and Mold Design**
3 credits (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 thermosets molding.

**MEL794 CAD/CAM**
4 credits (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.

**MEL796 Rapid Prototyping and Tooling**
4 credits (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 a midterm and an end-semester presentations (to all faculty and students) vis-a-vis the approved work plan. 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.

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 knowledge of program core courses. During the summer after 2nd semester, the student should work full-time on literature review, detailing of the work plan and deliverables at the end of Parts I and II. In the 1st week of the 3rd semester, the student should present these to the evaluation committee for review, approval and assessment. During the semester the progress will be assessed by the supervisor(s) at weekly coordination meetings. At the end of the semester, the committee will evaluate the work where the student will make a presentation. Grade will be decided on the basis of the two assessments.

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, meriodional 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 Turboexpanders
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)
MED831 Major Project Part –1 (Design of Mechanical Equipment)
6 credits (0-0-12)

MEL831 Advanced Theory of Vibration
4 credits (3-0-2)


MED832 Major Project Part-2 (Design of Mechanical Equipment)
12 credits (0-0-24)

MEL832 Multibody System Vibration Design
4 credits (3-0-2)
Definition of multibody systems, Introduction to rigid, multibody dynamics, Virtual work, Euler-Lagrange and Orthogonal complement approaches to derive the dynamic equations of multibody systems; Dynamics of flexible-body system, Modeling with flexible bodies; Mode shapes, modal analyses; Discrete and finite element modeling; Introduction to modal updating, Technique of correlation of analytical and experimental models.

MEL833 Impact Dynamics
4 credits (3-0-2)

MEL835 Special Topics
4 credits (3-0-2)
Contents of this course may vary from time-to-time.

MEL836 Advanced Lubrication Theory
4 credits (3-0-2)

MEL837 Advanced Mechanisms
4 credits (3-0-2)
Introduction to mechanism synthesis, Analytical and numerical methods in kinematics; Dynamics of mechanisms; Matrix methods in kinematic; Envelope theory; Optimal synthesis and analysis of mechanisms; Kinematic and dynamic analyses of spatial mechanisms; Synthesis of spatial mechanisms for path and function generations.

MEL838 Rotor Dynamics
4 credits (3-0-2)


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)

Mechanical Engineering

to Statistical Energy Analysis. Introduction to wave propagation. Group velocity, phase velocity, dispersion. Examples and applications to mechanical systems. Approximate methods, the finite element method.

**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)

**MED862 Major Project Part-2 (Industrial Engineering)** 12 credits (0-0-24)

**MEL866 Maintenance Management** 3 credits (3-0-0)
MEL868 Operations Research II
3 credits (3-0-0)

MEL870 Knowledge Management
3 credits (3-0-0)
Introduction, definitions, industrial motivation, Evolving Industrial Competition( multi attributed competition), flexibility, integration and automation in enterprises, growing Need for Knowledge and its effective Management (KM), role of IT, KM and challenges of CIMS, intelligent manufacturing, ERP, SCM and CRM, e-manufacturing etc. KM technical concepts: (data vs information vs knowledge), The Knowledge Edge, Knowledge Engineering, KM Framework (process steps), Aligning KM with Manufacturing Strategy, Business Strategy etc., design and deployment of KM in industrial enterprises( KM team, KM system analysis, Developing Effective Systems, Knowledge Audit), IT based tools, role of performance measurement, KM and competitive link, intelligent manufacturing, agile enterprises, cases, presentations, group exercises. Role of Simulation and Intelligent Systems, KM Deployment, Managing Innovation, Performance Measurement, Applications.

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 flow, 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/ ITL711
Measurement of product/process performance, Variation reduction approaches, Online and Off-line application of Design of experiments, Multi criteria optimization for quality and reliability, Parameter design, Tolerance design, Process capability analysis, Optimal design of test plans, Life cycle cost considerations, Six Sigma approach to product and process improvement, Software quality and reliability.

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)
MED895 Major Project (M.S. Research)
40 credits (0-0-80)
EPP109 Physics Laboratory - I
3 credits (0-0-6)
The experiments planned will be such to (i) bring clarity of understanding of concepts and mechanisms, (ii) provide measuring capability and feel of the functional behavior, and (iii) expose to the practical aspects in the areas of Modern Physics, Optics, Electromagnetics and Lasers.

EPN110 Introduction to Engineering Physics
2 credits (0-0-4)
Demonstration and interactive sessions with faculty in the areas of optics, photonics and photonic information processing; materials design and nano-technology; computational physics and device simulation; lasers, fiber optics and communication technology; plasma processing and technology; microelectronics. Visit to major facilities like TEM, SEM, XRD, AFM and R&D institutions and/or industry.

EPP110 Physical System Design
2 credits (0-0-4)
Disassembling/reassembling of various physical systems and self-learning through this hands-on-experience; design of systems/set-ups for measurement of physical quantities; design of demonstration systems for some functions; etc will be included in this course.

PHL110 Fields and Waves
4 credits (3-1-0)
Gauss law and its applications in electrostatics in vector form, electric polarization, permittivity, energy density in an electric field, Ampere's law, charged particle motion in E and B fields, magnetization, Faraday's law of electromagnetic induction; Equation of continuity, generalized Ampere's law, Maxwell's equations, wave equation, plane wave solutions, electromagnetic wave propagation in dielectrics and conductors, reflection/refraction, polarization, interference, diffraction of EM waves Origin of quantum hypothesis, de Broglie's hypothesis of matter waves, Uncertainty principle, Wave function and wave mechanics, Schroedinger equation, QM operators, Expectation value, one-dimensional solutions: zero potential, step potential, potential barrier and potential well.

PHL120 Physics of Materials
4 credits (3-1-0)
Nature of waves and particles, Wave-packets and uncertainty, Wave particle duality, Wave mechanics and its mathematical tools, Classical and quantum statistics, Statistics of discrete energy levels, Black body spectral density, Bose condensation; Free electrons, density of states, Kronig-Penny model, Effective mass, Band structure, Electrons in various types of solids, Particle in quantum well, Harmonic oscillator and Hydrogen atom problems, Application to semiconductor doping, Non-periodic materials; Tunneling of particles and examples, Tunneling through multiple barriers and semiconductor junctions; Interaction among quantum wells: materials under electric and magnetic fields, magnetic resonance effects; Nanostructures – Concepts of electrons in low dimensional confinement, Quantum wells and Super-lattices leading to new device concepts; Lasers – Einstein coefficients, Population inversion, Light amplification, Optical resonators, Characteristics of lasers; Superconductors – Vortex, Flux quantization, SQUID, Levitation and its applications.

EPL202 Quantum Mechanics and its Applications
4 credits (3-1-0)
Pre-requisites: PHL110 / PHL120 / EPL101
Many particle wave functions. Identical Particles, Symmetric and antisymmetric wave functions, and the Pauli Principle

**EPL204 Thermal and Statistical Physics**
4 credits (3-1-0)
**Pre-requisites:** PHL110 / PHL120 / EPL103
First and second laws of thermodynamics, micro and macro-states, entropy and disorder; the Carnot cycle; Some practical cycles; Entropy in quantum theory: the density of states, general definition of temperature; The canonical probability distribution, spin paramagnetism, the partition function technique, photons and phonons, computation of the density of modes, radiation pressure, radiative flux, entropy and evolution. Sound waves and phonons; The chemical potential; adsorption; the quantum ideal gas, occupation numbers and their estimation; fermions and bosons at low temperatures, white dwarf stars, Bose-Einstein condensation and liquid He; The free energies: Helmholtz, Gibbs; chemical equilibrium, phase equilibrium, adiabatic cooling; superfluidity, Gibbs’ phase rules, van der Waals equation of state, The Maxwillian gas equipartition theorem; Third law of thermodynamics, negative absolute temperature.

**EPL206 Solid State Physics**
4 credits (3-1-0)
**Pre-requisites:** PHL110 / PHL120 / EPL101
Crystal structure, Quasi crystals, Diffraction by a discrete lattice; X-ray, electron and neutron diffraction; Defects; Lattice vibration: concept of Debye and Einstein temperatures; thermal conductivity.

Dielectric properties of insulators: Types of polarisations, local field and Clausius-Mossotti equation, dielectric constants and dielectric loss, dielectric strength and insulation breakdown, capacitor dielectric materials, piezo, ferro and pyro electricity. Quartz oscillators and filters, piezo-spark generators, uni- and multi-axial ferroelectronics, pyroelectric detectors and devices. Magnetic properties: Unpaired d electrons in solids, classification of magnetic materials: dia, para, ferro, antiferromagnetism; magnetic domains, soft and hard magnetic materials; ferrites Superconductors, Meissner effect, flux quantisation, field penetration and high frequency effects, coherence, energy gap, Josephson junctions, SQUID, soft and hard superconductors, superconducting magnets, HTSC.

**EPL208 Principles of Electrodynamics and Plasmas**
4 credits (3-1-0)
**Pre-requisites:** PHL110 / PHL120 / EPL107
Basic laws of electrodynamics; Wave propagation in dielectrics, semiconductors and conductors: attenuation, dispersion, phase and group velocity; Wave propagation in plasma:
- Basics of plasma, methods of plasma production, electron motion in E and B fields, plasma wave, ion acoustic wave, electromagnetic waves, ionospheric propagation;
- Surface wave propagation, medium frequency communication;
- Waveguides: rectangular and cylindrical, Resonators;
- Antenna: dipole antenna, antenna pattern, antenna array, radar;
- Instabilities: two stream instability Cerenkov free electron laser;
- Relativistic covariance of Maxwell’s equations, Lienhard-Wichart Potentials, radiation from accelerated charges.

**EPL211 Principles of Material Synthesis**
4 credits (3-1-0)
**Pre-requisites:** PHL110 / PHL120
Overlaps with: PHL702
Thin films in solid state devices; Vacuum evaporation-Hertz-Knudsen equation, film thickness uniformity; Glow discharge and plasmas, DC, RF and microwave excitation; Sputtering processes- Sputtering of alloys; Reactive sputtering, Plasma chemistry, plasma etching mechanisms; CVD Deposition-Thermodynamics of CVD, gas transport, growth kinetics; Nucleation and Growth: models for 3D and 2D nucleation, grain structure and microstructure and its dependence on deposition parameters; Epitaxy: latitude misfit and imperfections; epitaxy of compound semiconductor, theories of epitaxy, Role of interfacial layer, Artificial semiconductors, Band-gap engineering; Stresses in thin films-internal stresses, Adhesion; Diffusion, Interdiffusion and Reactions in Thin Films: Electro-migration, metal-semiconductor reactions, silicides, Diffusion barriers, Oxidation-basic models, impurity redistribution during epitaxial growth and oxidation; Ion implantation: profiles of implanted ions, Annealing mechanisms and their role in epitaxy and ion-implantation, Rapid thermal annealing; laser modification effects.

**EPL213 Fundamentals of Semiconductors**
4 credits (3-1-0)
**Pre-requisites:** PHL110 / PHL120
Overlaps with: EEL218
Motion of electron in periodic potential: Effective mass and Brillouin zone, Kronig Penney Model, Nearly free electron model, Energy band gap in semiconductors, Holes, Methods of calculating band structure; Density of States in intrinsic carrier concentration, Donors and acceptors, carrier-drift diffusion, band structure; Phonons and scattering mechanisms: Electron-Phonon, electron-electron interactions, Ionized Impurity scattering; Generation and Recombination Processes: Basic mechanisms- Thermal and Shockley-Read, Hall, Impact-ionization and its transition rate; Optical Absorption in Semiconductors: Optical constants, Kramer-Kronig relations, free carrier absorption, plasma and cyclotron resonance, fundamental absorption, direct and indirect transitions, exciton, impurity and lattice absorption; Photo-conductivity: traps, photoconductive gain, photovoltaic effect, photo magnetic effect, emission of radiation from semiconductors; Junctions: Homojunctions, heterojunctions, metal-semiconductor and MIS junctions in equilibrium; Junctions under non-equilibrium, current flow.

**EPP215 Physics Laboratory - II**
3 credits (0-0-6)
**Pre-requisites:** EPP109
The experiments provide (i) measuring capability and feel of the functional behavior, and (ii) exposure to the practical aspects in the areas of Thermal and Statistical Physics, Solid State Physics, Superconductors, Vacuum Technology and Materials Science.

**EPP216 Physics Laboratory - III**
3 credits (0-0-6)
**Pre-requisites:** EPP110
The experiments planned will be such to (i) bring clarity of understanding of the concepts and mechanisms, (ii) provide measuring capability and feel of the functional behavior, and (iii) expose to the practical aspects in the areas of Thin Films, Semiconductors, Solid State Electronics, Plasma, Optoelectronics and Fiber Optics.

**EPP301 Design Laboratory**
4 credits (0-0-8)
**Pre-requisites:** EPP110 and EC 60
The course intends to go beyond the experience of the previous course and includes design of integrated physical systems involving various components on the lines of a mini project. About four such objectives to be attempted from different major areas.

**EPR310 Professional Practices (PH)**
2 credits (0-1-2)
**Pre-requisites:** EC 60
Spread over 5th and 6th semesters organization of Industrial tours/visits with on site demonstrations cum lectures (long duration tours during winter break between the two semesters), Lectures and discussion sessions by eminent personalities from Industry and R&D organizations.

**EPS310 Independent Study (PH)**
3 credits (0-3-0)
**Pre-requisites:** EC 80
The course details to be worked out by the faculty giving the course keeping in view the learning needs of the student.

**EPD310 Mini Project (PH)**
3 credits (0-0-6)
**Pre-requisites:** EC 80
The project details to be worked out by the faculty giving the project keeping in view the learning needs of the student.
EPL331 Vacuum Technology and Surface Physics
3 credits (3-0-0)
Pre-requisites: EC 60
Vacuum: its need in research and industry. Principles of low, high and ultra-high vacuum: production and measurement. Design aspects of vacuum systems for different applications, materials for vacuum systems.

Surface Properties: Structural-surface structure and reconstruction, Electronic-contact potential and work function, surface states and band bending, plasma and surface optics; Atomic motion-surface diffusion, surface melting and chemisorption

Surface Analytical Techniques: Electron spectroscopic techniques (AES, XPS); Principles and applications in materials/devices; Imaging of atoms and nano-clusters using tunneling and ultra-low forces (STM and AFM); Surface structure by LEED.

EPL332 Nuclear Science and Engineering
3 credits (3-0-0)
Pre-requisites: EC 60
Basics of Nuclear Physics, Nuclear particle detectors, activation analysis, Carbon dating, fission and fusion, principle/design/types of nuclear reactors, effect of nuclear radiation on materials, radiation protection and environment, nuclear tracer techniques in industry, nuclear radiography; thickness, density and other gauges, applications of radioisotopes in agriculture and medical areas

Fusion Energy: Nuclear kinetics; reaction analysis, Coulomb scattering; field effect trajectories; magnetic field configurations; particle transport; energy viability; burn cycles.

EPL333 Computational Physics
4 credits (3-0-2)
Pre-requisites: EC 60
Overlaps with: MAL235

EPL334 Lasers
3 credits (3-0-0)
Pre-requisites: EC 60
Overlaps with: PHL795
The Einstein coefficients, Spontaneous and stimulated emission, Optical amplification and population inversion; Lineshape Functions: Homogeneous and inhomogeneous broadening, Natural, Doppler and Collision broadening; Laser Rate Equations: Two level, Three level and Four level laser systems, Gain saturation; Optical amplifiers: Rare earth doped fiber amplifiers; Optical Resonators: Fabry Perot cavity, Spherical mirror resonators, Stable and unstable resonators, Longitudinal and Transverse modes of the cavity, Threshold condition for laser oscillation, Optimum output coupling; Q-switching and mode locking in lasers, Single longitudinal and single transverse mode oscillation; Laser systems: Ruby, Nd:Yag, Nd: Glass lasers; Tunable lasers: Ti-Sapphire laser; He-Ne, Argon ion, Carbon dioxide and Excimer lasers; Fiber lasers; Semiconductor lasers: Fundamentals, Operation Characteristics. Quantum well lasers and quantum cascade lasers; External cavity lasers; Laser diode arrays; Semiconductor Photodetectors: Types of photodetectors: photoconductors and photodiodes, PIN diodes and APDs. Noise in photodetection. Detector characteristics and device performance, phototransistors, solar cells and CCDs; Photovoltaic Cells: Single junctions under illumination, photon and carrier loss mechanism, graded and tandem junction devices; Optoelectronic integrated circuits (OEICs).

EPL336 Semiconductor Optoelectronics
4 credits (3-1-0)
Pre-requisites: EC 60
Overlaps with: PHL793
Review of Semiconductor Device Physics: Fermi level and quasi Fermi levels. n-p junctions, Schottky junction and ohmic contact. Semiconductor optoelectronic materials, band gap modification, quantum well structures; Semiconductor Photon Sources: Interaction of photons with electrons and holes in a semiconductor, Rates of emission and absorption. Electroluminescence; the LED: materials, structure and device characteristics; Semiconductor Laser: basic structure, theory and device characteristics, DFB, DBR, Quantum well and VCSE Lasers, Laser diode arrays; Semiconductor Photodetectors: Types of photodetectors: photoconductors and photodiodes, PIN diodes and APDs. Noise in photodetection. Detector characteristics and device performance, phototransistors, solar cells and CCDs; Photovoltaic Cells: Single junctions under illumination, photon and carrier loss mechanism, graded and tandem junction devices; Optoelectronic integrated circuits (OEICs).

EPL337 Materials Science and Engineering
4 credits (3-1-0)
Pre-requisites: EC 60
Overlaps with: PHL703
Elementary materials science concepts; Diffusion processes and their industrial applications; Phase diagrams: Gibbs phase rule, zone refining and pure Si crystals, First and Second order phase transitions; martensitic transformation and spinodal decomposition; Electrical and thermal behaviour; solid solutions and Nordheim’s rule, Skin effect, thin metal films and integrated circuit inter-connections; thermoelectricity, seebeck, Thomson and Peltier effects, thermoelectric heating and refrigeration, thermoelectric generators, the figure of merit; Elastic behaviour of solids, Anelasticity, thermoelasticity, viscoelastic deformation, Corrosion and Degradation of Materials: Electrochemical considerations, corrosion environments, corrosion prevention, Materials Selection and Design Considerations; Economic, Environmental and Societal issues in Materials Science and Engineering.

EPL338 Non-linear Phenomena in Physics and Engineering
4 credits (3-1-0)
Pre-requisites: EC 60
The dynamical system and its mathematical model, classification of dynamical systems; Oscillatory system and its properties, illustrative examples; Linear Oscillators, damped and driven oscillators, phase portraits, examples of applications in physics and engineering; Nonlinear oscillators, fixed points, stability Bifurcation theory, applications to electrical circuits, chemical reaction dynamics, duffing oscillator, transmission lines; Period doubling bifurcations, strange attractor, chaos, applications to Lorentz model and Van der Pol oscillator; Linear waves, weakly nonlinear and dispersive waves, solitons, KdV, NLS, Sine-Gordon systems, examples of applications in physics and engineering; Nonlinear optical phenomena: second harmonic generation, parametric processes, optical solitons, soliton-based all-optical communication systems; Nonlinear phenomena in condensed matter physics: Phase transitions, quasi-crystals, symmetry-breaking.

EPC410 Colloquium (PH)
3 credits (0-3-0)
Pre-requisites: registered for EPT410
This course will cover the presentations of the work carried out by
students during the Practical Training and will be attended by all students.

EPT410 Practical Training (PH)  
Non credit  
Pre-requisites: EC 90 at the end of 5th sem.  
Practical Training of 50 working days in an Indian industry or R&D organization.

EPD411 Major Project Part 1 (PH)  
3 credits (0-0-6)  
Pre-requisites: EC 120  
To set the objectives, deliverables, work plan, logistics planning and milestones with discernible outputs and then to demonstrate the feasibility through some initial work.

EPD412 Major Project Part 2 (PH)  
7 credits (0-0-14)  
Pre-requisites: EPD411  
Working out the detailed work plan and implementation of the project.

EPV430 Special Topics in Nano-Technology  
1 credit (1-0-0)  
Pre-requisites: EC 90  
Topics from the emerging areas of nano technology development will form the basis and the specialized/visiting faculty offering the course will provide the detailed course contents.

EPV431 Special Topics in Photonics and Optoelectronics  
1 credit (1-0-0)  
Pre-requisites: EC 90  
Topics from the emerging area of photonics and opto-electronics development will form the basis and the specialized/visiting faculty offering the course will provide the detailed course contents.

EPV432 Special Topics in Emerging Processes  
1 credit (1-0-0)  
Pre-requisites: EC 90  
Topics from the emerging area of process and technique development will form the basis and the specialized/visiting faculty offering the course will provide the detailed course contents.

EPV433 Special Topics in Emerging Materials  
1 credit (1-0-0)  
Pre-requisites: EC 90  
Topics from the emerging area of materials development will form the basis and the specialized/visiting faculty offering the course will provide the detailed course contents.

EPV434 Special Topics in Emerging Devices  
1 credit (1-0-0)  
Pre-requisites: EC 90  
Topics from the emerging areas of device development will form the basis and the specialized/visiting faculty offering the course will provide the detailed course contents.

EPL439 Microelectronic Devices  
3 credits (3-0-0)  
Pre-requisites: EEL218  
Basic Semiconductor: energy bands, donors and acceptors, carrier concentration, carrier transport, generation-recombination, high field effects, basic equations for device operation; p-n junctions: electrostatics, space charge, abrupt and linearly graded, current-voltage and capacitance-voltage characteristics, junction breakdown, transient behaviour hetero-junctions; Bipolar Transistor: transistor action, current gain, static characteristics, frequency response, transient behaviour, junction breakdown, modelling-Ebers-Moll/Gummel-Poon, thyristor; Metal-Semiconductor contact: Schottky effect, metal-semiconductor contacts, current-voltage characteristics, ohmic contacts; Field Effect Transistor: Junction field effect, MESFET, metal-insulator-semiconductor (MIS), MOS diode, MOSFET, characteristics, threshold voltage, frequency response, device scaling, modelling, charge couple devices (CCD).

Integrated Circuits: standard-bipolar/MOS/CMSO technology, circuit realization, semiconductor memories, RAM, ROM and PROMs, static and dynamic memories, design aspects, VLSI and ULSI.

EPL440 Quantum Electronics  
3 credits (3-0-0)  
Pre-requisites: EC 90  
Overlaps with: PHL792  
Propagation of light waves through bulk media, Review of electromagnetic waves, plane waves, Poynting vector, polarization, diffraction; propagation through anisotropic media, Nonlinear optical effects, Nonlinear polarization; Second order effects: Second harmonic generation, Sum and difference frequency generation, Parametric amplification, parametric fluorescence and oscillation, Periodically poled materials and their applications in nonlinear devices; Third order effects: Self Phase modulation, Temporal and spatial solitons, Cross Phase modulation, Four wave mixing, Phase conjugation; Quantization of the electromagnetic field; Coherent states and their properties; Squeezed states of light and their properties; Application of optical parametric processes to generate squeezed states of light; Optical resonance and two-level atoms, atom cooling and trapping; Ultra-intense laser matter interactions.

EPL441 Applications of Lasers in Technology  
3 credits (3-0-0)  
Pre-requisites: EC 90  
Overlaps with: PHL792  
Brief review of laser principles and operative mechanisms. Laser systems in Industrial research and development: CO, YAG, Excimer and Ruby lasers in material processing, Laser beam hardening; Lasers in material processing, thermal and non-thermal laser induced processes, laser applications in metal welding, cutting, drilling and nano-particle generation; Laser ablation and thin film deposition; Laser processing of semiconductors; Rapid thermal annealing and alloying; Production of nano-structured Si and compound semiconductors and their characterisation by laser Raman and photoluminesence spectroscopy; recent development in laser source technology; use of lasers in data storage, communication, information technology and medical instrumentation.

EPL442 Fiber and Integrated Optics  
3 credits (3-0-0)  
Pre-requisites: EC 90  
Overlaps with: PHL790, PHL791  
Propagation in planar optical waveguides-concepts of modes, prism film coupling, Effective index theory for 2-D waveguides, Coupled mode theory for directional couplers and periodic waveguides, I.O. devices, propagation in step and graded index fibers, pulse dispersion, Single-mode fibers and characteristics, Fiber technology and fiber characterisation, Optical communication system designs and recent trends, Non-linear fiber optics, Solitons, optical fiber sensors.

EPL443 Holography and Optical Information Processing  
3 credits (3-0-0)  
Pre-requisites: EC 90  
Overlaps with: PHL756, PHL758, IDL734  
Signals and systems, Fourier transform (FT), sampling theorem; Review of diffusion theory; Fresnel-Kirchhoff formulation and angular spectrum method, FT properties of lenses and image formation by a lens; Frequency response of a diffraction-limited system under coherent and incoherent illumination. Basics of holography, in-line and off-axis holography, plane and volume holograms, diffraction efficiency; Recording medium for holograms; Applications of holography: display, microscopy; memories, interferometry, NDT of engineering objects, etc.; Holo-optical elements. Analog optical information processing: Abbe-Porter experiment, phase
Physics

contrast microscopy and other simple applications; Coherent image processing; van-der-Waals filter; joint-transform correlator; pattern recognition, image restoration; Data processing from synthetic aperture radar (SAR), acousto-optic signal processing, discrete analog processors.

**EPL444 Functional Nanostructures**
3 credits (3-0-0)
Pre-requisites: EC 90
Overlaps with: PHL726
Basics of low dimensional (0D, 1D, 2D) structures, Quantum dots wires and wells, Nanoparticles-free and dispersed, Nanocrystalline and nanostructured films, Self organized structures; Nanostructures for optical and electronic applications, Quantum dot diodes, lasers and detectors, Single electron devices and logic applications, Optical computing and Information processing; Carbon based nanostructures, Electrical, mechanical and chemical properties of carbon nanotubes, Sensors and drug delivery vehicles, Data processing; Bulk nanostructured material and Photonic crystals; Nanostructures for Magnetic applications, Giant and Colossal Magnetoresistance. Nanostructured ferromagnetism, Random Access Memories; Nanostructures for catalysis and hydrogen storage, Nanodays, colloids and hydrogen storage nano materials. Organic and Biological nanostructures. Nanomachines and supra molecular devices.

**EPL445 Engineering Optics**
3 credits (3-0-0)
Pre-requisites: EC 90
Overlaps with: PHL751, IDL731
Lens systems and basic concepts in their design; Optical components: Mirrors, prisms, gratings and filters; Sources, detectors and their characteristics; Optical systems:Telescopes, microscopes, projection systems, photographic systems, interferometers and spectrometers; Concepts in design of optical systems; Applications in industry, defense, space and medicine; LCD, CCD, compact disc, scanner, laser printer, photocopy, laser shows, satellite cameras, IR imagers.

**EPL446 Spintronics and Data Storage**
3 credits (3-0-0)
Pre-requisites: EC 90
Basic magnetism, Spin polarization, Magneto and magneto-optical transport, Magnetic storage devices and other means of data storage, Ferromagnetic semiconductors and their use in recording media, Basics of QMR in materials and its applications in read heads, Spin valve and spin-tunnel devices in data storage, Magnetic RAMs, Superparamagnetic limit, Magnetic nanostructures for very large density recording, Future directions in data storage.

**EPL450 Selected Topics in Nano-Technology**
2 credits (2-0-0)
Pre-requisites: EC 90
Topics from the emerging areas of nano technology development will form the basis and the specialized/visiting faculty offering the course will provide the detailed course contents.

**EPL451 Selected Topics in Photonics and Optoelectronics**
2 credits (2-0-0)
Pre-requisites: EC 90
Topics from the emerging areas of photonics and opto-electronics development will form the basis and the specialized/visiting faculty offering the course will provide the detailed course contents.

**EPL452 Selected Topics in Emerging Processes**
2 credits (2-0-0)
Pre-requisites: EC 90
Topics from the emerging areas of processes and techniques development will form the basis and the specialized/visiting faculty offering the course will provide the detailed course contents.

**EPL453 Selected Topics in Emerging Materials**
2 credits (2-0-0)
Pre-requisites: EC 90
Topics from the emerging areas of materials development will form the basis and the specialized/visiting faculty offering the course will provide the detailed course contents.

**EPV434 Selected Topics in Emerging Devices**
2 credits (2-0-0)
Pre-requisites: EC 90
Topics from the emerging areas of device development will form the basis and the specialized/visiting faculty offering the course will provide the detailed course contents.

**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, Liend-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, 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, microcanonical, 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 pathways, Differential amplifiers, its parameter basic applications, Sinusoidal oscillators, Multi vibrators, Schmidt 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.

**PHL565 Cooperative Phenomena in Solids** 4 credits (3-1-0)

**PHL567 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)
Semiconductor 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; Odemic 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; Neutron diffraction; Electron Spectroscopy for chemical analysis; Auger Electron Microscopy; Secondary ion mass spectrometry; Electron Energy Loss Spectroscopy; X-ray Fluorescence; Rutherford back scattering; UV-VIS-NIR spectrophotometer & Ellipsometry; Deep LevelTransient Spectroscopy; Thermally Simulated Current; C-V and Admittance Spectroscopy; Hall effect and Time of Flight methods for charge carriers, Differential scanning calorimeter; 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)

**PHD658 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.

**PHL661 Selected Topics**
3 credits (3-0-0)

**PHL662 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, Raoult’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 thermodynamics 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 models 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)

**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, Si,N 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 bulks 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 SiO, 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, calcinations, 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: Metal, organic, inorganic; spectrosopies including Microwave, FTIR, Raman and surface enhanced Raman Spectro-scopy; Resonance Spectroscopies, Mossbauer Spectroscopy, Magnetic & Dielectric Analysis.

**PHL723 Vacuum Science and Cryogenics**
3 credits (3-0-0)

**PHL724 Magnetism and Super-conductivity**
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 cm structures, EAXS and Synchrotron radiation, Molecular solids and Network dimensionality, network solids, 8-N rule, topological defects and valence alternation, 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, Diff., 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 confinements 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-n photodetector, Charge coupled devices, Edge emitting, Surface emitting and Quantum wells, LED's and lasers. Hetro structure FET, Velocity modulation and quantum interference transistor, Hetrostructure bipolar transistor and Resonant tunneling devices.

**PHS731 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 nucleon, 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 symmetrisations of barions, 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 position 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)
Review of laser theory, properties of laser radiation, and laser safety; Common laser systems : Ruby-, Nd:YAG- and Nd:Glass lasers, diode-pumped solid state laser, Er-doped silica fiber laser, Ti:Sapphire laser, He-Ne, CO, and Ar-ion lasers, excimer-, dye-, X-ray- and free-electron lasers; Semiconductor lasers : Double heterostructure--and quantum-well lasers, VCSEL, DBR- and DFB lasers; Application of lasers in data storage, communication and information technology : CD players, DVDs, laser printers, bar-code scanners, and optical communication; Surface profile and dimensional measurements using diffraction and its variations; High-power laser applications: marking, drilling, cutting, welding, and hardening; laser fusion; Laser Doppler velocimetry, LIDAR, laser spectroscopy, medical applications of lasers.

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, orthormalization, and global search method; Tolerance analysis; Achromatic doublets, apochromats and applanats; 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 semiconducting 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 and 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, photoresist, photoconductor,
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 spheroscope, micro-optic autocollimator, knife edge and star test apparatus, Fizeau interferometer, Twyman Green interferometer, multiple beam inter-ferometer, 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 acoustooptic waveguide devices. Directional couplers, optical switch; phase and amplitude modulators; filters, etc. Y-junction, power splitters, Arrayed waveguide devices, fiber pigtailing, 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 characterization techniques including OTDR, Connectors, splices and fiber cable.

PHL792 Optical Electronics
3 credits (3-0-0)

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, VCELS & Laser diode arrays, Electroabsorption modulators and SEEDs, Semiconductor photodetectors; PINs and APDs, CCDs and OEICs.

PHL795 Optical 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 symmetric 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)
PHL810 Plasma Waves and Instabilities
3 credits (3-0-0)
Kinetic theory of plasma instabilities—unmagnetized plasma; magnetized plasma; Landau damping; cyclotron damping; bump- in-tail instability; beam driven instabilities; drift waves; temperature anisotropy driven modes; current drive instabilities; applications to RF heating in tokamaks and free electron laser.

PHD851 Major Project Part-I
6 credits (0-0-12)
PHD852 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.

**PH853 Advanced Optical Workshop II**  
3 credits (0-0-6)  
Fabrication of precision optical components/instruments.

**PH855 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 grating: 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.
TTN110 Introduction to Textile Technology
2 credits (0-0-4)
This course is an introduction to second year level courses in the department. The students are encouraged to self learn basic principles of relevant technology and its technical jargon by conducting simple experiments, making observations and reading brief handouts. This includes learning the importance of textile materials and structures in comparison to other known structural materials such as metals, ceramics, concrete, etc. Introduction to development of various structures of textile, such as fibres, yarn, fabric, and their conversion into everyday to technically critical applications. A trip to a textile industry and short seminar series by students will make an integral part of this course.

TTP200 Design of Textile Products and Processes
2 credits (0-0-4)
Pre-requisites: TTN110 / MEL110 / MEL120
Individual or group of students would be offered predefined product or process design project under the guidance of a faculty member. Emphasis of the projects set should be on achieving set objectives using known technological components, rather than new or fundamental research.

TTP211 Introduction to Fibres
2 credits (1-0-2)
Pre-requisites: PHL110 / MAL110 / CYL120
Classification of fibres-natural and manmade; Basic structure of a fibre; General properties of a fibre such as moisture absorption, tenacity, elongation, initial modulus, yield point, toughness, elastic recovery; Detailed chemical and physical structure of natural fibres-cotton, wool and silk, their basic properties; Introduction to important bast fibres. Laboratory exercises would include experiments on fibre identification through physical appearance, microscopic- optical, SEM and burning behaviour; Chemical identification through solvent treatment and FTIR; Identification using DSC (melting point and glass transition temperature), density measurement.

TTL211 Structure and Physical Properties of Fibres
3 credits (3-0-0)
Pre-requisites: PHL110 / MAL110 / CYL120
Molecular architecture, configuration, conformation, amorphous and crystalline phases, glass transition, plasticization, crystallization, melting, factors affecting Tg and Tm; Basic structure of a fibre-one dimensional oriented, semicrystalline, structure of fibrils; Role of molecular entanglement on fibre formation; Formation of structure in viscose and thermoplastic fibres i.e. PET, nylon, PP and acrylic; Methods of investigating physical structure of fibres such as WAXD, SAXD, DSC, DMA/TMA, FTIR, birefringence and sonic modulus; Moisture absorption properties, Rate of moisture absorption, Heat of sorption, water retention and swelling; Theories of moisture absorption-general view, absorption in crystalline and amorphous regions, quantitative theories; Theories of mechanical properties of natural and man-made fibres, viscoelastic behaviour, comparison of properties of various fibres; Fibre friction, Optical properties, Introduction to electrical properties such as dielectric properties and static charge generation; Thermal properties - heat-setting.

TTL212 Manufactured Fibre Technology
4 credits (3-1-0)
Pre-requisites: CYL120 / MAL110 / PHL110 / TTL212
Polymerization of nylon-6, nylon-66, poly(ethylene terephthalate) and polyacrylonitrile; Important reactions and their kinetic rate equations. Batch versus continuous reactors; Modification of PET and nylons; Introduction to polymer transport phenomena, Polymer rheology, Shear flow through a capillary, elongational flow in a spinning line; Melt instabilities; Melt spinning lines; stress induced crystallization in high speed melt spinning; Characteristic features of PET, polyamide and polypropylene spinning; Spin finish and its components; Wet and dry spinning processes; Effect of parameters on fibre breakage and fibre structure; Importance of dry jet wet spinning of PAN; Introduction to drawing and heatsetting in thermoplastic fibres.

TTP212 Manufactured Fibre Technology Laboratory
1 credit (0-0-2)
Pre-requisites: CYL120 / MAL110 / PHL110 / TTL212
(Concurrent registration with TTL212 permitted)
Experiments related to fibres production processes, for example, determination of moisture in chips. Effect of moisture and temperature on MFT of PET and PP, Melt spinning of PET, nylon-6 filament yarn on laboratory spinning machines, Single and two stage drawing of the as spun yarns and POY. Demonstration of high speed spinning machine; Heat setting of PET and nylon drawn yarns on heaters, in oil bath and steam. Effect of temperature, slack/taut condition on heatsetting; Determination of structure and mechanical properties of as spun, POY, drawn and heat set yarns using DSC, x-ray, FTIR, density, sonic modulus; Determination of polymer solution rheology using Brookfield rheometers and ball-fall method; Effect of shear rate, temperature on viscosity of solutions; Wet spinning or dry jet wet spinning of PAN copolymers; Demonstration of false twist and air jet texturing processes; Determination of structure of textured yarn under microscope.

TTL221 Yarn Manufacture - I
4 credits (3-1-0)
Pre-requisites: CYL120 / MAL110 / PHL110

TTP221 Yarn Manufacture Laboratory - I
1 credit (0-0-2)
Pre-requisites: CYL120 / MAL110 / PHL110
Practicals related to the theory course TTL221.

TTL222 Yarn Manufacture - II
4 credits (3-1-0)
Pre-requisites: TTN110

TTP222 Yarn Manufacture Laboratory - II
1 credit (0-0-2)
Pre-requisites: TTN110
Practicals related to the theory course TTL222.

TTL231 Fabric Manufacture - I
4 credits (3-1-0)
Pre-requisites: CYL120 / MAL110 / PHL110
Weaving: Loom elements, classification of looms, primary, secondary and auxiliary motions of loom, multiple boxes, over and under picking, beat-up, take up, let-off, weft stop and warp stop motion, weft feeder, warp protecting device and box motion. Cam design for shedding and picking. Dobbies and Jacquards: classification, mechanism and design developments. Automatic loom, basic features, pirm changing and shuttle changing mechanism. Loom winder and box loader.

Fabric structure: classification, notation of weave, draft and peg plan, plain weave with its derivatives and ornamentation, basic twill and satin weaves. Analysis of simple fabrics and calculations pertaining to yarn requirements. Calculation for production and efficiency related to winding, warping, sizing and weaving.

TTP231 Fabric Manufacture Laboratory - I
1 credit (0-0-2)
Pre-requisites: CYL120 / MAL110 / PHL110
Experiments related to TTL231.

TTL232 Fabric Manufacture - II
4 credits (3-1-0)
Pre-requisites: TTN110

Basic weft and warp knitted constructions; primary and secondary knitting elements; sequence of loop formation on warp and weft knitting machines; relation between machine gauge and yarn count; productivity of knitting machines; geometry of a loop in plain knitted fabric; control of loop length, fabric weight and dimensions. Properties of knitted fabric. Nonwoven fabrics: Definitions and classifications; production technology, selection criteria and important properties of fibres used. Different types of webs and bonding techniques. Production and properties of needle punched, stitch bonded, adhesive bonded, spunlaced, spun bonded and meltblown fabrics.

TTP232 Fabric Manufacture Laboratory - II
2 credits (0-0-4)
Pre-requisites: TTN110
Experiments related to TTL232.

TTL241 Technology of Textile Preparation and Finishing
3 credits (3-0-0)
Pre-requisites: CYL120 / MAL110 / PHL110
Natural and added impurities in textiles; Singeing, desizing, scouring, bleaching, mercerisation and optical whitening of cotton; Combined preparatory processes Carbonisation, scouring and bleaching of wool, degumming of silk; Preparation of synthetic fibres and blends; heat setting; Machinery for preparation of textiles; Surfactants and their application; Introduction to chemical and mechanical finishes; Chemical finishes for hand modification; Biopolishing; easy care; oil, water and soil repellent finishes; Fire retardancy; antimicrobial finishes; Finishes for wool; Mechanical finishes like shrinkproofing and calendering; Raising, sueding and emerising; Low liquor application techniques and machinery; Stenters and dryers.

TTP241 Technology of Textile Preparation and Finishing Laboratory
1.5 credits (0-0-3)
Pre-requisites: CYL120 / MAL110 / PHL110
Practicals dealing with desizing, scouring and whitening of cotton textiles; Combined preparatory processes; Carbonising, scouring and bleaching of wool and desizing of silk; Finishes for handle modification; functional finishes such as crease recovery, flame retardant, rot proofing of cotton and milling of wool.

TTL242 Technology of Textile Coloration
4 credits (3-1-0)
Pre-requisites: TTN110
The principles of dyeing and printing of textile; Basic characteristics of dyes, chemical structure of dyes and classification of dyes; Dyeing equipment and the specific dyes and procedures used to dye textiles; Evaluation of Fastness; Methods of printing namely, roller, screen, transfer, ink jet and the preparation of printing paste; Direct, discharge and resist printing styles; Physical chemistry of fibre/fabric dyeing; Physicochemical theories of the application of dyestuffs to textile and related materials, including the thermodynamics and kinetic principles involved; Discussion of colour science and computer match prediction in dyeing fibres, yarns and fabrics; Objective specification of colour, colour difference measurements and various colour spaces; Based on colour theory and numerical analysis, computer match prediction algorithms; Setting of Pass/Fail criterion and shade sorting; Colour communication; Using computer colour matching software.

TTP242 Technology of Textile Coloration Laboratory
1.5 credits (0-0-3)
Pre-requisites: TTN110
The principles of dyeing and printing of textile material; Dyeing equipment and the specific dyes and procedures used to dye textiles; Evaluation of Fastness; Methods of printing namely, roller, screen, transfer, ink jet and the preparation of printing paste; Direct, discharge and resist printing styles.

TTT301 Special Module in Yarn Manufacture
1 credit (1-0-0)
Pre-requisites: TTN110 and EC 60
The course aims at introducing new or highly specialized technological aspects in yarn manufacture. The course topic and content is likely to change with each offering depending upon the current requirement and expertise available with the department including that of the visiting professionals.

TTT302 Special Module in Fabric Manufacture
1 credit (1-0-0)
Pre-requisites: TTN110 and EC 60
The course aims at introducing new or highly specialized technological aspects in fabric manufacture. The course topic and content is likely to change with each offering depending upon the current requirement and expertise available with the department including that of the visiting professionals.

TTT303 Special Module in Textile Chemical Processing
1 credit (1-0-0)
Pre-requisites: TTN110 and EC 60
The course aims at introducing new or highly specialized technological aspects in textile chemical processing. The course topic and content is likely to change with each offering depending upon the current requirement and expertise available with the department including that of the visiting professionals.

TTT304 Special Module in Fibre Science
1 credit (1-0-0)
Pre-requisites: TTN110 and EC 60
The course aims at introducing new or highly specialized technological aspects in fiber science. The course topic and content is likely to change with each offering depending upon the current requirement and expertise available with the department including that of the visiting professionals.

TTT305 Special Module in Textile Technology
1 credit (1-0-0)
Pre-requisites: TTN110 and EC 60
The course aims at introducing new or highly specialized technological aspects in textile technology. The course topic and content is likely to change with each offering depending upon the current requirement and expertise available with the department including that of the visiting professionals.
change with each offering depending upon the current requirement and expertise available with the department including that of the visiting professionals.

TTD310 Mini Project (TT)  
3 credits (0-0-6)  
Pre-requisites: EC 80  
Project type design fabrication work under the guidance of a faculty member. Prior to registration, a detailed plan of work should be submitted by the student(s) to the head of the department.

TTL310 High Performance Fibrous Structures and Composites  
3 credits (3-0-0)  
Pre-requisites: EC 60  
Introduction to fibres for high performance composites; Different fibre architectures used for composites and their characteristics and properties; Influence of fibre architectures on the properties of composites; Unidirectional, planar, 3D and net-shaped processing; Introduction to matrix types and their properties, Polymeric matrices for rigid and flexible composites; Reinforcing materials and the effect of their geometry on the properties of composites; The fibre-matrix interface; role of coupling agents; Mechanism of stress transfer; Toughness and thermal behaviour of composites; Various techniques of composites design and fabrication; Composites for structural engineering, electrical, civil, aerospace, defense, automobile, sporting goods and other applications; Design and analysis of textile structural composites.

TTR310 Professional Practices (TT)  
2 credits (0-1-2)  
Pre-requisites: EC 60  
Overview of the state of art technology and practices in the industry presented by senior professionals from the industry.

TTS310 Independent Study (TT)  
3 credits (0-3-0)  
Pre-requisites: EC 80  
Research oriented activities or study of subjects outside regular course offerings under the guidance of a faculty member. Prior to registration, a detailed plan of work should be submitted to the head of the department for approval.

TTL311 High Performance and Specialty Fibres  
3 credits (3-0-0)  
Pre-requisites: TTL211 / TTL212 / TTP211  
Polymerization, spinning and properties of aromatic polyamides, high molecular weight polyester, rigid rod and ladder polymers such as BBL, PBO, PBT; Manufacturing of carbon fibres from PAN precursors, viscose and pitch fibres; Glass fibres; Liquid crystal fibres; Gel spinning of polyethylene; Hollow and profile fibres, design of spinnerette for such fibres; Membrane technology; Blended and bicomponent fibres; Medical textiles; Superabsorbent fibres; Plasma modification; Radiation processing; Industrial tapes; Biaxially oriented films and fibres therefrom; Barrier films and coatings.

TTP311 Simulation of Fibre Production Processes  
3 credits (1-0-4)  
Pre-requisites: TTL212  
Reaction rate equations for condensation polymerization, radical polymerization for batch and continuous stirred tank reactors; application of generating functions for formation of differential equations for infinite number of chains, analytical and numerical solutions of equations; force balance in melt spinning line; formation of differential equations on force dynamics; solutions using computational methods; modeling of coagulation process in wet spinning and other fibre forming processes.

TTL321 Mechanics of Spinning Machinery  
3 credits (2-1-0)  
Pre-requisites: TTL211 & TTL222  

TTL322 Mechanics of Spinning Processes  
3 credits (3-0-0)  
Pre-requisites: TTL221 & TTL 222  

TTL323 Process Control in Spinning  
3 credits (3-0-0)  
Pre-requisites: TTL221 & TTL222  

TTL324 Spinning of Man-made Fibres and Blends  
3 credits (3-0-0)  
Pre-requisites: TTL221 & TTL222  

TTL331 Fabric Structure and Analysis  
3 credits (2-0-2)  
Pre-requisites: TTL231 / TTL232 / TTL211 / TTL222  
structure. Extra warp and extra weft figuring. Detailed treatment of backed and double cloths. Interchanging warp and weft structure with figure effects. Center stitched double fabrics. Warp and weft pile fabrics. Velvet and velveteen. Analysis of fabrics referred to above for constructing weave (with draft and peg plan), constructional details and loom particulars etc. Computerized designing. Overview of Indian traditional woven textile designs.

**TTL332 Computer Aided Fabric Manufacturing**
3 credits (2-0-2)

Pre-requisites: TTL231 & TTL232

Electronic Dobby: Working principle, machine parameters, microelectronics electronics, design features, drive arrangement, systems for pattern data transfer and design development. Electronic Jacquard: working principle, constructional variants, various electronic jacquard systems, selection system, pattern data, transfer and management. CAD for dobby, Jacquard, label and carpet: Design algorithm, development of Jacquard designs, process of drafting and sketch design, development of figures, composition of design, geometric ornamentation, arrangement of figures, weave simulation.

Practicals: Working on electronic dobby and electronic Jacquard, working on CAD, development of various designs for Jacquard, level and carpet. Development of design samples.

**TTL333 Process Control in Weaving**
3 credits (3-0-0)

Pre-requisites: TTL231 & TTL232


**TTL341 Polymers and Surfactants for Textiles**
3 credits (3-0-0)

Pre-requisites: CYL230 / TTL241 / TTL242


**TTL342 Theory of Textile Structures**
5 credits (3-2-0)

Pre-requisites: TTL211 / TTL212 / TTL221 / TTL232


**TTP361 Textile Testing Laboratory**
1 credit (0-0-2)

Pre-requisites: TTL211/TTL212/TTL221/TTL232. Experiments related to course TTL361.

**TTL362 Theory of Textile Structures**
5 credits (3-2-0)

Pre-requisites: TTL211 / TTL212 / TTL221 / TTL232


**TTL363 Technical Textiles**
4 credits (3-1-0)

Pre-requisites: TTL211 / TTL221 / TTL232

Growth of industrial textiles; Engineering textile structures for industrial purposes; Properties and use of textiles in the design of flexible composites like tyres, hoses and belts; Use of textiles in rigid composites, properties and applications; Textiles in filtration; Agricultural application of textiles; Textiles in civil engineering applications; Design, production, properties and application of coated fabrics; Flame retardant fibers and fabrics and their use in protective clothings. Textiles in miscellaneous industrial applications.
TTL364 Intelligent and Functional Textile
2 credits (2-0-0)
Pre-requisites: TTL211 / TTP211 / TTL232 / TTL222
Definition of smart and intelligent textiles; Passive and active functionality; Textile with high protection and comfort properties; Extreme winter clothing with low heat transmission, heat absorbing, heat storing systems; Phase change materials, incorporation of PCMs in fibres and fabrics; Breathable textile; Multifunctional textiles with incorporated electronics for integrated communication, music, health monitoring, defence support functions, wearable computers; Environmentally sensitive textiles: photochromic and thermochromic (chameleonic) fabrics, camouflage (radar shielding) fabrics, variable heat absorption surfaces, stimuli sensitive polymers such as temperature, pH, ionic, magnetic sensitive materials, design and their applications to textile; Fibres as solar cells; Recent advances in multifunctional textiles.

TTL365 Costing and its Application in Textiles
4 credits (3-1-0)
Pre-requisites: EC 60

TTC410 Colloquium (TT)
3 credits (0-3-0)
Pre-requisites: Registered for TTT410
Evaluation will be based on practical training and presentation.

TTT410 Practical Training (TT)
Non credit
Pre-requisites: EC 90 at the end of 5th sem.
Fifty (50) working days or 400 hours of practical training and presentation

TTD411 Major Project Part 1 (TT)
4 credits (0-0-8)
Pre-requisites: EC 120
Formation of project team (up to two students and up to two faculty guides); formulation of work plan; completing targeted work for the semester and presentation of complete work of progress for award of grade.

TTD412 Major Project Part 2 (TT)
8 credits (0-0-16)
Pre-requisites: TTD411; with B Grade
Continuation of planned tasks started in Project Part 1, TTD411, to completion, thesis writing and presentation of complete work for the award of grade.

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 manufacturing; Atom transfer radical polymerization, Ionic polymerization, ring opening polymerization; Nylon-6 man-facturing; 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; Spectroscopic Electron Microscopy (SEM) of fibres.

TTL713 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 polyamide 6 and 66, polyethylene terephthalate and polypropylene fibres/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 isothersms, 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 tow 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, polyacetic 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, PTIR, 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; Microdenier 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 texturing and modern classification; False twist texturing process- mechanisms and machinery, optimization of texturing parameters, barre’, structure-property correlation of textured yarns; Draw-texturing- the need and fundamental approaches; Friction texturing- the need and development, mechanics of friction texturing, latest development in twisting devices, optimization of quality parameters. Noise control in texturing. 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 doby, 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 doby, 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 doby and electronic Jacquard, working on 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 nanofibers, carbon nanotube, 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 Dispersion 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 dyestuffs to textile and related materials, 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-n-wear and durable press applications; fire retardants for apparel and industrial textiles; silicon and amino silicon softeners; fluorochemicals for water repellency and soil release functions; water proof breathables 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 colour control. 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; Textile 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: (3-0-1)  
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, appearance, 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, zips, 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).

TPP761 Evaluation of Textile Material – I  
1 credit (0-0-2)  
Characterization of Fibre : Birefringence, sonic modulus, density measurements, thermal analysis, X-rays (orientation and crystallinity); Yarn Testing : Tensile properties, hairiness, cross-sectional studies and yarn preparation.

TPP762 Management of Textile Production  
3 credit (3-0-0)  
Pre-requisites: EC 90  

TPP762 Evaluation of Textile Material – II  
1 credit (0-0-2)  

TTL763 Technical Textiles  
3 credits (2-1-0)  
Definition, classification, products, market overview and growth

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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

**TTL771 Electronics and Controls for Textile Industry**
4 credits (3-0-2)


**TTL772 Computer Programming and its Applications**
3 credits (2-0-2)
C++ as Object-Oriented Programming Language- Classes and Objects, Data Abstraction, Inheritance - Multilevel and Multiple inheritance etc., Polymorphism - operator overloading and virtual functions, file handling.

Application development using C++.

**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)
Model and fluid transport phenomenon through textile structure; Multiscale Modeling: Geometrical modeling of textile structures, modeling of properties of fibrous assemblies using object oriented programming techniques; Curve Fitting Techniques: Prediction of mechanical properties of fibrous assemblies, process-structure-property relationship of fibrous structures.

**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 pursued by the student. The student must submit a detailed plan of work for the programme coordinator before approval of registration for the course.

**TTD891 Major Project Part-I (Fibre Science & Technology)**

6 credits (0-0-12)

**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 course.

**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; Numeric Representation 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/Sofware 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- Barlett 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 processing, 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; Pitch generation and Frequency Modulation 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; Mel 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 distinguish 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, mare, Thenvenin 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. Physcis 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 design using lumped and distributed elements, stability consideration in active networks. Base-band and Pulse Signaling: Sampling, quantizing and encoding, digital Signal formats: binary coding, differential coding, bit synchronization, multilevel signaling, intersymbol interference, differential pulse code modulation, delta modulation time division multiplexing, pulse time, pulse width, pulse position modulation, Amplitude modulation: Amplitude Modulation. Double sideband suppressed carrier, Asymmetric sideband signals, 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.
**Practicals:** Design, simulation (P spice), realization and characterization of high gain differential amplifier used in the first stage of an operational amplifier. Design and simulation of a current source, extraction spice parameters, gain characterization etc., Comparison of coding schemes, self-correcting codes, assembly language programming, operation a system in a closed loop for investigating the matched filtering performance, detecting the signal in a noisy environment. The already developed for RF Identification will be used for this experiment, Design fabrication and characterization of an RF antenna.

**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 GDT, and application to short-range communications.

**CRP718 RF and Microwave Measurement laboratory** 3 credits (0-0-6)
Experiments based on measurement and instrumentation techniques using: oscilloscopes, spectrum analyzers, network analyzers, lock-in-amplifiers, waveform generators, bit-error rate and S/N measurement, antenna characterization, telemetry, data recorders and display, etc. Experiments based on various sensors used in characterization of RF materials, devices, circuits and systems: acoustic, ultrasonic,magnetic, electrical, thermal, optical, radiation, and smart sensors, etc.

**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 fu ndamentals 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 receiver Architecture, 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.

**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 Ohmic contact formation. Varactor diode, equivalent circuit, C-V characteristics for linearly graded, abrupt, and hyper abrupt p-n junction, cut-off frequency. P-1-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 processes. 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.

**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 characterizaton 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 Tactemetry, 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 adm 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 MEMIS 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, evolution of semiconductor 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 MEM 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)

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 sematic 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 networking 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 contents satisfying desired quality of service. This course will focus on bringing the two broad areas of multimedia processing and communication together. In media processing fundamental concepts of media processing and compression will be introduced with exposure to current techniques and standards. In communication protocols and algorithms for both wired and wireless networks will be discussed in relation to multimedia communication.

**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 ions, typography, gestures, etc. for a variety of devices.

**SID888 Special Module in Computer Human Interaction**
1 credit (1-0-0) Pre-requisites: 120 credits for UG students

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.

**SID890 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

SBL101 Modern Biology for Engineers
3 credits (3-0-0) Pre-requisites: None
Darwinian evolution & molecular perspective; Conventional species classification & Genomic view of evolution tree; Commonalities among life forms; Cell physiology, multi-cellular assemblies – superorganisms; Organismal physiology; Infectious diseases, Immunology, Stem cells, Cancer biology, Molecular interventions to improve nutritional content and survival of Plants & Animals. Design activities – Random pattern generation and morphogenesis.

SBP200 Introduction to Practical Modern Biology
2 credits (0-0-4) Pre-requisites: SBL 101
Biosafety lab practices – use of lab coats, gloves, safety goggles, eyewash, shower; chemical and biological waste disposal; Buffers in biology – Preparation of standard biological buffers, buffering capacity and pKa of buffers, biomolecules such as enzymes, whole cells and plant tissues in different buffering conditions; Observing cell surface and intracellular contents using light and fluorescence microscopy, “autofluorescence” of cells, real-time video microscopy of motile cells, cell growth and division; Plant genomic DNA isolation; Protoplast isolation and viability; Computer Modeling-From Genome Sequence to Protein Sequence and structure to screening for a “Hit” Molecule.

SBL201 High-Dimensional Biology
3 credits (3-0-0) Pre-requisites: SBL101
Introduction to Genomics, proteomics, Metabolomics & Cellomics; Size vis-à-vis packaging and replication challenges, Biomolecular architecture and assemblies leading to function, Immortal cells and ageless: Genomes & Designer Genomes; Molecular Engines; Proteins as nanobiomachines; network circuits for genome organization and protein-protein interactions, date hubs, party hubs, structure-function axioms, Biochemical cycles and feedback loops, Omics Applications, forensics, drug targets.

SBD301 Mini Project
3 credits (0-0-6) Pre-requisites: SBL101 and EBC80
Systems Biology, Plant Molecular Biology, Bioprosppecting, Tissue culture and Developmental Biology, Virology, Structural Biology, Cell Biophysics, Cellular Signalling, Protein folding and misfolding, Computational Biology.

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; small-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 – symmetries, replication, maturation and release; Principles of viral pathogenesis- entry, cell tropism. Cellular pathogenesis, clearance and persistence; Respiratory viruses – Influenza, paramyxoviruses, adenoviruses, SARS, RSV; Viral gastroenteritis – causative agents, epidemiology; Hepatitis viruses – food borne and blood borne; Herpes viruses – infections in immunocompetent and immunocompromised individuals, latency; Enteroviruses – Polio, ECHO, coxsackie viruses; Congenital viral infections – effects on foetus, prevention; Retroviruses – HIV, AIDS; Arboviruses and Viral zoonoses – arthropod vectors, vertebrate hosts, transmission cycles, rabies and viral haemorrhagic fevers; Tumour viruses – oncogenic mechanisms of viruses; Strategies for control of viral infection – active and passive 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.

SBL710 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), obinucleotides, peptide, PNA mediated therapeutics, drug delivery systems (lipids, cell penetrating peptides), vaccine, monoclonal antibodies produced by and in the living organisms, nanobiopharmaceutics, overview of the technologies employed for identification, characterization and production of biologics, Bioprospecting for novel drug discovery and development, Gene prospecting, plant bioprospecting, marine bioprospecting Phytochemicals, plant secondary metabolites, herbal drugs, edible vaccines, Bioresource based alternative medicine systems - AYUSH, Southeast Asian medicine system, PIC, MAT and ABS, assessing the role of biomimetics, system biology, synthetic biology in biologic production, GMPs, legislations, Safety Regulations associated with biologics in biopharmaceuticals.

SBL707 Bacterial Pathogenesis
3 credits (3-0-0) Pre-requisites: EC 90 and BEL110 or CYL 110 or CYL 120 or Equivalent
Common features of bacterial pathogens, structural features, capsules and cell walls, Pathogenicity islands, types of toxins produced, effect of toxins on host cells, secretion systems, production and function of adhesions, attachment to host cells, mechanisms of cellular invasion, extracellular and intracellular invasion, intracellular survival and multiplication, virulence factors, mechanisms of antibiotic resistance, interaction with the host immune system- innate and adaptive, evasion strategies, Immunocompromised individuals and opportunistic pathogens, specific examples such as Listeria, Mycobacterium, Shigella, Yersinia etc., strategies for prevention and cure, drug designing and scope for future studies, emerging infectious bacterial pathogens.

SBL708 Epigenetics in Human Health and Disease
3 credits (3-0-0) Pre-requisites: EC 90 and BEL 110 or CYL 110 or CYL 120 or Equivalent
Introduction – overview of epigenetics in human health and disease; Epigenetic mechanisms – basic mechanisms: DNA methylation and genome imprinting – role of DNA methylation; Epigenetics in cancer Biology – global and region specific changes and effects on transcription; DNA methylation and repeat instability diseases; Epigenetic reprogramming and role of DNA methylation in mammalian development – role in embryogenesis; Epigenetics in pluripotency and differentiation of embryonic stem 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 CYL110 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, Nubracueticals, 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, sulphydrylation, 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.

**SBC795 Graduate Student Research Seminar-I**  
0.5 credit (0-0-1) Pre-requisites: EC 90  
The course is aimed at giving the student a forum to periodically present their research, to critique the research of colleagues and learn about the best research in their fields. Discussions will be held on scientific methodology and inculcated with a value system for pursuing a career in science. Activities will be carried out in workshop mode.

**SBC796 Graduate Student Research Seminar-II**  
0.5 Credits (0-0-1) Pre-requisites: EC 90  
Special topics in research will be assigned by Coordinator; results of the research of each student registered for the course will be discussed; Discussions on scientific material from recently published papers in areas related to their research; The "Laboratory" activities will include delivery of seminars on their research and participation in the seminars and critique.

**SBS800 Independent Study**  
3 credits (0-3-0) Pre-requisites: EC 120  
The course is aimed at providing the student an opportunity to pursue a special research topic. A research topic assigned and mutually agreed upon by the faculty and student. Registration will require the submission of a proposal through the research committee on the topic clearly delineating the objectives to be achieved.

**SBL801 Signal Transduction and Drug Target Identification**  
3 credits (3-0-0) Pre-requisites: ECI20  
Eukaryotic cellular communications, importance of signal transduction, principles of signaling, recurring themes of signal transduction, reception, transduction, response, signal amplification, coordination of signaling, cascade formation, structure to function, anchors, adaptors, scaffold, recruitment of signaling proteins, topology and functional domains, dual specificity, modules, convergence, divergence, cross talk, receptors, G-protein coupled signal transduction, growth factors and tyrosine kinases, mitogen activated protein kinases, insulin signal transduction, critical nodes, protein phosphorylation, drug target identification, mechanism of drug action against signal transduction, antagonists of cell surface receptors and nuclear and receptors, ion channel blockers, transport inhibitors, targeting protein kinases and phosphatases, inhibitors of kinases and phosphatases, pseudosubstrates, examples of clinical drugs against protein kinases/ phosphatases, new and emerging technologies to identify drug target like antisense , omics, RNAi, high content screening, target hopping, combination of mutations, systems approach, complexity in signaling, techniques in signal transduction.

**SBL802 Macromolecular Structure and Data Processing**  
3 credits (3-0-0) Pre-requisites: EC120  
Treatment of macromolecules to generate suitable crystals, hanging drop and sitting drop techniques, seedling, cryoprotecting and freezing crystals, acquisition of diffraction data, synchrotron radiation, indexing and scaling data, space group identification, symmetry elements, Fourier transformation and structure factors, the phase problem, heavy atom methods, molecular replacement, anomalous X-ray scattering, calculation of electron density, model building and phase refinement, co-crystallography, small angle X-ray scattering, preparing samples for transmission electron microscopy, negative staining, cryo-techniques for freezing grids, manual vs. automated data collection, cryotomography, software packages for data collection and processing, generating a model, refinement and validation, time resolved cryoEM.

**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.

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

ASL310 Fundamentals of Atmosphere and Ocean
4 credits (3-0-0)
Pre-requisites: EC 60
Composition of atmosphere and ocean, Thermodynamic state: distribution of temperature, density, pressure, water vapour, salinity, etc., Equations of state, Fundamental forces in the atmosphere and ocean; Pressure gradient, gravitational, Coriolis and frictional forces, Atmospheric chemistry: gas phase chemical reactions, tropospheric and stratospheric chemistry, Laws of motion in the rotating earth, geostrophic and hydrostatic balances, Thermodynamic laws and energy cycle: Radiation, conduction, convection and advection; adiabatic and diabatic cooling and warming, thermodynamic diagrams, General circulation in the atmosphere, Monssoons, Global ocean currents, unique characteristics of Indian Ocean circulation, Wave propagation: Gravity waves, Oceanic Tides, Surges and Tsunamis, Atmosphere-Ocean interaction: some examples of air-sea interaction.

ASL320 Climate Change: Impacts, Adaptation and Mitigation
4 credits (3-0-2)
Elements of physical climatology, climate variability; anthropogenic causes of climate change; concepts of radiative forcing climate feedbacks and climate sensitivity; Observed climate record and paleo reconstruction, modeling aspects of the climate system; Carbon emission pathways, scenario development, climate simulations of the future; Socio-economic impacts, quantifying uncertainties, tipping points and irreversible changes; Observed and projected changes in weather, monsoons, teleconnections, extreme weather events, see level in India; Climate hot spots, sector wise vulnerability and adaptation; Reducing greenhouse gas emissions, clean energy technologies, geoeengineering options.

ASL410 Numerical Simulation of Atmospheric and Oceanic Phenomena
4 credits (3-0-2)
Pre-requisites: EC 90
Density stratification in atmosphere and ocean, static stability, equations of motion of a rotating fluid, scale analysis, hydrostatic approximation, vorticity and divergence, a coordinate system for planetary scale motion, Saint-Venant (shallow-water) equations; meteorologically important waves, Rossby and vertically propagating waves; basic concepts of barotropic and baroclinic instability.

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 accident, 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.

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.

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
Parameter and thermodynamics of atmosphere: composition of air, stratification of the atmosphere, moist adiabatic processes, stability of the atmosphere, thermodynamics of dry and moist air.
radiation: the radiation balance of the earth: Atmospheric system. Basic equations governing atmospheric circulations: effects of rotation of the earth, scale analysis, hydrostatic and geostrophic approximations; circulation and vorticity. Waves in the atmosphere: sound waves and gravity waves, inertial oscillations, Rossby gravity waves. Planetary boundary layer: influence of obstacles on wind, mixing length theory, Ekman layer equations, the inversion layer. Weather prediction and climate studies: general circulation of the atmospheric, introducing different numerical techniques and physical parameterization schemes, the monsoon and its simulation by numerical models.

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 changes. 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 precipitation, severe storm detection, cyclonic storm detection and track prediction, hail detection and prediction, Lidar, acoustic radar and its principles.

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 modeling.

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.

ASP751 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: ASCII, GRIB, NetCDF. Introduction to Fortran 95, programming in Fortran 95; Examples for converting and reading ASCII, 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; and 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.

ASP752 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.

ASP801 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, Gills 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.

ASL803 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, Yanal, Rossby, inertia-gravity waves.

**ASL804 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.

**ASL808 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.

**ASL813 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.

**ASL814 Modelling of Dynamic Processes of Oceans and Atmosphere**  
3 credits (3-0-0)  
Overlap with: ASL850  
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, enstrophy and energy 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.

**ASL815 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 dumpings, impact of coastal ocean on living resources, petrochemical exploitation, wave power extraction, tidal energy, offshore thermal energy conversion, impact of salt water 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 Bjerknes 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, lightning, 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.

**ASL818 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, clouds 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; 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 (0-0-1)

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 density 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 non-equatorial 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)

**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

**ASL877 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

**ASL879 Special Topics in Remote Sensing**

3 credits (3-0-0)

To be given by the interested faculty

**ASV880 Special Module in Remote Sensing**

1 credit (1-0-0)

To be given by the interested faculty

**ASL880 Dynamic Oceanography**

3 credits (3-0-0)

Basic hydrodynamic equations of motion and continuity; mass transport and free surface equation; steady motion in the sea; unsteady motions and their solutions. Application of the transport equations; analytical modelling of the tropical ocean circulation; use of tracers in circulation studies; storm induced upwelling in the open ocean. One-dimensional models of the Upper Ocean and seasonal thermocline; numerical models of ocean tides; two and three dimensional models of ocean currents; models of equatorial currents; numerical models for computing currents from the observed density fields; numerical model for the propagation of hydrodynamic numerical models of coastal upwelling. Numerical simulation of storm surges by stair-step model, shear coordinate model, coastal zone model, inland inundation model, multilevel coastal zone model, refined grid model and the river-ocean coupled model; tide-surge interaction model.

**ASL881 Special Topics in Objective Analysis**

3 credits (3-0-0)

To be given by the interested faculty

**ASV882 Special Module in Objective Analysis**

1 credit (1-0-0)

To be given by the interested faculty

**ASL883 Special Topics in Clouds and Aerosols**

3 credits (3-0-0)

To be given by the interested faculty

**ASV 884 Special Module in Clouds and Aerosols**

1 credit (1-0-0)

To be given by the interested faculty

**ASL885 Special Topics in Lake Circulation Modelling**

3 credits (3-0-0)

To be given by the interested faculty

**ASV886 Special Module in Lake Circulation Modelling**

1 credit (1-0-0)

To be given by the interested faculty

**ASV887 Special Module in Numerical Weather Prediction**

1 credit (1-0-0)

**ASL888 Special Topics in Atmospheric Sciences**

3 credits (3-0-0)

To be given by the interested faculty

**ASL890 Special Topics in Geophysical Fluid Dynamics**

3 credits (3-0-0)

Inviscid shallow water theory: small amplitude motion (linear wave theory). Plane waves in a layer of constant depth, Poincare and Kelvin waves; Rossby waves; quasigeostrophic scaling in shallow water theory; quasigeostrophic Rossby waves; Rossby waves in a zonal current, Resonant interaction and multiple scale analysis; a brief review of viscous flows; Quasigeostrophic motion of a stratified fluid on a sphere; geostrophic approximation and its limitations, Quasigeostrophic potential vorticity equation for the atmospheric synoptic scales, Rossby-wave normal modes- The vertical structure Equation; Instability theory; The linear stability problem: condition for instability, Barolonic Instability, the basic mechanism, Eddy’s model, Charney’s model-critical layers; Instability in the two layer model-Barotropic Instability.

**ASS 800 Independent Study**

3 credits (0-0-3)

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

**BML330 Topics on Safety Principles for Engineers**
4 credits (3-0-2)  
Pre-requisites: EC 60  

**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)  

**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, 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 occuring in normal and abnormal conditions like atheroclerosis, cancers, utero-placental system and various imaging modalities.
Centre for Energy Studies

**ESL300 Self-organizing Dynamical System**
3 credits (3-0-0)
Pre-requisites: EC 60

Dynamical systems dissipative and area preserving, Patterns in Hamiltonian dynamics invariants and symmetry, KAM theorem / coherent structures, complexity and pattern formation, Belousov- Zhabutinsky reaction, Landau-Ginzburg / mean-field models, Cailing fractals, Cellular automata, Wavelet transforms, Phase transitions and order parameter, Criticality the border of order and chaos, Entropy and direction of time, Negentropic systems, Self-organized criticality, lattice models, Examples: Electrical circuits, Management systems, Astrophysical systems, Plasma and magnetic surface systems, Biological systems, Non-linear systems.

**ESL330 Energy, Ecology and Environment**
4 credits (3-1-0)
Pre-requisites: EC 60

Concepts of ecosystems and environment, Characteristics and types of ecosystems, Autecology and synecology, Energy flow in ecosystems, Feedback loops, Trophic webs, Eco-technology and Eco-development, Energy-environment interaction, Impact of energy sources (coal, oil, natural gas, solar, wind, biomass, hydro, geothermal, tidal, wave, ocean thermal and nuclear) on environment, local regional and global implications. Approaches to mitigate environmental emissions from energy sector, Global initiatives Kyoto Protocol, Clean development mechanism case studies.

**ESL340 Non-Conventional Source of Energy**
4 credits (3-0-2)

Pre-requisites: EC 60


**ESL350 Energy Conservation and Management**
3 credits (3-0-0)
Pre-requisites: EC 60


**ESL360 Direct Energy Conversion Methods**
4 credits (3-1-0)
Pre-requisites: EC 60

Energy classification, Sources and utilization, Principle of energy conversion, Indirect / direct energy conversion, Basic principles of design and operations of (i) Thermolectric (ii) Thermionic converters (iii) Photovoltaic energy systems (iv) Fuel cells (v) Plasma diodes (vi) Magneto hydrodynamic Power generators and (vii) Advanced energy conversion systems.

**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)

Relationship 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, Intercconversion 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)

Introduction, Thermodynamics of energy conservation, Energy and exergy concepts, Irreversibility and second law analysis and efficiency of thermal systems such as mixing, throttling, drying and solar thermal
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.

ESN725 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 and evaluation, Bioconversion of substrates into alcohols, Bioconversion into hydrogen, Thermo chemical conversion of biomass, conversion to solid, liquid and gaseous fuels, pyrolysis, gasification, combustion, Chemical conversion processes, hydrolysis and hydrogenation, Solvent extraction of hydrocarbons, Fuel combustion into electricity, case studies.

ESL734 Nuclear Energy
3 credits (3-0-0)
Introduction: Scope of nuclear energy (fission and fusion energy), typical reactions. Basics Concepts: Binding Energy of a nuclear reaction, mass energy equivalence and conservation laws, nuclear stability and radioactive decay, radioactivity calculations. Interaction of Neutrons with Matter: Compound nucleus formation, elastic and inelastic scattering, cross sections, energy loss in scattering collisions, polyenergetic neutrons, critical energy of fission, fission cross sections, fission products, fission neutrons, energy released in fission, γ-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.

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, CO₂ 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: generation, characterization, use as energy source, Biogas: aerobic and anaerobic bio-conversion processes, microbial reactions, purification, properties of biogas (composition and calorific value), Storage and enrichment, 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.

ESL745 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.

ESL746 Hydrogen Energy
3 Credits (3-0-0)
Pre-requisites: Nil
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)
Economic development and the environment, Relevance of environmental economics, Economic efficiency and markets, The economics of environmental quality, Frameworks for environmental cost and benefit analysis: criteria for evaluating environmental, Command and control strategies, Incentive based strategies - emission taxes
and subsidies, Transferable discharge permits, Environmental policies, International environmental agreements.

**ESL766 Environmental Regulation**  
3 credits (3-0-0)  
Environmental legislation and strategies to control pollution, Standards and setting criterion, 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)  

**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, Simplex method, Duality and post-optimality analysis, Integer programming, Optimal technology mix in micro and macro level energy planning exercises, Sequencing, Queuing theory, Networks, PERT and CPM, Decision theory, Markov analysis, Non linear programming, 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 greenhouse 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)  
Latest topics on energy, Integrated Gasification combined cycle (IGCC), Fuels for power generation, Advanced energy storage systems, Hydrogen power, Clean coal technologies, Pressurized fluidised bed combustion, Natural gas cycles, Integrated generation, Fuel cells,
Energy conservation in power plant, Battery vehicles, Electric vehicles, Algal bio fuels, Metal hydrates, Geological CO₂ sequestering.

ESN794 Principles of Chemical Processes and Combustion
0 credit (3-0-0)
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, Control 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 plasmas 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 plasma system, MHD cycles, MHD component (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, Toroidal equilibrium toroidal Stability, High-beta Tokamak, Experimental observations, Fusion Technology, Commercial Tokamak Fusion - power plant, Tandem - mirror fusion power plant, other Fusion reactors concepts, Inertial confinement fusion reactors, Reactor cavity, Hybrid fusion / fission systems, Process heat and synthetic fuel production.

ESL875 Alternative Fuels for Transportation
3 credits (3-0-0)
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.
Centre for Rural Development and Technology

RDL340 Technology and Community Development
4 credits (3-1-0)
Pre-requisites: EL 60
Concepts of appropriateness of technology to community, based on region specific factors. Technology assessment: Techno economic evaluation, energy audit, short and long term impacts of technology on environment and society. Basic needs and technology alternatives for sustainable development. Technology choices in agriculture (modern system, organic farming, permaculture, natural farming, equipments, implements and devices, water management); energy (renewable resources, biomass production, conversion and utilization, social forestry); housing (low cost materials, designs and habitats); health care (traditional practices, water and sanitation); rural industries (based on traditional and emerging technologies). Issues of Technology transfer.

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)
Land as a parameter in rural development. Wastelands and importance of using them. Biomass growth on various types of lands. Introduction to plant taxonomy, under-utilized terrestrial plants and aquatic weeds, flora of tropics, arid lands and hilly areas. Constituents of biomass, biochemical and chemical conversion processes.
Applications of biomass as unconventional plant-based source for food, cattlefeed, chemicals, fibres, construction materials and energy. An integrated technological approach to biomass and wasteland utilization. Possible ecological effects.

RDD750 Minor Project: Intensive Study on Topics of Specific Interest
3 credits (0-0-6)
Project work related to any topics of interest within the specified timeframe.

RDP750 Biomass Laboratory
3 credits (0-0-6)
Soil and Water analysis for Biomass Production: soil sampling from a plot/field and soil analysis for its texture, ph. EC. C.N.P and K. Water analysis: TDS, Alkalinity, Total Hardness, EC and pH.
Soil Microflora and Root Association: Isolation and culturing of nitrogen fixers (Rhizobium, Azotobacter, Azospirillum and blue green algae), ecto and endomycorrhizal fungi. Measurement of total microbial biomass in soil and respiration rate of microbes. Bacterial and fungal root infection.
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.

ITL706 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 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.

Various types of corrosion along with case studies - Galvanic, Thermogalvanic, High temperature corrosion. Intergranular, Fitting, Selective attack (leaching), Fretting corrosion-erosion, Cavitation, Stress corrosion cracking. Hydrogen embrittlement.

Corrosion fatigue and Corrosive wear.

Application of Non Destructive Techniques (NDT) for corrosion evaluation and monitoring.


**ITL730 Lubricants**

3 credits (2-0-2)


**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 (Hazard and Operability Study, 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 maintenance 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/Controller based system design with emphasis on real world interfacing. Study of optical instruments, interferometers and laser based instruments. Interferometers and laser based instruments: Experiments on optical techniques; Experiments with Fizeau Interferometer, Fitness/Curve/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, control 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 transducer; semiconductor transducers 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, photoemission, 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. Opto-electronic interfacing techniques. Application of CPU's 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)

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)

DIL731 Applied Ergonomics
13.5 credits (2-0-3)

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/opens, 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 devices. 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
3 credits (3-0-0)
Optical measurements: Photometry, Primary Standard, sub-standards and working standards, measurement of radiant intensity and flux.
Application of these measurements to optical systems, Eye and Vision, Optical Materials for UV, visible and IR regions. Photosensitive materials for photography, photolithography and photo fabrication. Optical fibres as optical components. Multimode and single mode fibres. Fibre coupling techniques. Introduction to fibre based sensors, imaging systems and communication links. Illuminating systems. Detection of optical radiation, noise in optical detection systems. Design considerations of opto-mechanical and opto-electronic systems, including encoders and choppers, with case studies.

**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, Time averaged, 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 multiplevavelength 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)

Pre-requisites: 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, refractometry, 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)

Pre-requisites: EPL105 or PHL558 and EC90


**IDL737 Information Display Devices and Technologies** 3 credits (3-0-0)

Pre-requisites: EC 90 and EPL105


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 radii 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)

Objective: To develop creative conceptualization capabilities in form and structural integration and its implications to user society and the producer. Configuration design for export. Behavioural aspects in product configuration. Product in its context, family of products, inter-changeability of parts, Indian and foreign standards, market availability. Detailing plastic products while using processes like injection moulding, compression moulding, blow moulding and FRP moulding using hand laying and compression processes. Detailing for fabricated products 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, stretches 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 deception. Colour theory, subtractive 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 task, 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 identity framework and understand design at the level of systems services. Development of integrated ethos in an organization : Corporate policy, management outlook, work ethics, in a social institution/public service. Development of a visual identity as a means of communication. Corporate mark : Logo, symbol, colour. Corporate alphabets or type style : Display style, text style or styles. Company paper : stationery design, all business forms, transmittal envelopes, mailing labels and containers.
Environment design and structures: Office architecture, plant architecture, reception, interiors and entrance design. Product design: Consumer items, service image, idea, visual, presentation. Package design advertising and sales promotion: All visual media. Signage and vehicle identification and uniforms. Exhibition and displays; design control manual.

IDL811 Selected Topics in Instrumentation
3 credits (3-0-0)
(No prescribed course contents)

IDC812 Term and Seminar
3 credits (3-0-0)

DIR 812 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/literature 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 sophisticated cation 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 story board 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/extents the potential/limits of the material or process.

DIR891 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.

DIR892 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 men, 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 - polymers, polycarbonates, polylamides, heteromeric 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, polylamides, polymers, 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, polyamides, polyurethanes, polyphenylene oxide, polyphenylene sulfide, PEEK and Engg. Thermosets such as USP, Epoxy, phenolics and aminoplasts.

**PTL712 Polymer Composites**  
3 credits (3-0-0)  

**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 excercises 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 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

JOD802 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 / technology development.

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 Power Generation Technology

JGL710 Power Plant Performance and Economics
3 credits (3-0-0)

Electricity demand and growth, siting of power plants. Variable load operation in a grid, load curves for different consumers. Cost of electric power from different types of power plants. Performance characteristics of major equipment, viz., boiler, turbine, condenser, etc, and changes with operation. Data acquisition and analysis, and use of software packages for monitoring and optimization. Introduction to regulatory mechanisms. Case studies, Optimal Generation mix, Economic load dispatch, Unit commitment, Hydro thermal scheduling.

JGL712 Power Plant Control and Instrumentation
3 credits (3-0-0)


JGL716 Selected Topics in Power Plants
3 credit (3-0-0)

Power Plant layout, foundations, erection and commissioning, Fuel for modern power plants - their storage, handling and combustion systems, Diesel and Gas Turbine Power plants stand by and - Captive power plants, Combined cycle power plants, Environmental impacts and pollution control from, Thermal power plants, Miscellaneous topics.

JGS800 Independent Study
3 credits (0-3-0)

JGD801 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).

JGD802 Major Project (Part-II)
12 credits (0-0-12)

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.

M. Tech. Programme in Polymer Science & Technology

JPD799 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)

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-II)
6 credits (0-0-12)

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

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<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tr>
<td>B.Tech.</td>
<td>Bachelor of Technology</td>
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<td>BPGS&amp;R</td>
<td>Board of Postgraduate Studies and Research</td>
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<td>CGPA</td>
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<td>IRD</td>
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<td>M.B.A.</td>
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<td>M.S.(R)</td>
<td>Master of Science (Research)</td>
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<td>M.Tech.</td>
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<td>PGS&amp;R</td>
<td>Postgraduate Studies and Research</td>
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<td>Ph.D.</td>
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<td>SRC</td>
<td>Standing Review Committee (for undergraduate programmes); also Student Research Committee (for M.S.(R) and Ph.D. student)</td>
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<td>UGS</td>
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**SLOT HOURS (1 YEAR M COURSES)**

**DAY**
- M: Monday
- Tu: Tuesday
- W: Wednesday
- Th: Thursday
- F: Friday

**M**
- A: 8:00 - 9:20
- B: 9:30 - 10:50

**Tu**
- C: 8:00 - 9:20
- D: 9:30 - 10:50

**W**
- C: 8:00 - 9:20
- D: 9:30 - 10:50

**Th**
- A: 8:00 - 9:20
- B: 9:30 - 10:50

**F**
- C: 8:00 - 9:20

**Note:**
- **2011-12**
- Courses include (PH/CY LAB)
- Effective from semester 2011-12
### Applied Mechanics

**SLOT HOURS (1 YEAR P COURSES) effective from 1 semester 2011-12**

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**Notes:**
- **Q (PH/CY LAB)**
- **HUN100**
- **A**
- **E**
- **D**
- **A (14.00 - 15.20)**
- **B (15.30 - 16.50)**
I, entry no.__________________________ , do hereby undertake that as a student at IIT Delhi:

(1) I will not give or receive aid in examinations; that I will not give or receive unpermitted aid in class work, in preparation of reports, or in any other work that is to be used by the instructor as the basis of grading; and

(2) I will do my share and take an active part in seeing to it that others as well as myself uphold the spirit and letter of the Honour Code.

I realize that some examples of misconduct which are regarded as being in violation of the Honour Code include:

- copying from another’s examination paper or allowing another to copy from one’s own paper;
- unpermitted collaboration;
- plagiarism;
- revising and resubmitting a marked quiz or examination paper for re-grading without the instructor’s knowledge and consent;
- giving or receiving unpermitted aid on take-home examinations;
- representing as one’s own work the work of another, including information available on the Internet;
- giving or receiving aid on an academic assignment under circumstances in which a reasonable person should have known that such aid was not permitted; and
- committing a cyber offence, such as, breaking passwords and accounts, sharing passwords, electronic copying, planting viruses, etc.

I accept that any act of mine that can be considered to be an Honour Code violation will invite disciplinary action.

Date: ___________________ Student’s signature__________________________

Name__________________________

Entry no.__________________________
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Hauz Khas
New Delhi-110 016
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(91) 011-2659 7135

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