COURSES OF STUDY FOR POST GRADUATE PROGRAMMES

(2019 - 2021)

Defence Institute of Advanced Technology (Deemed to be University)
Pune - 411025

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<td>5</td>
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<td>6</td>
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<td>7</td>
<td><strong>Optoelectronics and Communication Systems</strong></td>
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<td>8</td>
<td><strong>Technology Management($)</strong></td>
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<td><strong>Electronics and Communication Engineering (ECE)</strong></td>
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<td>Signal Processing and Communication</td>
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<td>Radar and Communication</td>
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<td>Defence Electronics Systems (DES)</td>
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<td>Navigation Systems</td>
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<td><strong>Material Science and Chemical Technology (MS &amp;CT)</strong></td>
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<td></td>
<td>Materials Science and Technology (MST)</td>
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<td>11</td>
<td><strong>Materials Engineering (#)</strong></td>
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<tr>
<td>12</td>
<td><strong>Corrosion Technology (#)</strong></td>
<td>460</td>
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## 2. MASTER OF SCIENCE (M.Sc) PROGRAM

<table>
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<th>Sr. No.</th>
<th>Programme Title</th>
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</thead>
<tbody>
<tr>
<td>01</td>
<td>M.Sc in Food Technology (#)</td>
<td>470</td>
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</tbody>
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## 3. POST GRADUATE DIPLOMA PROGRAM

<table>
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</tr>
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<tbody>
<tr>
<td>01</td>
<td>PG Diploma in Fire Engineering and Integrated Safety (#)</td>
<td>489</td>
</tr>
</tbody>
</table>

**NOTE:** *Robotics is a multidisciplinary specialization, M.Tech degree will be awarded as per the UG Degree of the student viz. M.Tech in EE/ME/AE etc.

# Sponsored (DRDO/Tri Services/DPSUs/PSUs/Industry) only.

$ Applicable for sponsored/self sponsored candidates only.

@ Applicable for MoD sponsored candidates only.

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**PREFACE**
This book gives comprehensive information on the structure, curriculum and syllabus of various Post Graduate programmes. The Board of Studies and Academic Council Continuously monitor these Courses and makes appropriate modifications / improvements from time to time.

In order to keep pace with the rapid developments in science and technology and also to keep in view the requirements of the nation and the aspirations of students, it is imperative that the academic programmes of the institute are reviewed continuously.

The academic system is semester based and hence the students are required to follow certain procedures and meet certain academic requirement each semester. The academic performance is monitored by Postgraduate Graduate Committee (PGC), which also reviews status of individuals after reviewing their performance.

The advisory system plays a very important role in a flexible curriculum of the type offered under the various programmes of the Institute. The choice of courses being very wide and considerable flexibility in the programme being its characteristic feature, students normally need guidance to formulate a meaningful and well knit programme for each of them.
Academic Calendar
<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Activity</th>
<th>Dates</th>
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<tr>
<td>1</td>
<td>• Registration (M. Tech. / MS (by Research)/ MSc/ PGD/ Ph. D)</td>
<td>24\textsuperscript{th} June – 28\textsuperscript{th} June 2019</td>
</tr>
<tr>
<td></td>
<td>• Re-examination for Spring semester courses</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Add/Drop Courses &amp; Finalizing Electives</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Orientation Programme</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Last date of Late Registration with late fee</td>
<td>10\textsuperscript{th} July 2019</td>
</tr>
<tr>
<td>3.</td>
<td>Sending Certified list of courses (Regular, Self study, Audit etc)</td>
<td>30\textsuperscript{th} Aug 2019</td>
</tr>
<tr>
<td></td>
<td>registered by the students - by Jt. Reg. (ACs) to COE</td>
<td></td>
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<tr>
<td>4.</td>
<td>Classes</td>
<td>1\textsuperscript{st} July – 02\textsuperscript{nd} Nov 2019</td>
</tr>
<tr>
<td>5.</td>
<td>Revision and Discussion / Make up Classes</td>
<td>04\textsuperscript{th} Nov - 08\textsuperscript{th} Nov 2019</td>
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<tr>
<td>6.</td>
<td>Sending the Panel of Examiners to COE</td>
<td>30\textsuperscript{th} August 2019</td>
</tr>
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<td>7.</td>
<td>Last date of submission of Examination form and Admit Card to COE by the Students.</td>
<td>16\textsuperscript{th} Sep. 2019</td>
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<tr>
<td>8.</td>
<td>Preparation for Exam</td>
<td>12\textsuperscript{th} Nov – 16\textsuperscript{th} Nov 2019</td>
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<td>9.</td>
<td>End Semester Examination</td>
<td>18\textsuperscript{th} Nov – 03\textsuperscript{rd} Dec 2019</td>
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<tr>
<td>10.</td>
<td>Oral Examination Committee approved by Vice-Chancellor to be sent to COE (Thesis first Phase evaluation)</td>
<td>08\textsuperscript{th} Nov 2019</td>
</tr>
<tr>
<td>11.</td>
<td>Seminar Presentation &amp; Evaluation / Practical Examination (M.Tech. 1\textsuperscript{st} Sem) / Thesis first evaluation (M.Tech. 3\textsuperscript{rd} Sem) / PhD progress review by DRMC</td>
<td>04\textsuperscript{th} Dec – 10\textsuperscript{th} Dec 2019</td>
</tr>
<tr>
<td>12.</td>
<td>Last date for submission of certified Statement of Marks to COE (Courses / Seminar / Lab / Thesis)</td>
<td>13\textsuperscript{th} Dec 2019</td>
</tr>
<tr>
<td>13.</td>
<td>Winter Vacation</td>
<td>16\textsuperscript{th} Dec – 29\textsuperscript{th} Dec 2019</td>
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<tr>
<td>14.</td>
<td>Result Declaration – Autumn Semester</td>
<td>23\textsuperscript{rd} Dec 2019</td>
</tr>
<tr>
<td>15.</td>
<td>Outstation Instructional Tour (Optional)</td>
<td>During the period provided for classes without affecting any academic activities.</td>
</tr>
<tr>
<td>Sl. No.</td>
<td>Activity</td>
<td>Dates</td>
</tr>
<tr>
<td>--------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------------------------------</td>
</tr>
</tbody>
</table>
| 1      | • Registration (M. Tech. / MS (by Research) / MSc/ PGD /Ph. D)  
• Re-examination for Spring semester courses  
• Add/Drop Courses & Finalizing Electives  
• Orientation Programme                                                                 | 24th Dec 2019 – 31st Dec 2019 |
| 2      | Last date of Late Registration with late fee                                                                                                                                                             | 10th Jan 2020                |
| 3      | Sending Certified list of courses (Regular, Self study, Audit etc) registered by the students - by Jt. Reg. (ACs) to COE                                                                                      | 28th Feb 2020                |
| 4      | Classes                                                                                                                                                                                                  | 01st Jan – 2nd May 2020      |
| 5      | Revision and Discussion / Make up Classes                                                                                                                                                                | 04th May – 8th May 2020      |
| 6      | Sending the Panel of Examiners to COE                                                                                                                                                                     | 28th Feb 2020                |
| 7      | Last date of submission of Examination form and Admit Card to COE by the Students.                                                                                                                                 | 16th March 2020              |
| 8      | Preparation for Exam                                                                                                                                                                                     | 11th May – 14th May 2020     |
| 9      | End Semester Examination                                                                                                                                                                                  | 15th May – 29th May 2020     |
| 10     | Oral Examination Committee approved by Vice-Chancellor to be sent to COE (Thesis 2nd Phase evaluation)                                                                                                     | 08th May, 2020               |
| 11     | Seminar Presentation & Evaluation / Practical Examination (M.Tech Thesis Final Evaluation / PhD progress review by DRMC)                                                                                     | 23rd May – 29th May 2020     |
| 12     | Last date for submission of certified Statement of Marks to COE (Courses / Seminar / Lab / Thesis)                                                                                                         | 2nd June 2020                |
| 13     | Summer Vacation                                                                                                                                                                                           | 03rd June – 30th June 2020   |
| 14     | Result Declaration                                                                                                                                                                                         | 15th June 2020               |
| 15     | Outstation Instructional Tour (Optional)                                                                                                                                                                 | During the period provided for classes without affecting any academic activities. |
Programmes Structure & Syllabus of Courses
The Department of Aerospace Engineering, formerly known as Faculty of Guided Missiles was established with a mission to impart knowledge to scientists and service officers to take up the
challenges in design, development and use of Guided Missiles. Later scope was widened to Air Armaments & UAVs.

**Vision of the Department:** To be a centre of excellence for education, training and research in Aerospace Technologies.

**Mission of the Department:** To impart higher education and pursue research in the field of Aerospace Engineering and Technology having a bearing on the defence requirements for the officers of the Ministry of Defence, Armed Forces, Public Sector Undertakings, other related Organizations and general public.

**Research Areas:**

- Flight Guidance and Control, Robust and Nonlinear Control
- Flight Dynamics and Trajectory Optimization
- Experimental Aerodynamics
- Aero-elasticity
- Flow control
- UAV Design

Currently, the department offers M.Tech. in Aerospace Engineering with three specializations namely Guided Missiles, UAVs and Air Armaments. The details of the programmes are given below:

**M. Tech. in Aerospace Engineering (Guided Missiles)**

**Brief Description:** The department had been involved in conducting post-graduate programme in Aerospace Engineering with specialization in Guided Missiles Technology. The programme consists of courses in the areas related to guided missiles, practicals, seminars, and dissertation work. The curriculum of the programme was formulated to meet the needs of the three services, Defence R&D Organization, DGOF, MSQA, CGQA and Public Sector Undertakings dealing
with missiles and related technologies. From academic year 2009-10 onwards, the programme was also opened up for civilian GATE qualified students.

**Eligibility:** B.E./B. Tech. degree in Aerospace, Aeronautical or AeSI / Mechanical/ Electrical/Electronics/ Electronics and Communication / from recognized university.

**Organization:** The programme will be of four-semester duration. In the first semester there are six courses. In the second semester there are six courses out of which three courses are electives. The third and fourth semesters are completely devoted for dissertation. All courses will have three tests and a final examination. Half yearly evaluation of the dissertation takes place at the end of the third semester. At the end of the final semester the student submits the thesis and makes a presentation about the project, which is evaluated by the committee consists of Internal and External examiners. Visits to various DRDO labs, National Laboratories, etc are planned to enhance student’s appreciation & understanding of the subject.

The details of the courses offered under the programme are given below:
## M. Tech. in Aerospace Engineering (Guided Missiles)

### Semester I

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Course Code</th>
<th>Course</th>
<th>Credits</th>
<th>Total Credits (*)</th>
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<td>L</td>
<td>T/P</td>
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<tr>
<td>1</td>
<td>AM 607</td>
<td>Mathematics for Engineers</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>AE 601</td>
<td>Aerospace Propulsion</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>AE 602</td>
<td>Aerodynamics</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>AE 603</td>
<td>Navigation, Guidance &amp; Control</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>AE 604</td>
<td>Aerospace Structures</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>AE 605</td>
<td>Flight Mechanics</td>
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<td>1</td>
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<tr>
<td></td>
<td></td>
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### Semester II

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<tr>
<td>1</td>
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<td>Flight Instrumentation</td>
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<td>Missile Guidance &amp; Control</td>
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<tr>
<td>3</td>
<td>AE 608</td>
<td>Missile Propulsion</td>
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<td><strong>Total</strong></td>
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</table>

Note: 04 weeks Practice school during summer vacation for scholarship students.

### Semester III

<table>
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<tr>
<th>Sl. No.</th>
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<tr>
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<td></td>
<td>M.Tech. Dissertation Phase I</td>
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<td>14</td>
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<td><strong>Total</strong></td>
<td><strong>28</strong></td>
<td><strong>14</strong></td>
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### Semester IV

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**Contact Hours/week

### List of Electives

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<td>AE 611</td>
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<td>2</td>
<td>AE 612</td>
<td>Experimental Aerodynamics</td>
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<tr>
<td>3</td>
<td>AE 613</td>
<td>Structural Dynamics and Aero-elasticity</td>
</tr>
<tr>
<td>4</td>
<td>AE 614</td>
<td>Estimation and Tracking for Aerospace Applications</td>
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<tr>
<td>5</td>
<td>AE 615</td>
<td>Nonlinear and Robust Control</td>
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<tr>
<td>6</td>
<td>AE 616</td>
<td>Avionics</td>
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<tr>
<td>7</td>
<td>AE 617</td>
<td>Robotic Control</td>
</tr>
<tr>
<td>8</td>
<td>AE 618</td>
<td>Signals and Systems</td>
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<tr>
<td>9</td>
<td>AE 619</td>
<td>Optimal Control with Aerospace Applications</td>
</tr>
<tr>
<td>10</td>
<td>AE 620</td>
<td>Advanced Missile Guidance</td>
</tr>
<tr>
<td>11</td>
<td>AE 621</td>
<td>Ducted Rocket &amp; Combustion</td>
</tr>
<tr>
<td></td>
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<td>Open electives from other Departments</td>
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</table>
M.Tech. in Aerospace Engineering (Air Armaments)

**Brief Description:** The aim of the program is to impart advanced training and to update knowledge in the field of design, development, quality assurance and Inspection of air armaments to engineering officers from Air Force, Navy & DRDO. At the end of the program the officer should be able to undertake R&D work and/or inspection, testing and evaluation of aircraft armament systems.

**Eligibility:** Bachelor’s Degree in Aerospace, Aeronautical/Mechanical Engineering of a recognized Institute/University.

**Organization:** The programme will be of four-semester duration. In the first semester there are six courses. In the second semester there are six courses out of which three courses are electives. The third and fourth semesters are completely devoted for dissertation. All courses will have three tests and a final examination. Half yearly evaluation of the dissertation takes place at the end of the third semester. At the end of the final semester the student submits the thesis and makes a presentation about the project, which is evaluated by the committee consists of Internal and External examiners. Visits to various DRDO labs, National Laboratories, etc are planned to enhance student’s appreciation & understanding of the subject.

The details of the courses offered under the programme are given below:
## M.Tech. in Aerospace Engineering (Air Armaments)

### Semester I

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Course Code</th>
<th>Course</th>
<th>Credits</th>
<th>Total Credits (*)</th>
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<td>L</td>
<td>T/P</td>
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<tr>
<td>1</td>
<td>AM 607</td>
<td>Mathematics for Engineers</td>
<td>3</td>
<td>1</td>
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<tr>
<td>2</td>
<td>AFW 601</td>
<td>Ballistics of Bombs &amp; Projectiles</td>
<td>3</td>
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<tr>
<td>3</td>
<td>AFW 602</td>
<td>Design of Air Armament - I</td>
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<td>4</td>
<td>AE 601</td>
<td>Aerospace Propulsion</td>
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<td>5</td>
<td>AE 602</td>
<td>Aerodynamics</td>
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<td>6</td>
<td>AE 605</td>
<td>Flight Mechanics</td>
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<tr>
<td><strong>Total</strong></td>
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<td></td>
<td><strong>18</strong></td>
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</table>

### Semester II

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Course Code</th>
<th>Course</th>
<th>Credits</th>
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<td></td>
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<td>T/P</td>
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<tr>
<td>1</td>
<td>AFW 603</td>
<td>Air Armament Control &amp; Guidance</td>
<td>3</td>
<td>1</td>
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<tr>
<td>2</td>
<td>AFW 604</td>
<td>Airborne Weapon System Effectiveness</td>
<td>3</td>
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<td>3</td>
<td>AFW 605</td>
<td>Warhead Design and Mechanics</td>
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<td>4</td>
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<td>Elective-I [From Department]</td>
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Note: 04 weeks Practice school during summer vacation for scholarship students.

### Semester III

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<td>M.Tech Dissertation Phase I</td>
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Semester IV

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**Contact Hours/week**

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<tbody>
<tr>
<td>1</td>
<td>AFW 606</td>
<td>Design of Air Armament - II</td>
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<td>2</td>
<td>AFW 607</td>
<td>Testing and Certification of Air Armament Stores</td>
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<td>AFW 608</td>
<td>Fire Control Systems</td>
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<td>AE 604</td>
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<td>8</td>
<td>AE 609</td>
<td>UAV Guidance &amp; Control</td>
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<td>AE 610</td>
<td>UAV Design</td>
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<td>Computational Aerodynamics</td>
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<td>Experimental Aerodynamics</td>
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<td>AE 613</td>
<td>Structural Dynamics and Aero-elasticity</td>
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<td>Estimation and Tracking for Aerospace Applications</td>
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<td>AE 621</td>
<td>Ducted Rocket &amp; Combustion</td>
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<td>Open electives from other Departments</td>
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M. Tech. in Aerospace Engineering (UAVs)
Brief Description: The program consists of courses in the areas related to UAVs and dissertation work. The curriculum of the program was formulated to meet the needs of the tri-services, Defence R&D Organization, and Public Sector Undertakings dealing with UAVs and related technologies.

Eligibility: B.E./B. Tech. degree in Aerospace, Aeronautical or AeSI / Mechanical/ Electronics/ Electrical/ Electronics and Communication from recognized university.

Organization: The programme will be of four-semester duration. In the first semester there are six courses. In the second semester there are six courses out of which three courses are electives. The third and fourth semesters are completely devoted for dissertation. All courses will have three tests and a final examination. Half yearly evaluation of the dissertation takes place at the end of the third semester. At the end of the final semester the student submits the thesis and makes a presentation about the project, which is evaluated by the committee consists of Internal and External examiners. Visits to various DRDO labs, National Laboratories, etc are planned to enhance student’s appreciation & understanding of the subject.

The details of the courses offered under the programme are given below:
# M. Tech. in Aerospace Engineering (UAVs)

## Semester I

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<tr>
<td>1</td>
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<td>AE 601</td>
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<td>Aerodynamics</td>
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17
No. | Code | Course Code | L | T/P | Credits (*) |
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1   | AE 652 | M.Tech. Dissertation Phase II | 28** | | 14 |

**Contact Hours/week

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<td>AE 611</td>
<td>Computational Aerodynamics</td>
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**AE 601 Aerospace Propulsion**

**Introduction:** Classification & mode of operation of various Propulsion Systems.

**Basic Thermodynamics & Fluid Dynamics:** Thermodynamic Laws, Conservation laws for mass, momentum and energy, Thrust Equation, Compressible flow, Isentropic Relations, Normal & Oblique Shock Waves, Quasi One-Dimensional flow through variable area ducts, Flow with Friction and Heat Transfer.

**Gas Turbine Engine:** Parametric Analysis of Ideal Turbojet, Turbofan & Turboprop engine, Specific Fuel Consumption, Propulsive, Thermal & Overall Efficiency, Component Performance (Subsonic & Supersonic Inlets, Axial and Centrifugal Compressors, Combustor, Turbine & Nozzle)

**Piston Engines:** Cycle Analysis, Engine Components and Classification, Engine Systems (Fuel Injection, Ignition, Lubrication, Supercharging, Inter Cooling)


References


AE 602 Aerodynamics
Incompressible flow: Introduction, Governing equations, Flow kinematics, Elementary flows, Non-lifting and lifting flows, Flow over airfoils; Kutta-Joukowski theorem, Kutta condition, Kelvin’s theorem, Thin airfoil theory; Flow over wings; Prandtl’s lifting line theory; Viscous fluid flow, Turbulent flow, flow separation, Boundary layer.
Aerodynamic characteristics of an aircraft; Aerodynamic characteristics of an UAV/MAV; Aerodynamic characteristics of a missile.

Introduction to experimental aerodynamics.

Text/References:


**AE 603 Navigation, Guidance & Control**

**Navigation:** Navigation systems and principles of operation. Continuous waves and frequency modulated radars, MTI and Doppler radars; types of navigation: ILS, Optical landing, VOR, INS, and GPS.

**Guidance:** Classification and phases of missile guidance. Guidance laws: pursuit, LOS, CLOS, BR and PN laws. Advance Guidance Systems such as Imaging, Scene Correlation, Millimeteric wave, Non-LOS Guidance Systems, Laser Based Guidance Systems.

**Control:** Classical linear time invariant control systems, transfer function representations, stability, Time domain characteristics, Frequency domain characteristics, Root Locus, Nyquist and Bode plots, Introduction to state space analysis.

**Texts/References:**


**AE 604 Aerospace Structures**


Introduction to Aerospace Materials – Metal Alloys and Fiber Reinforced Composite.

Introduction to different types of constructions: Monocoque, Semi-Monocoque, Truss, and Corrugated shell.

Introduction to Aircraft and Missile Structural Components: Spars; Ribs; Stringer; Longerons.

Analysis of stress; Analysis of strain.

Material Constitutive Relations; Analysis of pressure vessels; Bending, Shear and torsion of thin-walled members; Buckling of Columns; Failure Theories;

Introduction to Vibration and Fatigue.

**Texts/References:**


Text/References:

Suggested References:

AE 606 Flight Instrumentation

Basic concepts of measurements: Generalized characteristics of sensors, instruments, and measurement systems. Measurement of physical quantities such as pressure, force, altitude, temperature, flow, strain and vibration, and angle of attack. Inertial sensors: gyroscope and accelerometer with recent advancements therein.

Signal processing: Operational amplifiers, instrumentation and Charge amplifiers. Analog to digital and digital to analog converters. Data acquisition system.

Data transmission: Signal transmission by analog and digital means, methods of modulation and demodulation, multiplexing time division and frequency division, telemetry systems and trajectory tracking devices such as Electro-optic tracking systems.

Tracking and data fusion: Thermal imagining system, scanning techniques, detectors and range analysis and multi sensor data fusion for trajectory analysis.

Texts/References:

**AE 607  Missile Guidance & Control**

**Missile Kinematics:** Kinematics of various courses, time of flight, lateral acceleration demand and turning rate spectrum for each case.

**Guidance Laws:** Optimal guidance, Advanced PN guidance laws, comparative study of different guidance schemes.

**Inertial Guidance:** Introduction, inertial sensors, coordinate systems and its transformation, Schuler tuning and gimbaled platform systems. Guidance used for ballistic missiles.

**Missile control methods:** Aerodynamic and thrust vector control, Polar and Cartesian control

**Mathematical modeling:** Force and moment equations. Linearization. Transfer function representation of airframe

**Missile servo system:** Hydraulic, Pneumatic and Electromechanical

**Missile instruments:** accelerometer, gyroscopes, altimeter, resolvers

**Autopilot design based on classical approach:** Roll stabilization. Lateral autopilots based on various combinations of rate gyro and accelerometer feedbacks. Three loop autopilot.

**Modern control of missile:** State space representation of missile dynamics. Controllability and Observability. State feedback control, Pole placement techniques, Design of observers. Missile autopilot designs based on state space methods.

**Text/References:**


**AE 608  Missile Propulsion**

**Introduction:** Classification and characteristics of various propulsive devices used for Missiles & Weapon Systems.

**Thermodynamic Cycle Analysis:** Engine cycles (Turbojet, Turbofan, Pulsejet, Ramjet and Rocket Engine). Thrust equation, specific impulse & fuel consumption. Thermal efficiency, propulsive efficiency & overall efficiency of propulsion systems.


Text/References:

4. M. J. Zucrow, Gas Dynamics, John Wiley & Sons; Volume 1, 1976

AE 609 UAV Guidance & Control

UAV Guidance: Overview of UAV guidance techniques, General guidance laws for UAVs, Kinematic models for guidance, Path planning, Way-point guidance, Path following for straight
line and orbits, Guidance of swam of UAVs, obstacle avoidance guidance. Vision Based Navigation and Target Tracking for Unmanned Aerial Vehicles

**Inertial guidance:** Introduction, inertial sensors, coordinate systems and its transformation, Schuler tuning and related issues. INS systems, GPS-INS Integration, Data fusion.

**Servo systems:** Electromechanical


**Text/References:**


**AE 610 UAV Design**


Aircraft design; UAV system design. UAV system identification. UAV project life cycles. Stages of Aircraft design. Initial sizing: aircrafts and of UAVs. UAV aerodynamics, structures and propulsion. Ground control systems. Ground and flight testing of UAVs. UAV guidance and Navigation. Design for reliability.

Introduction to UAV system Development.

**Text books:**


**AE 611 Computational Aerodynamics**
Governing equations, model equations and classification of PDEs. Euler equations, Navier Stokes equations, Burger’s equation.

Introduction to finite difference, finite element and finite volume methods.

Basics of grid generation. Structured grid, unstructured grid

Analysis of numerical schemes for accuracy, stability, dispersion and dissipation. RK method, schemes with spectral-like resolution, Riemann solver, TVD, and ENO. Implementation of boundary conditions.

Boundary layer, shock-capturing, turbulence, aeroacoustic and aeroelastic computations.

Textbooks:


AE 612 Experimental Aerodynamics

Need and Objectives of Experimental study, Fundamentals of Aerodynamics, Governing equations.

Wind Tunnels: Classification of wind tunnels, Subsonic wind tunnel, Transonic wind tunnel, Supersonic wind tunnel, Hypersonic wind tunnel, Special purpose wind tunnels: Icing tunnel, plasma tunnel, shock tubes, atmospheric tunnel, automobile wind tunnel etc., Wind Tunnel Instrumentation & Calibration, Wind tunnel balances.

Pressure Measurements: Manometers, Pressure Probes, Pressure transducers, Pressure sensitive paints.

Velocity measurements: Pressure-based velocity measurements, Hot-wire anemometers (CTA & CCA), Laser Doppler anemometer (LDA), Particle Image Velocimetry (PIV).

Temperature Measurements: Thermocouples, RTD, Temperature sensitive paints, Pyrometers.

Flow Visualization: Surface flow visualization, Tufts, Particle tracer methods: Smoke or Die injection method, Smoke wire, Helium or Hydrogen bubble technique, Optical methods: Shadowgraph, Schlieren photography and Interferometry. Measurement of aerodynamic forces and moments.

Specific experimental environments & measurement techniques, Flight testing, Data acquisition, Data processing, Uncertainty analysis.

Text/References:

AE 613 Structural Dynamics and Aero-elasticity


Continuous systems: Vibration of strings, bars, and beams (Euler and Timoshenko beam theories); Various boundary conditions; Determination of natural frequencies and modes; Modeling of damping, Rayleigh method, Steady state and transient response using modal analysis, Approximate methods for computing natural frequencies and modes.

Aeroelasticity: Static and dynamic aeroelasticity, Discrete models for aeroelastic problems, Steady state aeroelastic phenomenon with specific reference to wing divergence and control system reversal. Flutter analysis and prediction.

Texts/ References:


AE 614 Estimation and Tracking for Aerospace Application

Prolog: Historical Review Of Estimation Theory, Application of Estimation Theory in Engineering, Application to Aerospace Problem (Online and Online Estimation).


- Online Estimation Theory:
  a) Linear dynamical systems with random inputs: Linear stochastic systems, objectives. Continuous-time linear stochastic systems: state space model and solution of continuous-time state-space representation. Discrete-time linear stochastic systems: state space model and solution of discrete-time state-space representation.
c) **Estimation for kinematic models:** Discretized continuous-time kinematic modes. Direct discrete kinematic models. LS and KF estimation for noiseless kinematic models. Steady state filters ((α, β)) tracker for noisy kinematic models. Process and Measurement Noise.


**Application of Estimation Theory To Aerospace Problem:** Parameter Estimation of Spring mass damper system, Aerodynamic Parameter Estimation, Sensor bias estimation, Design of Radar and Seeker online Tracker

Solving the assignment problems using MATLAB tool boxes is mandatory. This proposed course is modification of current elective **AE 615 Estimation with Applications to Tracking and Navigation**

**References**


**AE 615 Nonlinear and Robust Control**


**Texts/References:**


**AE 616 Avionics**
Maps and geodesy; co-ordinate systems and transformations; great circle and rhumb line navigation; dead reckoning; INS-gyrosopes and accelerometers, platform stability and strapped down INS; horizontal and vertical mechanizations in INS; baro-altimeter, air speed indicator, compass and gyro compass; radio navigation - beacons, VOR, DME, LORAN and other nav-aids; primary and secondary surveillance radars; Doppler navigation; GPS principles - space and control segments architecture; DOP and computation of position and velocity; GPS in air, surface and space navigation; considerations in air traffic control. Aids to approach and landing. Head-Up displays: Helmet mounted displays; Head-down displays. Data fusion. Displays Technology. Control and data entry. Radar and communication FMS. Avionics system integration. Data bus. Introduction to safety systems.

Texts/References:

1. Albert Helfrick, Principles of Avionics, Avionics Communications, 2009

AE 617 Robotic Path Planning and Control


Unit III: Linear Second Order-Order SISO Model of a Manipulator Joint, Joint Actuators, Partitioned PD Control Scheme, PID Control Scheme, Computed Torque Control, Force Control of Robotic Manipulators, Description of force control tasks, Force control strategies, Hybrid Position/ Force Control, Impedance Force/ Torque Control.

Textbooks:


AE 618 Signals and Systems

Representation of Signal: Continuous and discrete time signals - definition and mathematical representation of basic signals- step, impulse, ramp and exponential signals. Classification of Signals Periodic, aperiodic, even, odd, energy and power signals. Deterministic and random signals, complex exponential and sinusoidal signals, periodicity. Transformations:
time scaling, time shifting. Determination of Fourier series representation of continuous time and discrete time periodic signals. Explanation of properties of continuous time and discrete time Fourier series.


- **Design of Frequency Domain Filters**: Design of low-pass, high-pass, notch filters. Solving the assignment problems using MATLAB tool boxes is mandatory.

**References**


**AE 619 Optimal Control with Aerospace Applications**

- **Introduction and review of basic concepts**: Introduction, motivation and overview, matrix algebra, review of numerical methods.

- **Static optimization**: Unconstrained optimization, constrained optimization - Lagrange

**Optimal control of continuous time system by indirect method:** Optimal control through calculus of variation, Euler-Lagrange necessary condition, Legendre necessary condition, Jacobi necessary condition, Bolza problem, Mayer problem, Lagrange problem. Some sufficiency conditions to the simplest problem, Transversability conditions, Complete optimal control formulation using calculus of variation. Fixed terminal time and free terminal time problem, Continuous-time linear quadratic regulator (LQR). Steady-state closed-loop control and suboptimal feedback, Numerical solution of two-point boundary value problem.

**Optimal control of continuous time system by direct method:** Simple shooting method, Multiple shooting method, Collocation method, Pseudo spectral methods.

**Comparison of direct and indirect method of solution:** Solution of Brachistochrone problem, Flight Vehicle trajectory optimization using both methods with in flight path constraints and terminal constraints. Advantages and disadvantages of indirect and direct methods.

Solving the assignment problems using MATLAB tool boxes is mandatory.

**References:**


**AE 620 Advanced Missile Guidance**

**Inertial Navigation Systems:** Kinematics, Angular Velocity and torque equations of gimbaled system, errors in INS; Strap Down Inertial Navigation System: Inertial Alignment System, flow diagram and direction cosine computation algorithm of SDINS.

**Global Positioning System:** Introduction, modes of operations, signals and codes, position fixing, Differential GPS and GPS coordinate transformation. Kalman filtering and integration of GPS and INS.

Guided missile design: Top down approach; Guidance & control systems specifications, specifications on aerodynamics, Roll dynamics & rolling moment gradient limit, Autopilot & it’s hardware. Requirements, Seeker specifications- Range, Antenna & radome slope error specs RF & IR Seeker based Guidance, Seeker angle tracking and stabilization systems – Isolation & Decoupling; Nominal scheme & Decoupling loop scheme based approach for guidance – Generic performance comparison; LOS reconstruction approach for faster cost effective homing guidance, performance comparisons of different schemes through 3-DOF simulations. Radome error modelling, Guidance & control system with radome error-static effects and dynamic effects, Deleterious effects of radome error on guidance, Radome error characterization and compensation

Seeker estimator: Inside and outside seeker mechanization, performance comparison, eclipsing effects & performance-Multiple PRF seeker

Text/References

2. G.M. Siouris, Missile Guidance and control systems, springer verlag, New Yor, 2004

AE 621 Ducted Rocket & Combustion

Ramjet and integral rocket ramjet: Thrust and thrust coefficients, effective jet velocity, Combustion efficiency, Classification and comparison of IRR propulsion system. Two-phase nozzle flows, Scramjet, Solid fuel ramjets, Advances in Propulsion Technology.

Experimental techniques for rocket testing: General layout of solid, liquid, and IRR Thrust stand, auxiliaries, safety measures. Thrust, pressure, flow and temperature measurements. Evaluation of tests.

Combustion: Pre-mixed flames - flame speed, inflammability limits, one dimensional flame propagation, Diffusion flames, Detonation and deflagration.

Texts/References:

3. K. Kuo, Principles of Combustion, 2nd Ed, John Wiley & Sons, 2005

AFW 601 Ballistics of Bombs & Projectiles

dynamics, plane trajectory, boost plane trajectory models, rocket accuracy (dispersion and stability), rocket-assisted projectiles. Bomb Ballistics: Aerodynamic forces and moments acting on a bomb, Drag co-efficient, Terminal velocity and Ballistic index, Trajectory of bombs, Simulated stores (similitude) and their trajectories, Bomb stability derivatives and analysis (in roll, pitch and yaw), wind tunnel testing, Bomb trajectory calculations with point mass and Six Degrees of Freedom Equations. Calculation of Moment of Inertia and Centre of Gravity of bombs.

Text/References:


AFW 602 Design of Air Armament - I

Aerodynamics Decelerators: definitions, types, applications of parachute for escape, recovery and armaments systems. Supersonic inflatable decelerators.


Parachute materials, porosity of fabric. Parachute & reefing system design, Case study on design of parachute recovery and landing system. Testing of Parachutes

Design of aircraft bombs & tail units: Classification, design data, factors affecting bomb design, spatial functioning considerations, bomb design for stability and accuracy requirements. Design and use of cluster bomb.

Design of HE Bomb: Bombs case design, analysis of stresses in thin and thick cylinders, various failure theories, stages of manufacturing of forged bomb case


Fuses: Classification, general design considerations, principles of fuse initiation, design, working and safety features of mechanical fuses, safety & arming devices. Introduction to electrical, electronic fuses, proximity and long delay fuses. Latest trends in fuse development.
**Guided Bombs:** Classification and types, Design Criteria, Working principle, Type of Lasing equipment (LDP, PLDs, UAV assisted). Range Enhancement techniques.

**Chaffs, flares, EAX and power cartridges:** Basic principles, design aspect and lifting methodology.

**Text/References:**

1. Text Book of Air Armament, Royal Air Force publication.
3. Air Force Wing Précis on Stores Separation.
6. Air Force Wing Précis on Bomb and Fuse Design.

**AFW 603**

**Air Armament Control & Guidance**

Basic design features, Design Criteria, Classification and types of Air Launched Missiles, Specific design requirements.

**Missile Controls:** Missile control methods: Aerodynamic and thrust vector control, Polar and Cartesian control.

**Mathematical modeling:** Force and moment equations. Linearization, Transfer function representation of airframe.

**Missile servo system:** Hydraulic, Pneumatic and Electromechanical.

**Missile instruments:** Accelerometer, gyroscopes, altimeter, resolvers.

**Autopilots Design:** Autopilot design based on classical approach: Roll and roll rate stabilization. Lateral autopilots based on various combinations of rate gyro and accelerometer feedbacks. Three loop autopilot.

**Introduction to sensors & signal processing**


**Guidance System:** Classification of guidance system, phases of guidance, command guidance, MMW seeker head, image infra-red, scene correlation area navigation system and laser based system. Introduction to INS and SDINS.

**GPS:** Introduction, description of satellite coordinates and calculation of user coordinates. Concept of GPS INS integration.

**Missile Kinematics:** Trajectory computation, time of flight, Lateral acceleration demand and turning rate for various courses.

**Text/References:**

AFW 604 Airborne Weapon System Effectiveness

**Basic tools and methods used in Weaponeering:** Weaponeering process, elementary statistical methods, weapon trajectory, delivery accuracy of guided & unguided armaments, target vulnerability assessment, introductory and advanced methods.

**Weaponeering process of air launched weapons against ground targets:** single weapon directed against point & area target, Stick deliveries, projectiles, cluster munitions, Weaponeering for specific target (bridges, building, tunnels etc), simple collateral damage modeling, and direct & indirect fire system.

**Introduction to Fire Control System:** definitions, classification, applications of modern FCS.

**Text/References:**


AFW 605 Warhead Design & Mechanics

**Introduction to warhead:** Configuration and classification. Formation of kill mechanisms and target interaction. Omni-directional, directional and directed energy warheads. Explosives used in warheads.


Introduction to Warhead Simulation techniques.

**Text/References:**

AFW 606  

Design of Air Armament – II

**Aircraft Guns:** Design Criteria, Specific design requirements, Energy requirements in aircraft guns (automatic, blowback, recoil and gas operation), Gatling guns, kinematics diagram. Design of buffers & recuperators, Gun barrels designing and rifling, muzzle breaks & boosters, Current trends in aircraft automatic gun design.

**Aircraft Ammunition:** Classification and types of ammunition, Design Criteria, Specific design requirements, Gun ammunition propellant and their characteristics, optimization of grain size for a given weapon. Cartridge case design, Ignition system design, Stability of projectile, driving band design, stresses in shells. Terminal considerations and design of ac gun ammunition fuses. Modern trends in ammunition design.

**Aircraft Rockets:** Design considerations, proof and testing of aircraft rockets.

**Text/References:**


AFW 607  

Testing and Certification of Air Armament Stores


**Weapon Accuracy Analysis:** Concept of probability, probability distribution, systematic and random errors, error in fire dispersion, probability of kill SSKP, CKP, CEP, (SE, PE, MAE,CPE, CD, EPE,SPE).

**Carriage & Release:** Design criteria for location of weapon station, Effects of external Carriage and Advanced Carriage concepts, calculation of lug & sway brace reactions for single & twin suspension configuration, Bomb carriers. MIL STD 8591, 7743, 1289.

**Mathematical Concept of Stores Separation & Towed body:** Similarity concept, stores trajectory simulation, modeling of stores separation.

**DDPMAS -2002:** Definition, Process of development, Development Phase, Production Phase, Indigenization, Flight Testing by user services.

**Procurement Policy:** Principals of public buying, preparation and approval of ASQRs, Capital & Revenue procurement of stores.
Composite Materials and polymers for AA applications


Text/References:

1. DIAT Air Force Wing Précis and MIL STD 8591, 7743, 1289.
2. Joint services guide on Environmental testing of armament stores and missile JSG-0102-1984 and JSS_0256-01.

AFW 608 Fire Control Systems

Introduction to fire control system: Definitions, classification, application of modern FCS, brief description of aircraft and helicopter FCS.

Theoretical aspects of the FCS problems and its solution

Functional elements of FCS: Acquisition and tracking system, fire control computing system, weapon pointing system, command control & communicating element, data transmitting element, integration of functional element into FCS, compatibility problem.

Design Philosophy: Development of mathematical model & simulation, Model verification & validation, filtering and prediction, accuracy consideration and analysis, hit & kill probability theory, error analysis in FCS, fire control testing.

Designing for reliability, maintainability, ease of operation and safety

Text/References:

3. Air Force Wing Précis.
Department of Mechanical Engineering

About the Department: The Mechanical Engineering Department seeks to combine excellence in education and research with service to Defence. The goal of our academic programmes in mechanical engineering is to provide students with a balance of intellectual and practical experiences that enable them to address a variety of Defence needs. The Department is one of the largest departments.

The Department is known for research and projects in fluid dynamics, heat transfer, finite element methods, vibrations, experimental stress analysis, vehicle dynamics and other areas. Experimental and computational facilities are being continuously upgraded. The Department has established, over the years, a close interaction with the DRDO laboratories and industry. It has carried out a large number of consultancy and sponsored research projects, which have been successfully completed. A number of sponsored research projects are ongoing.

The Department has carried out significant curriculum development work in Mechanical Engineering. Apart from the regular courses the department offers, on a continual basis, a wide variety of short-term intensive programmes for personnel from DRDO laboratories, Armed Forces and industrial establishments. User-oriented M. Tech programmes on Armament/Combat Vehicles and Marine Engineering has been formulated as per the needs of the Defence sector. The Programmes offers a wide choice of specializations, electives and research areas. The department has laboratories
M. Tech. in Mechanical Engineering (Marine Engineering)

**Brief Description:** The aim of the programme is to impart advanced training and to update knowledge in the field of marine systems like gas turbine, engines, tribology, warship transmissions and nuclear engg etc, to engineering officers from Indian Navy, DRDO scientists, DPSUs and GATE qualified students. At the end of the programme the officer/student should be able to undertake R&D work and evaluation of Marine Engineering Equipment systems.

**Eligibility:** Bachelor’s Degree in Mechanical/Marine Engineering of a recognised Institute/University.

**Organization:** M. Tech Mechanical Engineering with specialisation Marine Engineering is a four-semester programme. In the first semester there are six courses. In second semester, there are six courses. In each of these semesters, there will be three tests and a final semester examination of every course. In third semester and fourth semester, only dissertation work is to be completed. Half yearly evaluation of the project takes place at the end of the third semester. At the end of the final semester, student submits a thesis and makes a presentation about the project, which is evaluated by the Internal and External examiners.

Visits to various DRDO labs like NSTL, ARDE, VRDE, Industry like MDL, GSL involved with Indian navy and naval technical facility are planned to enhance student’s appreciation & understanding of the subject and provide them with opportunity to get hands on experience on various test equipment and procedures related to design, manufacturing and testing of Marine Engineering Equipments. The details of the courses offered under the programme:
### Semester I

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Course Code</th>
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### List of Electives

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<th>Course Code</th>
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<td><strong>Elective I, II, III, IV</strong></td>
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<tr>
<td>1.</td>
<td>ME 604</td>
<td>Advanced Materials and Processing</td>
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<tr>
<td>2.</td>
<td>ME 608</td>
<td>Finite Element methods</td>
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<td>3.</td>
<td>ME 611</td>
<td>Design for Manufacturability</td>
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<td>4.</td>
<td>ME 615</td>
<td>Trials &amp; Evaluation of Weapon Systems</td>
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<td>5.</td>
<td>ME 616</td>
<td>Thermal Management of Defence Equipment</td>
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<td>6.</td>
<td>ME 617</td>
<td>Kinematics and Dynamics of Machinery</td>
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<td>7.</td>
<td>ME 618</td>
<td>Composite Structures</td>
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<td>8.</td>
<td>ME 619</td>
<td>Tribology for Design</td>
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<td>9.</td>
<td>ME 627</td>
<td>Fatigue, Fracture and Failure Analysis</td>
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<td>10.</td>
<td>ME 628</td>
<td>Design of Hydraulic and Pneumatic Systems</td>
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<td>11.</td>
<td>ME 629</td>
<td>Design of Experiments</td>
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<td>12.</td>
<td>ME 630</td>
<td>Design of Machinery</td>
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<td>13.</td>
<td>ME 631</td>
<td>Product Design and Development</td>
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<td>14.</td>
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<td>Design Optimization</td>
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<td>15.</td>
<td>ME 633</td>
<td>Mechanical behavior of materials</td>
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<td>16.</td>
<td>ME 634</td>
<td>Experimental Stress Analysis</td>
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<td>ME 636</td>
<td>MEMS: Design, Fabrication and Characterization</td>
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<td>ME 637</td>
<td>Design of Pressure Vessels</td>
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<td>ME 642</td>
<td>Automatic Control Systems</td>
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<td>ME 654</td>
<td>Advanced Heat &amp; Mass Transfer</td>
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<td>ME 655</td>
<td>Performance Testing and Instrumentation</td>
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<tr>
<td>ME 657</td>
<td>Marine Hydrodynamics</td>
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**Notes:**

1. Department has to decide which subjects should be offered as (i) Elective I, II in Semester II
2. Practice school (Optional) of 4 weeks duration during Summer Vacation is included
3. 1 credit in Theory/Tutorial means one contact hour and 1 credit in Practice/Project Thesis means two contact hours.

**Course Name- Advanced Mechanics of Materials**  
**Course Code- ME 602**

**Unit I: Theory of Elasticity**-Introduction, Stress. Differential equations of equilibrium, strain, compatibility conditions, plane problems of elasticity, stress strain relations, stress functions and applications in 2D problems. Pressurized cylinders & rotating disks, Governing equations, Stresses in thick walled cylinder under internal and external pressures. Introduction to experimental stress analysis.

**Unit II: Energy Methods**-Work done by forces and strain energy, reciprocal relations, Castigliano’s theorems, Fictitious load method, statically indeterminate structures, theorem of virtual work, generalization of castigliano’s theorem.

**Unit III: Asymmetrical Bending of beams**-Bending of prismatic bars and unsymmetrical bending. Concept of shear centre in symmetric and un-symmetric bending, Plate bending, bending of curved beams.

**Unit IV: Torsion of non-circular sections**-Introduction, torsion of general prismatic solid section like circular, elliptical, rectangular, triangular shafts, membrane analogy, torsion of thin walled tubes, torsion of thin walled multiple cell closed sections.

**Text/References:**

Course Name- Advanced Fluid Mechanics

Course Code- ME 603


Unit II: Dynamics of Ideal Fluid Motion, Applications, Integration of Euler’s equations of motion. Governing Equations of fluid flow in differential form, Navier-Stokes Equations and exact solutions, Energy Equation and solution of fluid flow with thermal effects.

Unit III: Dimensional Analysis. Prandtl’s Boundary Layer equations, Laminar Boundary Layer over a Flat Plate, Blausius solution. Turbulent flows in two-dimensional channels and pipes, Velocity field, Smooth and Rough pipes, Drag reduction in pipes, Turbulent Boundary Layer over a Flat Plate, Laws of wall over Flat Plates, Effect of Pressure gradient, Boundary Layer control.

Unit IV: Speed of sound and Mach number, Basic equations for one dimensional flows, Isentropic relations, Normal-shock wave, Rankine-Hugoniot relations, Fanno and Rayleigh curve, Mach waves, Oblique shock wave, Prandtl-Meyer expansion waves, Quasi-one dimensional flows, Compressible viscous flows, Compressible boundary layers.

Practice:

- Steady State Determination of heat transfer temperature difference and surface heat transfer coefficient for a single tube in a transversely flowing air stream.
- Determination of the Relationship between Nusselt and Reynolds Number for the forward stagnation point on a cylinder in cross flow using the Direct Heat Transfer Cylinder.
- Determination of the heat transfer rate and the exchanger effectiveness.
- Measure the distribution of Total pressure and Static Pressure along the duct and to compare these with the predictions of Bernoulli’s equation.
- Measure the Temperature of Furnace by using the thermal Image Camera.

Text/References:

2. Boundary Layer Theory, 8th ed, 2000, Herrmann Schlichting, Springer

Course Name- Advanced Materials and Processing

Course Code- ME 604
Unit I: Introduction of advanced materials and its manufacturing processes for engineering applications.

Piezoelectric materials (PZT)- Piezoelectric effect, Dielectric hysteresis, piezoelectric constants, piezoelectric charge constants, dynamic behaviour of PZT transducers, piezoelectric materials and manufacturing techniques (stability, poling and depolarisation).

Unit II: Shape memory alloys (SMA)- Shape memory effect and the metallurgical phenomenon of SMA, Temperature assisted shape memory effect, Visco-elastic behaviour, magnetic shape memory effect. Various shape memory alloys. Manufacturing technology of SMAs.

Unit III: Electro rheological (ER) and magneto-rheological (MR) materials- Characteristics of ER and EM fluids. ER and EM materials.

Unit IV: Composite materials- Design and manufacturing of polymer matrix, metal matrix and ceramic matrix composites. Various forms and type of reinforcements, fillers and additives. Design of composites for structural, wear resistance and high temperature applications.


Text/References:

Course Name- Computational Fluid Dynamics (CFD)
Course Code- ME 607

Unit I: Basic of Computational Fluid Dynamics. Governing Equations of fluid mechanics and heat transfer, physical boundary conditions, basic aspects of Discretization.

Unit II: Finite Difference and Finite Volume formulation of steady/transient one-dimensional conduction equation, Finite Volume formulation of steady one-dimensional convection and diffusion problems,

Unit III: Solution algorithms for pressure-velocity coupling in steady and unsteady flows. discretization equations for two dimensional convection and diffusion.


Practice:
1. Turbulent Flow in a 2D elbow. (use water)
2. Laminar Flow in a 2D Pipe. (use water)
3. Flow over an Airfoil. (use air)
4. Laminar flow over a flat plate.

Text/References:
2. Introduction to Computational Fluid Dynamics, 2005, Anil W Date, Cambridge University Press, NY, USA.

Course Name- Finite Element Methods
Course Code- ME 608

Unit I: Prerequisites to FEM-Application of FEM, Strain- displacement relations, Stress-strain relations, Differential equations of equilibrium, Co-ordinates, basic element shapes, interpolation function, Minimum potential energy. Properties of stiffness matrix, treatment of boundary conditions, solution of system of equations, shape functions and characteristics.

Unit II: 1-D structural problems-Analysis of axial bar element - stiffness matrix, load vector, temperature effects, Quadratic shape function. Analysis of Trusses - Plane Truss elements, Transformation matrix, stiffness matrix, load vector Analysis of Beams - Hermite shape functions – beam stiffness matrix - Load vector - Problems

Unit IV: Scalar field problems-1-D Heat conduction through composite walls, fins of uniform cross section, 2-D heat conduction problems, Torsional problems.


Practice:

(i) Stress Analysis of Plate With Cut-outs using ANSYS/ABAQUS Software
(ii) Modal Analysis Of Cantilever Beam using ANSYS/ABAQUS Software
(iii) Case Studies etc.

Text /References:


3. A First Course in the Finite Element Method by Daryl L. Logan.


Course Name- Mechanical Vibrations
Course Code- ME 609

Unit I: Single Degree of Freedom Systems- Free and forced vibrations of damped and undamped systems; Simple harmonic excitation; steady state response; torsional vibrations.

Unit II: Vibration of Systems with Two Degrees of Freedom- Free and forced vibration of spring-mass-damper systems; torsional vibrations; modal analysis of undamped and damped systems; numerical methods: Matrix iteration, Holzer’s method, Dunkerley’s lower and Rayleigh’s upper bound approximations; Dynamic vibration absorbers
Unit III: Vibration of Multi-degree of Freedom and Continuous Systems: Vibrating string; Longitudinal and torsional vibration of rods; Free and forced vibration of beams; Properties of vibrating systems: Flexibility and stiffness influence coefficients; Reciprocity theorem; Eigenvalue analysis; Orthogonality of eigenvectors; Modal matrix

Unit IV: Experimental methods in vibration analysis: Vibration instruments: exciters, transducers, analysers, measurement devices: vibrometers, velocity meters and accelerometers; Signal analysis techniques: time domain analysis, frequency domain analysis, amplitude and power spectra, coherence, auto and cross correlations, amplitude and frequency modulations; Tests for free and forced vibrations

Unit V: Case studies (A) - Vehicle dynamics: introduction to nonlinear and random vibrations, vehicle subjected to random vibrations (for example an uneven road); Fluid-structure interaction problems: vibration of suspension bridges. Case studies (B) - Introduction to nonlinear and random vibrations, structures subjected to random vibrations, Noise control and acoustics.

Practice:

1. Undamped free vibration test of Single degree of freedom on Vibration Fundamental Trainer (VFT)
2. Frequency response function of spring mass damper system for various damping mediums: air, water, and oil.
3. Beam lateral experiment.

Text Books:

1. Introductory Course on Theory and Practice of Mechanical Vibrations, J.S.Rao, K.Gupta, Revised second edition, New Age International Publishers

Reference Books:


Course Name- Design for Manufacturability
Course Code- ME 611

Unit I: Manufacturing Considerations in Design- Design for manufacture, Tolerencing and tolerance analysis. Processing techniques and limitations for metals, polymers and ceramics.
Influence of materials in processing and tooling on the design of components. Finishing, surface coatings and surface modifications of materials.

**Unit II: Engineering Design**- Design of cast, forged, sheet metal parts and welded constructions. Design for assembly and dismantling, modular constructions. Erection, operation, inspection and maintenance considerations, Ergonomics.

**Unit III: Machining considerations**- Design for accuracy, locating pins and registers, machining in assembly, adjustment. Backlash and clearance adjustment. Examples illustrating the various principles. Available design variants for some of the common basic functional requirements.

**Text/References:**


**Course Name- Trials & Evaluation of Weapon Systems**

**Course Code- ME 615**

**Unit I:** Weapon system requirements. Weapon performance characterization, firing environment and ambient conditions. Factors affecting accuracy and consistency. Statistical methods. Mean and standard deviation, Error estimation due to normal distribution, Probable Errors, test of hypothesis, Design of experiment. Acceptance testing.

**Unit II:** Static test procedures, Shock and vibration tests, Accelerated environmental tests. Closed vessel test. Conditioning chambers. Test methods for evaluation of safety. Static trials of warheads.


**Text/References:**


Course Name- Thermal Management of Defence Equipment
Course Code- ME 616

Unit I: Heat-transfer fundamentals: conduction, convection, radiation, phase change, and heat transfer across solid interfaces.

Unit II: Heat-generating electronic equipment: ICs, power converters, circuit cards and electrical connectors.

Unit III: Thermal management equipment: heat sinks, interface materials, heat spreaders including liquid loops, and air movers. System design: system packaging architectures, facilities, system analysis. Advanced Topics: spray cooling, refrigeration


Text/References

Course Name- Kinematics and Dynamics of Machinery
Course Code- ME 617

Unit I: Machine kinematics- Overview, Degrees of freedom, Links and joints, Grashof condition, 4-bar linkage, slider-crank, and inverted slider crank

Unit II: Machine Dynamics- Newtonian solution method, Force analysis of linkage, Shaking force and torque, Balancing linkage, Flywheels

Unit III: Gears and gear trains- Terminologies of gears and gear trains, Interface, undercutting, contact ratio, Simple gears and compound gear trains, Planetary gear trains

Unit IV: Cam systems- Cam terminologies, Cam function design and sizing

Unit V: Programmable mechanisms- Introduction to industrial manipulators, Kinematic chains and classifications, Coordinate transformation, Forward and inverse kinematics
Text/References:


Course Name- Composite Structures
Course Code- ME 618

Unit I: Introduction composite materials-Classification and characteristics, mechanical behavior of composite materials, basic terminology, and manufacture of laminated fiber-reinforced composite materials, current and potential advantages of fiber-reinforced composite materials, applications of composite materials.

Unit II: Macro-mechanical behavior of lamina-Introduction, stress-strain relations for anisotropic materials, stiffnesses, compliances, and engineering constants for orthotropic materials, restrictions on engineering constants, stress-strain relation for plane stress in an orthotropic material, stress-strain relations for lamina of arbitrary orientation, invariant properties of an orthotropic lamina, strengths of an orthographic lamina, biaxial strength criteria for an orthotropic lamina.

Unit III: Micro-mechanical behavior of lamina-Introduction, mechanics of materials approach to stiffness, elasticity approach to stiffness, comparison of approaches to stiffness, mechanics of materials approach to strength.

Unit IV: Macro-mechanical behavior of laminates-Introduction, Classical Lamination Theory, Special Cases Of Laminate Stiffness, Theoretical Versus Measured Stiffness, Strength Of Laminates, Inter-Laminar Stress.

Unit V: Introduction to design of composites structures-Introduction to structural design, material selection, configuration selection, laminate joints design requirements and design failure criteria, optimization concepts, design analysis philosophy for composite structures.


Unit VII: Testing and characterisation of composites-Lamina strength characterization, tensile testing, compression testing, in-plane shear testing, short beam test, double cantilever beam test. Physical properties characteristion void content evaluation, fibre Volume Fraction Evaluation, DMA, DSC FOR Tg, Wet Properties Of Lamina, NDE Methods, Ultrasonic A-scan and CT-Scan Methods For Chracteristion Of Composites.

Reference books:


Course Name- Tribology for Design
Course Code- ME 619

Unit I: Introduction-Defining Tribology, Tribology in Design - Mechanical design of oil seals and gasket - Tribological design of oil seals and gasket, Tribology in Industry (Maintenance), Defining Lubrication, Basic Modes of Lubrication, Properties of Lubricants, Lubricant Additives, Defining Bearing, Terminology - Sliding contact bearings -Rolling contact bearings, Comparison between Sliding and Rolling Contact Bearings


Unit IV: Hydrodynamic Thrust Bearing-Introduction - Flat plate thrust bearing - Tilting pad thrust bearing, Pressure Equation - Flat plate thrust bearing - Tilting pad thrust bearing, Load - Flat plate thrust bearing - Tilting pad thrust bearing, Center of Pressure - Flat plate thrust bearing - Tilting pad thrust bearing, Friction - Flat plate thrust bearing - Tilting pad thrust bearing

Unit V: Hydrostatic and Squeeze Film Lubrication-Hydrostatic Lubrication - Basic concept - Advantages and limitations - Viscous flow through rectangular slot – Load carrying capacity and flow requirement - Energy losses - Optimum design, Squeeze Film Lubrication - Basic concept -
Squeeze action between circular and rectangular plates - Squeeze action under variable and alternating loads, Application to journal bearings, Piston Pin Lubrications.


**Unit VII: Gas (Air-) Lubricated Bearings** - Introduction, Merits, Demerits and Applications, Tilting pad bearings, Magnetic recording, discs with flying head, Hydrostatic bearings with air lubrication, Hydrodynamic bearings with air lubrication, Thrust bearings with air lubrication.

**Unit VIII: Tribological Aspects of Rolling Motion** - The mechanics of tyre-road interactions, Road grip and rolling resistance, Tribological aspects of wheel on rail contact. **Finite Bearings** - Hydrostatic bearings, Hydrodynamic bearings, Thrust oil bearings, Porous Bearings, Foil bearings, Heat in bearings.

**Practice:**
1. Surface roughness test,
2. Friction & Wear test on Pin on disc Machine
3. Case studies etc.

**Text/ References:**
Unit III: Physical Aspects of Fatigue - Phase in fatigue life - Crack initiation - Crack growth - Final Fracture - Dislocations - fatigue fracture surfaces.


Unit V: Fatigue Design and Testing - Safe life and Fail-safe design philosophies - Importance of Fracture Mechanics in aerospace structures - Application to composite materials and structures.

Text/References:

Course Name - Design of Hydraulic and Pneumatic Systems
Course Code - ME 628


Unit IV: Design of Pneumatic Circuits - Servo systems – Hydro Mechanical servo systems, Electro hydraulic servo systems and proportional valves. Fluidics – Introduction to fluidic
devices, simple circuits, Introduction to Electro Hydraulic Pneumatic logic circuits, ladder diagrams, PLC applications in fluid power control. Fluid power circuits; failure and troubleshooting.

**Text Books:**


**Reference Books:**


**Course Name- Design of Experiments**

**Course Code- ME 629**

**Unit I:** Overview and Basic Principles, Simple Designs and Analysis of Variance,

**Unit II:** Block Designs, Latin Squares and Related Designs, Full Factorial Designs, 2-level Full Factorial and Fractional Factorial Designs.

**Unit III:** Response surface methods and designs, Designs with Random Factors, Nested Designs, and split-plot Designs.

**Text/ References:**


**Course Name- Design of Machinery**

**Course Code- ME 630**

**Unit I: Introduction**- Classification of mechanisms – Basic kinematic concepts and definitions – Degree of freedom, Mobility – Kutzbach criterion, Grueblers criterion – Grashofs Law – Kinematic inversions of four-bar chain and slider crank chains – Limit positions – Mechanical


Unit III: Dynamics of mechanisms/machineries-Dynamics Fundamentals, Dynamic Force Analysis, Balancing, Engine Dynamics, Multi cylinder Engines.


Text/References:

Course Name- Product Design and Development
Course Code- ME 631
Unit I: Introduction- Significance of product design, product design and development process, sequential engineering design method, the challenges of product development,

Unit II: Product Planning and Project Selection- Identifying opportunities, evaluate and prioritize projects, allocation of resources Identifying Customer Needs: Interpret raw data in terms of customers need, organize needs in hierarchy and establish the relative importance of needs.,
Unit III: Product Specifications- Establish target specifications, setting final specifications, Concept Generation: Activities of concept generation, clarifying problem, search both internally and externally, explore the output.

Unit IV: Industrial Design-Assessing need for industrial design, industrial design process, management, assessing quality of industrial design, Concept Selection: Overview, concept screening and concept scoring, methods of selection.

Unit V: Theory of inventive problem solving (TRIZ)- Fundamentals, methods and techniques, General Theory of Innovation and TRIZ, Value engineering Applications in Product development and design, Model-based technology for generating innovative ideas

Unit VI: Concept Testing- Elements of testing: qualitative and quantitative methods including survey, measurement of customers’ response. Intellectual Property- Elements and outline, patenting procedures, claim procedure, Design for Environment- Impact, regulations from government, ISO system.,

Text/References:

4. Inventive thinking through TRIZ: a practical guide, By Michael A. Orloff, Springer

Course Name- Design Optimization
Course Code- ME 632


Unit III: Multi Variable and Constrained Optimization Techniques-Optimality criteria - Direct search Method - Simplex search methods - Hooke-Jeeve’s pattern search method -
Powell’s conjugate direction method - Gradient based method - Cauchy’s method - Newton’s method - Conjugate gradient method. Kuhn - Tucker conditions - Penalty Function - Concept of Lagrangian multiplier - Complex search method - Random search method

Unit IV: Intelligent Optimization Techniques - Introduction to Intelligent Optimization - Soft Computing - Working principles of Genetic Algorithm Types of reproduction operators, crossover & mutation. - Simulated Annealing Algorithm - Particle Swarm Optimization (PSO) - Graph Grammer Approach - Example Problems

Unit V: Engineering Applications - Structural applications - Design of simple truss members. Design applications - Optimum design of simple axial, transverse loaded members - Optimum design of shafts - Optimum design of springs. Dynamic applications - Optimum design of single, two degree of freedom systems and gear vibration absorbers. Mechanisms applications - Optimum design of simple linkage mechanisms

Text/References:

5. R.Saravanan, Manufacturing optimization through intelligent techniques, Taylor & Francis, Publications.

Course Name- Mechanical Behavior of Materials
Course Code- ME 633

Unit I: Introduction to deformation behaviour- Concept of stresses and strains, engineering stresses and strains, Different types of loading and temperature encountered in applications, Tensile Test - stress – strain response for metal, ceramic and polymer, elastic region, yield point, plastic deformation, necking and fracture, Bonding and Material Behaviour, theoretical estimates of yield strength in metals and ceramics.

Unit II: Elasticity Theory- The State of Stress and strain, stress and strain tensor, tensor transformation, principal stress and strain, elastic stress-strain relation, anisotropy, elastic behaviour of metals, ceramics and polymers.

Unit III: Yielding and Plastic Deformation- Hydrostatic and Deviatoric stress, Octahedral stress, yield criteria and yield surface, texture and distortion of yield surface, Limitation of engineering strain at large deformation, true stress and true strain, effective stress, effective
strain, flow rules, strain hardening, Ramberg- Osgood equation, stress - strain relation in plasticity, plastic deformation of metals and polymers.

**Unit IV: Microscopic view of plastic deformation**- crystals and defects, classification of defects, thermodynamics of defects, geometry of dislocations, slip and glide, dislocation generation - Frank Read and grain boundary sources, stress and strain field around dislocations, force on dislocation - self-stress, dislocation interactions, partial dislocations, twinning, dislocation movement and strain rate, deformation behavior of single crystal, critical resolved shear stress (CRSS), deformation of poly-crystals - Hall-Petch and other hardening mechanisms, grain size effect - source limited plasticity, Hall- Petch breakdown, dislocations in ceramics and glasses.

**Unit V: Fracture**- Fracture in ceramics, polymers and metals, different types of fractures in metals, fracture mechanics – Linear fracture mechanics -KIC, elasto-plastic fracture mechanics - JIC, Measurement and ASTM standards, Design based on fracture mechanics, effect of environment, effect of microstructure on KIC and JIC, application of fracture mechanics in the design of metals, ceramics and polymers.

**Unit VI: Deformation under cyclic load- Fatigue**- S-N curves, Low and high cycle fatigue, Life cycle prediction, Fatigue in metals, ceramics and polymers.

**Unit VII: Deformation at High temperature**- Time dependent deformation - creep, different stages of creep, creep and stress rupture, creep mechanisms and creep mechanism maps, creep under multi-axial loading, microstructural aspects of creep and design of creep resistant alloys, high temperature deformation of ceramics and polymers.

**Text/References:**


**Course Name- Experimental Stress Analysis**

**Course Code- ME 634**

**Unit I: Measurements & Extensometer**-Principles of measurements, Accuracy, Sensitivity and range of measurements. Mechanical, Optical Acoustical and Electrical extensometers and their uses, Advantages and disadvantages.

**Unit II: Electrical Resistance Strain Gauges**-Principle of operation and requirements, Types and their uses, Materials for strain gauge. Calibration and temperature compensation, cross
sensitivity, Rosette analysis, Wheatstone bridge and potentiometer circuits for static and dynamic strain measurements, strain indicators.

**Unit III: Photoelasticity**-Two dimensional photo elasticity, Concept of light – photoelastic effects, stress optic law, Interpretation of fringe pattern, Compensation and separation techniques, Photo elastic materials. Introduction to three dimensional photo elasticity.

**Unit IV: Brittle Coating and Moire Methods**-Introduction to Moire techniques, brittle coating methods and holography.

**Unit V: Non-Destructive Testing**-Fundamentals of N DT, Radiography, ultrasonic, magnetic particle inspection, Fluorescent penetrant technique, Eddy current testing, Acoustic Emission Technique.

**Text Books:**


**Reference Books:**


**Course Name- CAD/CAM**

**Course Code- ME 635**

**Unit I:** Criteria for selection of CAD workstations, Shigle Design Process, Design criteria, Geometric modeling, entities, 2D & 3D Primitives.


**Unit III:** Surface entities, Surface Representation. Analytic Surface – Plane Surface, Ruled Surface, Surface of Revolution, Tabulated Cylinder. Synthetic Surface-Cubic, Bezier, Bspline, Coons. Graph Based Model, Boolean Models, Instances, Cell Decomposition & Spatial – Occupancy Enumeration, Boundary Representation (B-rep) & Constructive Solid Geometry (CSG).

Text/References:


Course Name- MEMS - Design, Fabrication, and Characterization
Course Code- ME 636

Unit I: MEMS Fabrication- Conventional MEMS fabrication using VLSI technology: lithography, chemical etching: isotropic and anisotropic, Plasma etching, reactive ion etching (RIE), oxidation, chemical vapour deposition (CVD), LPCVD, PECVD, surface micromachining, LIGA, single layer and higher layer fabrication. Non-conventional MEMS fabrication: laser micromachining and welding, processing of metals and nonmetals with laser, Electro Discharge and Electro Chemical micromachining (EDM and ECM), Microstereolithography: scanning process, dynamic mask process. Electronic packaging.

Unit II: MEMS: Design and Analysis- Basic concepts of design of MEMS devices and processes, Design for fabrication, Other design considerations, Analysis of MEMS devices, FEM and Multiphysics analysis, Modeling and simulation, connection between molecular and continuum mechanics, MEM system level analysis from perspective of control theory.


Text/References:


Course Name- Design of Pressure Vessels
Course Code- ME 637


Unit III: Buckling Of Vessels-Buckling phenomenon – Elastic Buckling of circular ring and cylinders under external pressure – collapse of thick walled cylinders or tubes under external pressure – Effect of supports on Elastic Buckling of Cylinders – Buckling under combined External pressure and axial loading.

Text/References:


Course Name- Warship Transmission and Tribology
Course Code- ME 641
Unit I: Warship Transmission Design- Specifications, design and design checks of Marine Gearboxes (Spur and helical gears, Gear Tooth loads, Bearing loads, Reaction torque, Causes and classification of gear failures, gear noise and stress analysis).

Unit II: Shafting- Shafting (NES requirements, torsional and bending strength calculations), Shaft-line Bearings (NES requirements, types, numbers and load distribution), Clutches and Couplings

Unit III: Tribology- Theory of wear, its types and reduction, Theory of hydrodynamic lubrication, properties of marine lubricants, Bearings classification, selection, and performance. Theories of design of Journal Bearings and Rolling element bearings with performance and life estimation

Texts Books:

Course Name- Automatic Control Systems
Course Code- ME 642

Unit I: Basic concepts of Automatic Control- Transfer Functions-Modeling of systems-Mechanical, Electrical, hydraulic system block diagram, signal flow graphs, closed and open loop systems. Feedback and Feed forward control system.


Unit IV: Control System Implementations- Pneumatic Systems, Hydraulic Systems, Electrical Systems, Microprocessor Based Systems, Programmable Logic Controllers, Micro Controllers and Network Based Distributed Control Systems,


Texts Books:


Course Name- Ship Dynamics and Marine Systems
Course Code- ME 643


Unit II: Staff Requirements for new ship design- Formulation of requirements, general role, speed, endurance, armament, logistic requirements, procedure for formulating outline, agreed and approved staff requirements, procedure for finalization of ship designs. Choice & Selection of Propulsion System and Auxiliaries

Unit III: General requirements of marine machinery Design for shock protection. Types of main propulsion and their evaluation. Selection of Distillation & Desalination Plants, Power Generation, Air conditioning & Refrigeration, Ships Systems,

Unit IV: NBCD Requirements, Marine Controls and Instrumentation.

Unit V: Trials: Sea trials, their requirements and procedures.

Texts Books

1. Introduction to Naval Architecture, TC Gilmer, Bruce Johnson, Naval Institute Press, 1982.

Course Name- Marine Diesel & Steam Engines
Course Code- ME 644

Unit I: Basic Concepts- Reactive Thermodynamics, complete and incomplete combustion, volumetric efficiency. Design Requirements, Materials, Types of Supercharging
Unit II: Marine Diesel Engine rating, selection, engine-propeller matching - Terminology, Service Rating, Corrections for ambient conditions, Diesel engine Characteristics, Principles of matching, Modifications to allow for Service conditions, Towing Loads, Auxiliary Loads, CPP.


Unit IV: Boiler Design - Boiling process, heat transfer and fluid flow dynamics, boiler design considerations, procedure. Steam cycles analysis: Steam turbine thermodynamics, Simple Rankine cycle, Power output and efficiency calculations, measures to improve cycle performance parameters.

Unit V: Steam turbines - Impulse and reaction turbines, multistaging in turbines, compounding of turbines, design and part load performances, turbine losses. Steam turbine design procedure.

Texts Books


Course Name - Marine Gas Turbines

Course Code - ME 645


Unit II: Turbo Machinery Aerodynamics Design: Compressor design and Performance - Pressure losses separation & friction losses, Definition delta upon D, De Hallers no. Stage loading and flow parameters, degree of reaction, stall, Use of IGVs & VGVs, multi-spooling, variable temp rise distribution. Compressor design co-relations & example.

Unit III: Mechanical Design and Performance of Turbine and Compressors: Blade shapes, methods of design. Velocity triangles, reaction, stage loading, flow coefficient. Design for maximum power. Stage efficiency, over-tip leakage. Design correlations & example. Centrifugal, Gas, Inertia Loads acting on turbo-machinery,

Unit IV: Creep design, Fatigue design, Requirements of naval application. Marine GT Combustors Design. Design & Materials for Marine GTs. Requirements, properties, Super-

**Texts Books/References**


**Course Name- Nuclear Reactor Engineering**

**Course Code- ME 646**

**Unit I: Nuclear Reactor Physics:** Introduction to nuclear physics: nuclear fission, nuclear reactions and radiations. Reactor analysis, reactor kinetics and control,

**Unit II: Nuclear Reactor Engineering:** Thermal & hydraulic aspects of reactor design, energy removal. Core and Fuel design. Reactor process system, reactor fuel design. Design aspects of major reactor components, material selection, shielding design. Overview of nuclear fuel cycle. Different reactor systems,

**Unit III: Nuclear Reactor Safety:** Overview of nuclear safety philosophy, defense in depth principle, different safety systems,

**Unit IV: Health Safety:** Effects of different types of radiation, dosage, radiation monitoring.

**Unit V: Nuclear Reactor Control & Instrumentation:** General features of reactor control, control in reactor operation. Basics of reactor instrumentation, instrumentation range and wide range of detectors used. Visit to BARC Mumbai for one day.

**Texts Books**


**Course Name- Advanced Heat & Mass Transfer**

**Course Code- ME 654**
Unit I: Conduction Heat Transfer - Fourier's law, 1-D heat diffusion equation, 3-D form (Laplacian), Solution, Thermal resistance concept - electrical analogy, Fick's and Ohm's laws, Radial heat conduction, critical radius of insulation, Heat diffusion equation - general form, Transient conduction, extended surface heat transfer

Unit II: Convective Heat Transfer - Applications, Forced, free and mixed convection, Internal and external flow, Heat transfer coefficient and its physical significance, Dimensional analysis in convective heat transfer, Conservation equations - mass, momentum and energy, boundary condition

Unit III: External laminar forced convection - Boundary layer equation, Energy equation and similarity solution for flow over flat plate for various boundary conditions and Prandtl numbers, Scale analysis, Approximate method, Viscous dissipation effect of laminar boundary layer

Unit IV: Internal laminar forced convection - Developing and developed flow and heat transfer in a duct and circular pipe having various boundary conditions

Unit V: Mass convection - Various non-dimensional numbers and their analogy to those of heat transfer, Analogy friction, heat transfer and mass transfer coefficients, Species equations, Examples of simultaneous heat and mass transfer

Unit VI: Heat transfer in phase change - Boiling, Condensation and Radiation - Kirchhoff’s law, Black and grey bodies, Gaseous radiation, Solar energy

Text/References:

1. Convective Heat Transfer by L. C. Burmeister (John Wiley and Sons)
2. Convective Heat Transfer by Adrian Bejan (John Wiley and Sons)
3. Boundary Layer Theory by H Sctllichting (McGraw-Hill)
5. Introduction to Convective Heat Transfer Analysis by Patrick H. Oosthuizen and David Laylor (McGraw-Hill)

Course Name- Performance Testing and Instrumentation
Course Code- ME 655


Unit III: Fundamental & Importance of Instrumentation, types of instruments, selection of instruments, performance of instruments, error in measurement, calibration & standard, Calibration of Instruments: Methods & analysis, Introduction to Transducer & types, Process Instrumentation, recording instruments, indicating & recording Instruments.

Unit IV: Measurements of temperature, pressure, relative humidity, moisture content & velocity & flow.

Reference/Text books:-

2. Engineering Metrology, R KJain, Khanna Publishers, Delhi
4. Industrial Instrumentation, John Wiley Eastern Ltd, New Delhi

Course Name- Marine Hydrodynamics
Course Code- ME 657

Unit I: Ideal and viscous incompressible fluid; Kinematics of fluid; Lagrangian and Eulerian methods of description, velocity, acceleration, streamlines, pathlines, vorticity; Equation of continuity; Euler’s Equations of motion; Bernoulli’s equation and its application,

Unit II: Two dimensional motion - velocity potential, stream function, Sources, sinks, dipoles; Flow past a circular cylinder with and without circulation; Blausius Theorem; Problems on the motion of perfect fluids - steady translation of a cylinder in an infinite fluid medium, unsteady translation; Added mass of cylinders; Spheres;

Unit III: The vortex system-circular vortex, two dimensional sources and vortex distributions, vortex sheets; Lifting Surfaces, Aerofoil theory; Velocity and pressure distribution on aerofoils; Viscous fluids- Navier-Stokes equations, Laminar flow, Poiseuille flow, Couette flow, flow through a pipe; Boundary layer Theory-Reynolds Number; Boundary layer along a flat plate; Blasius solution; Separation, Von Karman momentum integral method;

Unit IV: Introduction to Turbulence; Gravity waves- Airy's wave; Free surface condition; Velocity potential- Dispersion relation; Surface tension effects; Orbital motion; Group velocity and its dynamical significance; Wave energy; Standing waves; Loops and nodes, Wave forces and Morison's equation, Long waves and waves in a canal; Tides.
Text/References:

Course Name- M. Tech. Dissertation Phase– I
Course Code- ME 651

Course Name- M. Tech. Dissertation Phase– II
Course Code- ME 652

--------------------------------------------------------------------------------------------------

M. Tech. in Mechanical Engineering  
(Armament and Combat Vehicles)

Brief Description: DRDO has been involved in the design and development of efficient and economical Combat Engineering & Armament Systems for Indian Armed Forces. The programme is designed to provide students with the principles of Combat Vehicle Technology and Armament Engineering. The programme pays special attention to:

- The study of advances in combat vehicle technology and armament engineering.
- Developing skills in the analysis and evaluation of new concepts against changes and developments in the threat.
- The user requirements needed to meet the threat and its implications.

Eligibility:

1. The eligibility for the postgraduate programme will be Bachelor’s degree in Mechanical/Production/Automobile Engineering disciplines from recognized university.

2. This programme is open for civilian GATE qualified candidates, DRDO Scientists/Officers and Officers from Tri-services. This programme is also open to foreign nationals from the countries approved by GOI.
**Organization:** M. Tech Mechanical Engineering with specialisation in Armament and Combat Vehicles is a four-semester programme. In the first semester there are six courses, in second semester, there are six courses. In each of these semesters, there will be three tests and a final semester examination for every course. In third semester M. Tech. (phase I) dissertation is there and in fourth semester, only dissertation work is to be completed. Half yearly evaluation of the project takes place at the end of the third semester. At the end of the final semester, student submits a thesis and makes a presentation about the M. Tech. project, which is evaluated by the Internal and External examiners.

### Semester I

<table>
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<tr>
<th>S. No.</th>
<th>Course Code</th>
<th>Course</th>
<th>Contact Hours/week</th>
<th>Credits</th>
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<tr>
<td>1</td>
<td>AM 607</td>
<td>Mathematics for Engineers</td>
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<tr>
<td>2</td>
<td>ME 601</td>
<td>Armament &amp; Combat vehicles-I</td>
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<td>3</td>
<td>ME 602</td>
<td>Advanced Mechanics of Materials</td>
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<td>4</td>
<td>ME 609</td>
<td>Mechanical Vibrations</td>
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<td>5</td>
<td>ME 604</td>
<td>Advanced Materials and Processing</td>
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<td>6</td>
<td>ME 605</td>
<td>Introduction to Combat Systems</td>
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### Semester II

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<tr>
<td>1</td>
<td>ME 607</td>
<td>Computational Fluid Dynamics</td>
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<td>2</td>
<td>ME 608</td>
<td>Finite Element Methods</td>
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<td>ME 613</td>
<td>Armour Protection Systems</td>
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<td>4</td>
<td>ME 610</td>
<td>Armament &amp; Combat Vehicles-II</td>
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<td>5</td>
<td>Elective – I</td>
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<td>Elective – II</td>
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### Semester III

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<th>S. No.</th>
<th>Course Code</th>
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<tbody>
<tr>
<td>1</td>
<td>ME 651</td>
<td>M.Tech. Dissertation Phase I</td>
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</table>
## Semester IV

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<th>S. No.</th>
<th>Course Code</th>
<th>Course Name</th>
<th>Contact Hours /week</th>
<th>Credits</th>
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<tbody>
<tr>
<td>1</td>
<td>ME 652</td>
<td>M.Tech. Dissertation Phase II</td>
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<td><strong>Total</strong></td>
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<td><strong>28</strong></td>
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**Contact Hours/week**

* 1 credit in Theory/ Tutorial implies one contact hour and 1 credit in Practice/ Thesis implies two contact hours.

### List of Electives

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<tr>
<th>S. No.</th>
<th>Course Code</th>
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<tbody>
<tr>
<td>1.</td>
<td>ME 611</td>
<td>Design for Manufacturability</td>
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<tr>
<td>2.</td>
<td>ME 612</td>
<td>Modeling and Simulation of Military vehicles</td>
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<td>3.</td>
<td>ME 654</td>
<td>Advanced Heat and Mass Transfer</td>
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<td>4.</td>
<td>ME 614</td>
<td>Unmanned Ground Vehicles</td>
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<td>5.</td>
<td>ME 615</td>
<td>Trials &amp; Evaluation of Weapon Systems</td>
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<td>6.</td>
<td>ME 616</td>
<td>Thermal Management of Defence Equipment</td>
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<td>7.</td>
<td>ME 617</td>
<td>Kinematics and Dynamics of Machinery</td>
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<td>8.</td>
<td>ME 618</td>
<td>Composite Structures</td>
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<td>9.</td>
<td>ME 619</td>
<td>Tribology for Design</td>
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<td>10.</td>
<td>ME 620</td>
<td>High Energy Material Technology</td>
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<tr>
<td>11.</td>
<td>ME 621</td>
<td>Dynamics &amp; Armament Mechanisms</td>
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<td>12.</td>
<td>ME 622</td>
<td>Ballistics of bombs and projectiles</td>
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<td>13.</td>
<td>ME 623</td>
<td>Design of ordnance, basic structure and super structure</td>
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<td>14.</td>
<td>ME 624</td>
<td>Small arms and cannons</td>
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<td>15.</td>
<td>ME 625</td>
<td>Combat Vehicle Technology</td>
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<td>ME 626</td>
<td>Vehicle Dynamics</td>
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<td>ME 627</td>
<td>Fatigue, Fracture and Failure Analysis</td>
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<td>ME 628</td>
<td>Design of Hydraulic and Pneumatic Systems</td>
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<td>ME 629</td>
<td>Design of Experiments</td>
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<tr>
<td>ME 630</td>
<td>Design of Machinery</td>
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<tr>
<td>ME 642</td>
<td>Automatic Control System</td>
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<td>Open Electives from other departments</td>
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</tbody>
</table>
Unit VI: Structural Design and Protection: Structural requirements of armoured and non-armoured vehicles; Armour Failure modes against Kinetic Energy (KE); Chemical Energy (CE), Small Armr and Splinters; Passive Armour - Rolled Homogenous Armour Steels, Aluminiumarmour, Ceramic / Composite armour, Laminated / Spaced Armour, Explosive Reactive Armour; Active Armour - Soft Kill techniques and Hard Kill techniques.

Text/References:

Course Name- Advanced Mechanics of Materials
Course Code- ME 602

Unit I: Theory of Elasticity-Introduction, Stress. Differential equations of equilibrium, strain, compatibility conditions, plane problems of elasticity, stress strain relations, stress functions and applications in 2D problems. Pressurized cylinders & rotating disks, Governing equations, Stresses in thick walled cylinder under internal and external pressures. Introduction to experimental stress analysis.

Unit II: Energy Methods-Work done by forces and strain energy, reciprocal relations, Castigliano’s theorems, Fictitious load method, statically indeterminate structures, theorem of virtual work, generalization of castigliano’s theorem.

Unit III: Asymmetrical Bending of beams-Bending of prismatic bars and unsymmetrical bending. Concept of shear centre in symmetric and un-symmetric bending, Plate bending, bending of curved beams.

Unit IV: Torsion of non-circular sections-Introduction, torsion of general prismatic solid section like circular, elliptical, rectangular, triangular shafts, membrane analogy, torsion of thin walled tubes, torsion of thin walled multiple cell closed sections.

Text/References:

Course Name- Advanced Fluid Mechanics
Course Code- ME 603


Unit II: Dynamics of Ideal Fluid Motion, Applications, Integration of Euler’s equations of motion. Governing Equations of fluid flow in differential form, Navier-Stokes Equations and exact solutions, Energy Equation and solution of fluid flow with thermal effects.

Unit III: Dimensional Analysis. Prandtl’s Boundary Layer equations, Laminar Boundary Layer over a Flat Plate, Blausius solution. Turbulent flows in two-dimensional channels and pipes, Velocity field, Smooth and Rough pipes, Drag reduction in pipes, Turbulent Boundary Layer
over a Flat Plate, Laws of wall over Flat Plates, Effect of Pressure gradient, Boundary Layer control.

Unit IV: Speed of sound and Mach number, Basic equations for one dimensional flows, Isentropic relations, Normal-shock wave, Rankine-Hugoniot relations, Fanno and Rayleigh curve, Mach waves, Oblique shock wave, Prandtl-Meyer expansion waves, Quasi-one dimensional flows, Compressible viscous flows, Compressible boundary layers.

Practice:
- Steady State Determination of heat transfer temperature difference and surface heat transfer coefficient for a single tube in a transversely flowing air stream.
- Determination of the Relationship between Nusselt and Reynolds Number for the forward stagnation point on a cylinder in cross flow using the Direct Heat Transfer Cylinder.
- Investigation of the effect of external fins on the heat transfer watt density of plain tube bundles in cross flow.
- Determination of the heat transfer rate and the exchanger effectiveness.
- Measure the distribution of Total pressure and Static Pressure along the duct and to compare these with the predictions of Bernoulli’s equation
- Measure the Temperature of Furnace by using the thermal Image Camera.

Text/References:
2. Boundary Layer Theory, 8th ed, 2000, Herrmann Schlichting, Springer

Course Name- Advanced Materials and Processing
Course Code- ME 604

Unit I: Introduction of advanced materials and its manufacturing processes for engineering applications.

Piezoelectric materials (PZT)- Piezoelectric effect, Di-electric hysteresis, piezoelectric constants, piezoelectric charge constants, dynamic behaviour of PZT transducers, piezoelectric materials and manufacturing techniques (stability, poling and depolarisation).

Unit II: Shape memory alloys (SMA)- Shape memory effect and the metallurgical phenomenon of SMA, Temperature assisted shape memory effect, Visco-elastic behaviour, magnetic shape memory effect. Various shape memory alloys. Manufacturing technology of SMAs.

Unit III: Electro rheological (ER) and magneto-rheological (MR) materials- Characteristics of ER and EM fluids. ER and EM materials.

Unit IV: Composite materials- Design and manufacturing of polymer matrix, metal matrix and ceramic matrix composites. Various forms and type of reinforcements, fillers and additives. Design of composites for structural, wear resistance and high temperature applications.


Text/References:

Course Name- Introduction to Combat Systems
Course Code- ME 605

Unit I: Threat Spectrum - Types of Conflicts - Low level, Medium level, Heavy conflicts - Combat Vehicle during World Wars I & II - Post world wars Combat Vehicles. Conventional threats - Tank threat, Mine threat, Missile threat; Non-conventional threats - Ariel threat - Aircrafts, Helicopters, Drones - Precision munitions delivered from various platforms - Nuclear threat - Conflicts in builtup areas - Close combat - peace keeping missions.

Unit II: Basic Design parameters - Firepower - Non lethal, low calibre, Heavy calibre (tank / Arty), Cannon launched Missiles; Mobility - Tactical, Strategic, Battle field Mobility - weight, transportability, logistics; Protection - Small arms, Splinters, KE attack, CE Attack, Passive and Active, camouflage and stealth; Command-Control-Communication-Computer-Intelligence (C4I) - Network Centric Warfare - Battlefield Management System - Situational awareness through sensors

Unit III: Vehicle Configuration - On Road and Off Road vehicles; Soft skinned - logistics, strategic transport (special railway wagons and multi-axle road trailers), Medium Armoured (both wheeled and Tracked) - Infantry Combat Vehicles (ICV), Missile / Mortar Carrier Vehicle, Artillery Vehicles, Armoured Repair and Recovery Vehicle (ARRV), Bridge Layer, Main Battle Tank (MBT);

Unit IV: Man Machine Interface - Human System Integration - Ergonomics - Environmental Control System - Packaging of systems

Unit V: Maintainability - Design for maintenance - Maintenance Repair and Overhaul (MRO) - Modularity in design - Adaptability to different missions, Line Replaceable Units
Unit VI: Combat Vehicle Evaluation Techniques - Automotive trials - Specialized test track for automotive trials; Weapon Trials - Special equipment for proving weapon, proving Ammunition and Proving Combat system as a whole; Different types of Trials - Development trials, User trials, Usage trials, Deployment trials.

Text/References:
1) Fighting vehicle, TW Terry, Brassey’s, 1991

Course Name: Computational Fluid Dynamics (CFD)
Course Code: ME 607
Unit I: Basic of Computational Fluid Dynamics. Governing Equations of fluid mechanics and heat transfer, physical boundary conditions, basic aspects of Discretization.
Unit II: Finite Difference and Finite Volume formulation of steady/transient one-dimensional conduction equation., Finite Volume formulation of steady one-dimensional convection and diffusion problems,
Unit III: Solution algorithms for pressure-velocity coupling in steady and unsteady flows. discretization equations for two dimensional convection and diffusion.
Practice:
1. Turbulent Flow in a 2D elbow. (use water)
2. Laminar Flow in a 2D Pipe. (use water)
3. Flow over an Airfoil. (use air)
4. Laminar flow over a flat plate.

Text/References:
6. Introduction to Computational Fluid Dynamics, 2005, Anil W Date, Cambridge University Press, NY, USA.

Course Name: Finite Element Methods
Course Code: ME 608
Unit I: Prerequisites to FEM-Application of FEM, Strain- displacement relations, Stress-strain relations, Differential equations of equilibrium, Co-ordinates, basic element shapes, interpolation
function, Minimum potential energy. Properties of stiffness matrix, treatment of boundary conditions, solution of system of equations, shape functions and characteristics.


Unit IV: Scalar field problems - 1-D Heat conduction through composite walls, fins of uniform cross section, 2-D heat conduction problems, Torsional problems.

Unit V: Dynamic considerations - Dynamic equations - Eigen values, Eigen vector, natural frequencies - mode shapes - modal analysis. 3-D problems - Tetrahedron element - Jacobian matrix - Stiffness matrix, CAD softwares and its applications, Brief description to analysis of Plates & Shells.

Practice:
(iv) Stress Analysis of Plate With Cut-outs using ANSYS/ABAQUS Software
(v) Modal Analysis Of Cantilever Beam using ANSYS/ABAQUS Software
(vi) Case Studies etc.

Text /References:
3. A First Course in the Finite Element Method by Daryl L. Logan.

Course Name- Mechanical Vibrations
Course Code- ME 609

Unit I: Single Degree of Freedom Systems- Free and forced vibrations of damped and undamped systems; Simple harmonic excitation; steady state response; torsional vibrations.

Unit II: Vibration of Systems with Two Degrees of Freedom- Free and forced vibration of spring-mass-damper systems; torsional vibrations; modal analysis of undamped and damped systems; numerical methods: Matrix iteration, Holzer’s method, Dunkerley’s lower and Rayleigh’s upper bound approximations; Dynamic vibration absorbers

Unit III: Vibration of Multi-degree of Freedom and Continuous Systems: Vibrating string; Longitudinal and torsional vibration of rods; Free and forced vibration of beams; Properties of
vibrating systems: Flexibility and stiffness influence coefficients; Reciprocity theorem; Eigenvalue analysis; Orthogonality of eigenvectors; Modal matrix

**Unit IV: Experimental methods in vibration analysis:** Vibration instruments: exciters, transducers, analysers, measurement devices: vibrometers, velocity meters and accelerometers; Signal analysis techniques: time domain analysis, frequency domain analysis, amplitude and power spectra, coherence, auto and cross correlations, amplitude and frequency modulations; Tests for free and forced vibrations

**Unit V: Case studies (A) - Vehicle dynamics:** introduction to nonlinear and random vibrations, vehicle subjected to random vibrations (for example an uneven road); Fluid-structure interaction problems: vibration of suspension bridges. **Case studies (B) -** Introduction to nonlinear and random vibrations, structures subjected to random vibrations, Noise control and acoustics.

**Practice:**
1. Undamped free vibration test of Single degree of freedom on Vibration Fundamental Trainer (VFT)
2. Frequency response function of spring mass damper system for various damping mediums: air, water, and oil.
3. Beam lateral experiment.

**Text Books:**
1. Introductory Course on Theory and Practice of Mechanical Vibrations, J.S.Rao, K.Gupta, Revised second edition, New Age International Publishers

**Reference Books:**

**Course Name- Armament and Combat Vehicles II**

**Course Code- ME 610**

**Unit I:Armament Systems:** Weapon System classification, Characteristics and Operating Principles (Large caliber & Small caliber, Rockets, Missiles & Directed Energy Weapons (DEW)); Principles and Factors affecting Design of Projectile and Weapon; Automatic Fire - Blowback, Recoil, Gas Operation systems and externally driven; Subsystems - Feed Systems, Trigger and Firing Systems, Extraction and Ejection Systems, Locking, Mechanical Safety and Muzzle Attachments;

**Unit II: Introduction to ballistics: Gun and Rocket:** Internal, Intermediate, External and Terminal ballistics; Factors affecting performance of the weapon.

**Unit III: Warhead Mechanisms:** Configuration and classification of Warhead; Kill mechanisms - Kinetic Energy (long rod, fragmentation), Chemical Energy (Blast, Shaped Charge – HEAT, HESH, Explosive dynamics.); Explosives used in warheads.
Unit IV: Ammunition: Charge systems BL and QF. Primers and explosive trains; Design aspects of various types of fuzes.

Unit V: Introduction to Weapon Sighting system
Unit VI: Introduction to Fire Control System

Texts/References

Course Name- Design for Manufacturability
Course Code- ME 611

Unit I: Manufacturing Considerations in Design- Design for manufacture, Tolerencing and tolerance analysis. Processing techniques and limitations for metals, polymers and ceramics. Influence of materials in processing and tooling on the design of components. Finishing, surface coatings and surface modifications of materials.


Unit III: Machining considerations- Design for accuracy, locating pins and registers, machining in assembly, adjustment. Backlash and clearance adjustment. Examples illustrating the various principles. Available design variants for some of the common basic functional requirements.

Text /References:

Course Name- *Modeling and Simulation of Military Vehicles*

Course Code- *ME 612*

1. **Introduction to Multi Body Dynamics.**
2. **Vehicle dynamics evaluation using commercial software**
   (i) LMS Virtual Lab (or)
   (ii) ADAMS, ADAMS (ATV) (or)
   (iii) Recurdyn

2(a). Modelling of Track
   ➢ Super Element Track Modelling
   ➢ Discrete track modelling

2(b). Modelling of tyre

2(c). Modelling of Terrain
   ➢ 3D Surface modelling
   ➢ Representation of soft terrains

2(d). Steering and motion controls

2(e). Co-simulation techniques

2(f). Modelling of contact elements
   ➢ Contact between track and terrain
   ➢ Contact between track and other turning gear elements
   ➢ Contact between tyre and terrain

3. **Introduction to Modal Analysis**
   ➢ Virtual Experimental Modal Analysis (VEMA) using.

4. **Structural analysis of hull and chassis**
   ➢ Flexi body MBD modelling

5. **Prediction of vehicle performance characteristics using vehicle dynamics model** –
   ➢ Ride evaluation
   ➢ Low speed, high speed handling
   ➢ Obstacle crossing
   ➢ Mobility evaluation

6. **Introduction to CFD softwares.**
   ➢ CFD analysis of hull/body for hydrodynamic performance of vehicles engaged in swimming, planning, steering and other manoeuvres.

7. **Armour / Ballistics**
   ➢ Introduction to softwares such as LS Dyna, Radios
   ➢ Prediction for survivability of blast load or incoming projectile; penetration, or elastic and plastic deformation.

8. **Experimental testing of vehicle and systems for validation of simulation models.**

Text/References:


Course Name- Armour Protection Systems
Course Code- ME 613
Threats to Armoured vehicles and systems. Frontal, top, side and bottom attacks. Armoured distribution on a typist MBT, ICV, body Armour.


Case studies.

Reactive protection, explosive reactive Armour (ERA), Inert Reactive Armour (IRA), Electric Armour. Methods to detect ERA case studies.

Active protection system, Layout and integration to platform, Sensors and control mechanism, Intercepting mechanism. Case studies.

Signature Management for acoustic, Thermal, usual and EM emissions. Deceptions and decoys, Early warning systems, Camoufages and concealments.

Text/References:
2. Jane’s Armor and Artillery 2011-12, Christopher F Foss, IHS Janes, ISBN 0978-0710629609
Course Name- *Unmanned Ground vehicles*

Course Code- *ME 614*


Text/References:

1. Autonomous Mobile Robots by Roland Siegwart, Illah R. Nour bakhsh, Davide Scaramuzza (Printice Hall)
2. Autonomous robots: From biological inspiration to implementation and control, By Bekey, G.A.
3. Intelligent unmanned ground vehicles- autonomous navigation research at carnegie mellon, By Hebert, M.H. Thorpe, C Stentz, A.
4. Robot technology fundamentals, by Keramas, J.G.

Course Name- *Trials & Evaluation of Weapon Systems*

Course Code- *ME 615*


Text/References:


**Course Name:** Thermal Management of Defence Equipment  
**Course Code:** ME 616  
**Unit I:** Heat-transfer fundamentals: conduction, convection, radiation, phase change, and heat transfer across solid interfaces.  
**Unit II:** Heat-generating electronic equipment: ICs, power converters, circuit cards and electrical connectors.  
**Unit III:** Thermal management equipment: heat sinks, interface materials, heat spreaders including liquid loops, and air movers. System design: system packaging architectures, facilities, system analysis. Advanced Topics: spray cooling, refrigeration  
**Unit IV:** Introduction, Basic aspect of compactness, Scaling laws of heat exchangers, surface optimization, Industrial compact heat exchangers: Plate Fin heat exchangers, Tube Fin heat exchangers, Printed Circuit heat exchangers, Plate and Frame heat exchangers, Spiral heat exchangers, Plate and Shell heat exchangers. Surface comparisons, Size, shape and weight relationships, Surface types and correlations, Thermal Design-LMTD method.  
**Text/References**

**Course Name:** Kinematics and Dynamics of Machinery  
**Course Code:** ME 617  
**Unit I:** Machine kinematics- Overview, Degrees of freedom, Links and joints, Grashof condition, 4-bar linkage, slider-crank, and inverted slider crank  
**Unit II:** Machine Dynamics- Newtonian solution method, Force analysis of linkage, Shaking force and torque, Balancing linkage, Flywheels  
**Unit III:** Gears and gear trains- Terminologies of gears and gear trains, Interface, undercutting, contact ratio, Simple gears and compound gear trains, Planetary gear trains  
**Unit IV:** Cam systems- Cam terminologies, Cam function design and sizing  
**Unit V:** Programmable mechanisms- Introduction to industrial manipulators, Kinematic chains and classifications, Coordinate transformation, Forward and inverse kinematics  
**Text/References:**
Course Name- Composite Structures  
Course Code- ME 618  

Unit I: Introduction composite materials-Classification and characteristics, mechanical behavior of composite materials, basic terminology, and manufacture of laminated fiber-reinforced composite materials, current and potential advantages of fiber–reinforced composite materials, applications of composite materials.

Unit II: Macro-mechanical behavior of lamina-Introduction, stress-strain relations for anisotropic materials, stiffnesses, compliances, and engineering constants for orthotropic materials, restrictions on engineering constants, stress relation for plane stress in an orthotropic material, stress-train relations for lamina of arbitrary orientation, invariant properties of an orthotropic lamina, strengths of an orthographic lamina, biaxial strength criteria for an orthotropic lamina.

Unit III: Micro-mechanical behavior of lamina-Introduction, mechanics of materials approach to stiffness, elasticity approach to stiffness, comparison of approaches to stiffness, mechanics of materials approach to strength.

Unit IV: Macro-mechanical behavior of laminates-Introduction, Classical Lamination Theory, Special Cases Of Laminate Stiffness, Theoretical Versus Measured Stiffness, Strength Of Laminates, Inter-Laminar Stress.

Unit V: Introduction to design of composites structures-Introduction to structural design, material selection, configuration selection, laminate joints design requirements and design failure criteria, optimization concepts, design analysis philosophy for composite structures.


Unit VII: Testing and characterization of composites-Lamina strength characterization, tensile testing, compression testing, in-plane shear testing, short beam test, double cantilever beam test. Physical properties characterization void content evaluation, fibre Volume Fraction Evaluation, DMA, DSC FOR Tg, Wet Properties Of Lamina, NDE Methods, Ultrasonic A-scan and CT-Scan Methods For Characterization Of Composites.

Text books:

Reference books:
3. Liquid moulding technologies, c d Rudd, a c long, k n Kendall and c g e Mangin, woodhead publishing limited, Cambridge England.
Course Name- Tribology for Design
Course Code- ME 619

Unit I: Introduction-Defining Tribology, Tribology in Design - Mechanical design of oil seals and gasket
- Tribological design of oil seals and gasket, Tribology in Industry (Maintenance), Defining Lubrication, Basic Modes of Lubrication, Properties of Lubricants, Lubricant Additives, Defining Bearing, Terminology - Sliding contact bearings -Rolling contact bearings, Comparison between Sliding and Rolling Contact Bearings


Unit IV: Hydrodynamic Thrust Bearing-Introduction - Flat plate thrust bearing - Tilting pad thrust bearing, Pressure Equation - Flat plate thrust bearing - Tilting pad thrust bearing, Load - Flat plate thrust bearing - Tilting pad thrust bearing, Center of Pressure - Flat plate thrust bearing - Tilting pad thrust bearing, Friction - Flat plate thrust bearing - Tilting pad thrust bearing

Unit V: Hydrostatic and Squeeze Film Lubrication-Hydrostatic Lubrication - Basic concept - Advantages and limitations - Viscous flow through rectangular slot – Load carrying capacity and flow requirement - Energy losses - Optimum design, Squeeze Film Lubrication - Basic concept - Squeeze action between circular and rectangular plates - Squeeze action under variable and alternating loads, Application to journal bearings, Piston Pin Lubrications.


Unit VII: Gas (Air-) Lubricated Bearings-Introduction, Merits, Demerits and Applications, Tilting pad bearings, Magnetic recording, discs with flying head, Hydrostatic bearings with air lubrication, Hydrodynamic bearings with air lubrication, Thrust bearings with air lubrication.

Practice:
1. Surface roughness test,
2. Friction & Wear test on Pin on disc Machine
3. Case studies etc.

Text/References:

Course Name- High Energy Material Technology
Course Code- ME 620
Unit III: Gun Propellants: Introduction and Gun propellants developed in India, Classification, ingredients and manufacturing of gun propellants (SBP, DBP, TBP, LOVA), Combustible Cartridge Case for gun ammunition, Closed Vessel evaluation and Performance prediction of gun propellants, Future trends.
Unit IV: High Explosives: Introduction and uses, Classification and manufacture of high explosives, Theory of detonation and blast, Plastic Bonded explosives, explosive compositions for Low Intensity Conflict (LIC), Explsive Reactive Armour, Fuel – Air explosive, Thermobaric explosives compositon, Measurement and instrumentation.
Unit V: Pyrotechnics: Introduction, Classification and manufacture, Electo-explosive devices, Pyrotechnics smoke, Pyrotechic delays, Pyrotechnic Flares, Other devices, Instrumentation for performance measurement. DETINICS, PBX & Insensitive Explosives.

Course Name- Dynamics & Armament Mechanisms
Course Code- ME 621
Unit II: Mechanisms: Linear, Rotary, Hydraulic and Pneumatic systems. System dynamics for first and second order systems and response in time and frequency domain.
Launcher Platform Leveling, Laying, Sighting, Rocket Pinaka, Control Mechanisms.

Course Name- Ballistics of Bombs & Projectiles
Course Code- ME 622
Unit I: Basics of Ballistics of any projectile, Difference between precision, accuracy and CEP.
Unit IV: External Ballistics of Rockets: Launch dynamics, plane trajectory, boost plane trajectory models, rocket accuracy (dispersion and stability), rocket-assisted projectiles.
Unit V: Bomb Ballistics: Aerodynamic forces and moments acting on a bomb, Drag coefficient, Terminal velocity and Ballistic index, Trajectory of bombs, Simulated stores (similitude) and their trajectories, Bomb stability derivatives and analysis (in roll, pitch and yaw), wind tunnel testing, Bomb trajectory calculations with point mass and Six Degrees of Freedom Equations. Calculation of Moment of Inertia and Centre of Gravity of bombs.

Texts/References:


Course Name- Design of Ordnance, Basic and Super Structure
Course Code- ME 623
Unit II: Breech Mechanism: Principles of operation and design of Muzzle Brakes, Fume Extractors and Firing Mechanisms
Unit III: Design of Structural Elements: Design of gun superstructure and basic structures. Curvilinear and soft recoil systems, articulation and suspension systems.

Texts/References:

Course Name- Small Arms and Cannons
Course Code- ME 624


Unit II: Operating Principles: Analytical and Comparative Study of Blowback, Recoil and Gas Operation systems, and Externally Driven Weapon Systems.


Manufacturing; Inspection; Life Estimation; Modern Trends; Typical Weapon Study: INSAS.

Texts/References

Course Name- Combat Vehicle Technology
Course Code- ME 625

Unit I: AFV Characteristics: Concept of Tank warfare and design philosophies of AFVs, Development of Tanks, Design parameters of combat vehicles to include configuration, overall dimensions etc.

Unit II: Firepower: Characteristics, components, main gun and tank ammunition including ATGMs, secondary armament, Ranging & Sighting systems including NVD, GCE & ALG, Probability of Kill, Errors & Biases, Fire Control system.

Unit III: Mobility: Types, performance parameters, obstacle crossing ability, navigation – GPS & GLNS.

Unit IV: Protection: Types, Armour Protection, Active protection systems, Protection against NBC and Fire.

Tank communication & IFF, Maintainability, Availability, Reliability and Ergonomics.

Unit V: Critical Dimensions and Design: Steerability ratio, Track Width, Pitch ratio, NGP, MMP, Angle of approach and Angle of departure, Pitch of tank, No of Road Wheels, Interrelation between all dimensions and Design requirements.

Unit VI: Latest Trends, FMBT, FICV, Lt Tank, AFV Variants

Text/References:
5. Jane’s Armor and Artillery 2011-12, Christopher F Foss, IHS Janes, ISBN 0978-0710629609
8. Protection Levels for Occupants of Logistic and Light Armored Vehicles, NATOSTANAG 4569

Course Name- Vehicle Dynamics
Course Code- ME 626


Unit II: Wheeled Vehicle : Vehicle transfer function. Kinematic behaviour of vehicles with rigid wheels and with compliant tyres, neutral steer point, static margin, over and under steer. Derivation of generalized equations of motion for a vehicle, stability derivative notation. Solution with two degree of freedom in the steady in yaw. Frequency response in yaw. Extension of two degree of freedom theory to include effects of traction and braking, self aligning torque, dual wheels and bogies. Development of equations of motion to include roll of sprung mass, Effect on steady state and frequency response.

Unit III: Tracked Vehicle Handling : Analysis of sprocket torques and speeds, required to skid steer a tracked vehicle. Modification of theory to allow for soil conditions and lateral Weight transfer. Application of theory of steering of articulated and half – track vehicles.

Unit IV: Terramechanics : Nature of soil vehicle interaction, Characteristics of soil and bearing capacity, Empirical approaches for prediction of vehicle mobility.

Text/References:

Course Name- Fatigue, Fracture and Failure Analysis
Course Code- ME 627
Unit II: Statistical Aspects of Fatigue Behaviour-Low cycle and high cycle fatigue - Coffin-Manson’s relation - Transition life - cyclic strain hardening and softening - Analysis of load histories - Cycle counting techniques -Cumulative damage - Miner’s theory - Other theories.
Unit III: Physical Aspects of Fatigue-Phase in fatigue life - Crack initiation - Crack growth - Final Fracture - Dislocations - fatigue fracture surfaces.
Unit V: Fatigue Design and Testing-Safe life and Fail-safe design philosophies - Importance of Fracture Mechanics in aerospace structures - Application to composite materials and structures.

Text/References:

Course Name- Design of Hydraulic and Pneumatic Systems
Course Code- ME 628

Unit IV: **Design of Pneumatic Circuits** - Servo systems – Hydro Mechanical servo systems, Electro hydraulic servo systems and proportional valves. Fluidics – Introduction to fluidic devices, simple circuits, Introduction to Electro Hydraulic Pneumatic logic circuits, ladder diagrams, PLC applications in fluid power control. Fluid power circuits; failure and troubleshooting.

**Text Books:**

**Reference Books:**

**Course Name:** Design of Experiments  
**Course Code:** ME 629

**Unit I:** Overview and Basic Principles, Simple Designs and Analysis of Variance,  
**Unit II:** Block Designs, Latin Squares and Related Designs, Full Factorial Designs, 2-level Full Factorial and Fractional Factorial Designs.  
**Unit III:** Response surface methods and designs, Designs with Random Factors, Nested Designs, and split-plot Designs.

**Text/ References:**

**Course Name:** Design of Machinery  
**Course Code:** ME 630


Unit III: Dynamics of mechanisms/machineries - Dynamics Fundamentals, Dynamic Force Analysis, Balancing, Engine Dynamics, Multi cylinder Engines.


Outcomes:
Upon completion of this course, the students can able to apply fundamentals of mechanism/machines for the design of new mechanisms/machines and analyse them for optimum design.

Text/References:

Course Name- Automatic Control Systems
Course Code- ME 642
Unit I: Basic concepts of Automatic Control- Transfer Functions-Modeling of systems-Mechanical, Electrical, hydraulic system block diagram, signal flow graphs, closed and open loop systems. Feedback and Feed forward control system.


Unit IV: Control System Implementations- Pneumatic Systems, Hydraulic Systems, Electrical Systems, Microprocessor Based Systems, Programmable Logic Controllers, Micro Controllers and Network Based Distributed Control Systems,


Texts Books:

Course Name- Advanced Heat & Mass Transfer
Course Code- ME 654

Unit I: Conduction Heat Transfer - Fourier's law, 1-D heat diffusion equation, 3-D form (Laplacian), Solution, Thermal resistance concept - electrical analogy, Fick's and Ohm's laws, Radial heat conduction, critical radius of insulation, Heat diffusion equation - general form, Transient conduction, extended surface heat transfer

Unit I: Convective Heat Transfer - Applications, Forced, free and mixed convection, Internal and external flow, Heat transfer coefficient and its physical significance, Dimensional analysis in convective heat transfer, Conservation equations - mass, momentum and energy, boundary condition

Unit I: External laminar forced convection - Boundary layer equation, Energy equation and similarity solution for flow over flat plate for various boundary conditions and Prandtl numbers, Scale analysis, Approximate method, Viscous dissipation effect of laminar boundary layer

Unit I: Internal laminar forced convection - Developing and developed flow and heat transfer in a duct and circular pipe having various boundary conditions

Unit I: Mass convection - Various non-dimensional numbers and their analogy to those of heat transfer, Analogy friction, heat transfer and mass transfer coefficients, Species equations, Examples of simultaneous heat and mass transfer

Unit I: Heat transfer in phase change - Boiling, Condensation

Unit I: Radiation - Kirchhoff's law, Black and grey bodies, Gaseous radiation, Solar energy
Reference/Text books:
1. Convective Heat Transfer by L. C. Burmeister (John Wiley and Sons)
2. Convective Heat Transfer by Adrian Bejan (John Wiley and Sons)
3. Boundary Layer Theory by H Sctllichting (McGraw-Hill)
5. Introduction to Convective Heat Transfer Analysis by Patrick H. Oosthuizen and David Laylor (McGraw-Hill)

Course Name- M. Tech. Dissertation Phase– I
Course Code- ME 651

Course Name- M. Tech. Dissertation Phase– II
Course Code- ME 652

M. Tech in Robotics

Brief Description: M.Tech in Robotics is an interdisciplinary Masters Programme composed of five basic disciplines namely Mechanical Engineering, Electronics Engineering, Electrical Engineering, Computer Science and Engineering, and Aerospace Engineering. There is a growing demand for students specialized in this area in Indian industries, defence applications, atomic energy, space research, medical research etc. Hence this degree would help in generating trained and qualified manpower in this area.
Eligibility:

1. The eligibility for the M.Tech. in Robotics will be Bachelor’s Degree in Mechanical/Electronics/Mechatronics/Electrical/Aeronautical engg/ Computer Science/ Aerospace Engineering and Instrumentation Engineering disciplines from recognized university.

2. This programme is open for civilian GATE qualified candidates, DRDO Scientists/Officers and Officers from Tri-services. This programme is also open to foreign nationals from the countries approved by GOI.

Organization: M. Tech in Robotics is a four-semester master’s programme. There are six compulsory courses in the first semester, two compulsory and four electives in the second semester. In each semester, three tests as a part of continuous evaluation and an end semester examination will be conducted for each course. M.Tech dissertation first phase evaluation is done by a committee duly constituted by VC at the end of third semester. At the end of the final semester, student submits a thesis and makes a presentation about the project, which is evaluated by duly constituted committee constituted by Controller of Examinations, DIAT (DU), Pune.

The details of the courses offered under the programme are given below:

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<th>S. No.</th>
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<td>3</td>
<td>*EE 628/ **ME 639</td>
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<td>4</td>
<td>AM 602</td>
<td>Mathematical Modelling and System Analysis</td>
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<td>ME 626</td>
<td>Introduction to Robotics</td>
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<td>Mechatronics</td>
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Note: *EE 628 for (Non- Electronics) & **ME 639 for (Non – Mechanical)

### Semester II

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<td>SoC and Embedded Systems</td>
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<td>Robot Sensors and Instrumentation</td>
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Note: 04 weeks’ industrial practice school during summer vacation for scholarship students.

### Semester III

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<td>ME 651</td>
<td>M.Tech. Dissertation Phase I</td>
<td>28**</td>
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<td><strong>Total</strong></td>
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### Semester IV

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<tr>
<th>S. No.</th>
<th>Course Code</th>
<th>Course</th>
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<td>1</td>
<td>ME 652</td>
<td>M.Tech. Dissertation Phase II</td>
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<td><strong>Total</strong></td>
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* 1 credit in Theory/ Tutorial means one contact hour and 1 credit in Practice/Project Thesis means two contact hours.

**Contact Hours/ week

### List of Electives

<table>
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<tr>
<th>S. No.</th>
<th>Course Code</th>
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<tbody>
<tr>
<td>1</td>
<td>ME 638</td>
<td>Field and service Robots</td>
</tr>
<tr>
<td>2</td>
<td>ME 631</td>
<td>Product Design and Development</td>
</tr>
</tbody>
</table>
**Detailed Contents**

**Course Name: Mathematics for Engineers**  
**Course Code: AM 607**

**Unit I:** Linear Algebra: General (real) vector spaces, Subspaces, Linear independence, Dimension, Norms, Orthogonal bases and Gram-Schmidt orthogonalization. Principles of floating point computations and rounding errors.

**Unit II:** Systems of Linear Equations: factorization methods, pivoting and scaling, residual error correction method. Iterative methods: Jacobi, Gauss-Seidel methods with convergence analysis, Conjugate gradient methods.

**Unit III:** Nonlinear systems: Newton and Newton like methods. Interpolation: review of Lagrange interpolation techniques, Newton interpolation, piecewise linear, cubic splines and Bezier curves, error estimates. Approximation: uniform approximation by polynomials, data fitting and least squares approximation.

**Unit IV:** Numerical differentiation and integration: Differentiation and integration by interpolation, adaptive quadratures and Gaussian quadrature. Initial Value Problems for Ordinary Differential Equations: Euler, Modified Euler, Runge-Kutta methods, multi-step methods, predictor and corrector methods, stability and convergence analysis.

**Unit V:** Two Point Boundary Value Problems: finite difference methods with convergence results. Solution of PDE: Parabolic, Hyperbolic and Elliptic Equations using finite difference method.

**Text/References:**

Course Name- Artificial Intelligence and Expert Systems
Course Code- CE 696

Introduction to AI, Knowledge-based Intelligent Systems, and Rule based Expert Systems;

**Unit I: Uncertainty Management in rule-based expert systems:** Introduction to Uncertainty, Basic Probability Theory, Bayesian reasoning, Certainty Factors;

**Unit II: Fuzzy Expert Systems:** Introduction to Fuzzy thinking, Linguistics variables and Hedges, Fuzzy Rules, Fuzzy Inference, Defuzzification;

**Unit III: Learning:** Overview of different forms of learning, Learning Decision Trees, Neural Networks, Natural Language Processing.

**Unit IV: Artificial Neural Networks:** Basics of Neuron, Perceptron, Multi-layer neural network, Hop-field network, Self-Organizing Neural Networks;

**Unit V: Evolutionary Computation:** Genetic Algorithms, Evolution Strategies

**Unit VI: Hybrid Intelligent Systems:** Neuro-Fuzzy, ANFIS; Probabilities, Bayesian Networks.

**Unit VII: Applications of AI in Robotics:** Subsumption Robots, Subsumption Architecture, Strengths and Weaknesses of the Architecture. Sensors, vision camera etc. for perception and obstacle avoidance.

Text/References:


Course Name- Introduction to Mechanisms (Non-Mechanical)
Course Code- ME 639


Practice:
1. Msc ADAMS Tutorials,
2. Mechanisms Design in Solidworks,
3. Analysis Simulations etc.

Reference Text Books:

Course Name: ADVANCED ELECTRONICS SYSTEMS (Non - Electronics)
Course Code: EE628

UNIT -I: Introduction

UNIT -II: Sensors and advanced topics
Sensors as system components- Temperature sensors- Force and pressure sensors- Magnetic field sensors - Optical sensors - Microwave sensors - Miscellaneous sensors –MEMS-Fabrication steps.
UNIT -III: Analog IC Design
Analog Conditioning circuits. Advanced Current Sources & sinks; Voltage Reference circuit, Operational amplifiers - Architectures- Instrumentation Amplifiers, feedback-Filter Design- ADC-DAC. Concepts of Virtual Instrumentation: Lab View (can be supported by laboratory).

UNIT -IV: Digital IC Design
MOS inverter- Static and switching characteristics, Combinational MOS logic circuits –static logic Synchronous system and Sequential circuits design.

UNIT -V: RF Microelectronics
Low Noise Amplifier (LNA), Mixer, Oscillator, VCO and PLL, Power amplifier-Transceiver Architecture.

REFERENCE BOOKS:
5. Handbook of Modern Sensors by Fraden

LIST OF EXPERIMENTS

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Name of the Experiments</th>
</tr>
</thead>
</table>
| 01    | Write VHDL programs for the a) Full Adder b) Multiplexer c) BCD-Gray code converter d) Shift Registers e) Barrel Shifters.  
Aim:  
1. To understand the Various modeling such as a) data flow modeling b) behavioural modeling C) Structural modeling of VHDL.  
2. Writing the test bench to create various stimulus for the DUT. |
| 02    | Implement the Booth Multiplier using structural modeling in FPGA.  
Aim:  
1. To understand the Structural modeling of VHDL.  
2. To understand the wordlength effects.  
3. To understand the use of Xilinx ISE 16.1.  
4. Hands on experience in SPARTAN 3E FPGA kits. |
| 03    | Implement a Traffic Light controller using Mealy Machine in FPGA.  
Aim:  
1. To understand the Mealy State machine.  
2. To understand the use of Xilinx ISE 16.1. |
| 04 | Implement a Sequence Detector using Moore machine in FPGA. Aim:  
1. To understand the Moore State machine.  
2. To understand the use of Xilinx ISE 16.1.  
3. Hands on experience in SPARTAN 3E FPGA kits. |
| 05 | Design a 8 bit Processor contain both combinational and sequential circuits to perform various arithmetic and logical operations. Aim:  
1. To understand the mixed modeling styles of VHDL.  
2. To understand the use of Xilinx ISE 16.1.  
3. Hands on experience in SPARTAN 3E FPGA kits. |

**Course Name: Mathematical Modelling and System Analysis**

**Course Code: AM 602**

**Unit I: Mathematical Modelling:** Introduction to modelling and simulation, Classification of systems into continuous and discrete, Structural characterization of mathematical model and validation techniques

**Unit II: Modelling Techniques:** Dimensional analysis: Concept behind dimensional approach, Buckingham Pi theorem, Models using dimensional approach - Continuous approach: Models based on physical laws

**Unit III: Discrete Approach:** Models based on discrete approach. Prey - Predator models - Combat Modelling: Modelling the Lanchester laws with System Dynamics

**Unit IV: System Analysis:** The state of a system, mathematical models of continuous linear lumped parameter, time invariant systems, Discrete time systems, Linear approximation of non-linear systems, Topological models of system, Block diagram representation, Signal flow graph, and Mason ‘s rule. A generalized approach to modelling. Principles of conservation and continuity and Applications. Basics of simulator technology.

**Text Books / References**


**Course Name- Introduction to Robotics**

**Course Code- ME 626**

**Unit I:** Robot definition, Robotics and programmable automation Historical background, laws of Robotics. Robotics systems and Robot anatomy, specification of Robots. Robot geometrical configuration.

**Unit II:** Performance Definition - Accuracy / Repeatability / Precision with respect to Position & Path, payload, speed, acceleration, cycle time - Challenges, Applications and uses of Mobile and other robots: wheeled, tracked, legged, aerial, underwater robots, surgical robots, rehabilitation robots, humanoid robots, Nano Robots.

**Unit III:** Classification of end effectors, Types of Grippers Hooks, scoops and other devices, Gripper force analysis and design of Drive system for gripper – communication of robots – **Unit IV:** Euler angles for specifying orientation, Euler angles for roll-yaw-roll geometry, Gripper positioning by Euler angles for roll-yaw-roll geometry - Euler angles for roll - pitch - yaw geometry, Cylindrical Robot coordinates polar Robot coordinates, calculation of cylindrical, polar coordinates, Some applications.

**Practice:**
1. Firebird Robot Platform Experiments,
2. Languages, Simulation Softwares for Robotics,
3. Case studies etc.

**Text/References:**
Course Name- Mechatronics  
Course Code- ME 627  


Unit II: Mechanical Actuation Systems: Mechanical Systems, Types of Motions, Kinematic chains, Cams, Gear Trains, Ratchet and pawl, belt and chain drives, Bearings, Mechanical aspects of motor selection.


Unit IV: Introduction to Robot Control: Introduction: Open loop and Closed loop systems, feedback and feed forward Control systems, Mathematical modelling of control systems: Mechanical Electrical Hydraulic, Pneumatic system. Transfer functions; Block diagrams, signal flow graphs - Components of the Robotic Control systems: Potentiometers, Synchros, Controllers, DC and AC servo motors, Tachogenerators, gear -train, Gyroscope.

Practice:  
1. Firebird Robot Platform Experiments,  
2. Design, Simulation Softwares for Automation and Mechatronics,  
3. Case studies etc.

REFERENCES:  

**Course Name- Robotic Path Planning and Control**

**Course Code- AE 619**

**Unit I: Time Response:** Transient response and steady state error analysis of first and second order systems. Stability analysis Frequency response, Root locus analysis, Nyquist Criteria, design of compensators - state space method: Introduction to State space representation of dynamical systems. Solution of state equation. Controllability and observability, State feedback control, Pole placement techniques and design of observers.


**Unit III:** Linear Second Order-Order SISO Model of a Manipulator Joint, Joint Actuators, Partitioned PD Control Scheme, PID Control Scheme, Computed Torque Control, Force Control of Robotic Manipulators, Description of force control tasks, Force control strategies, Hybrid Position/ Force Control, Impedance Force/ Torque Control.

**References and Text**

Course Name- **Robot Kinematics and Dynamics**

Course Code- **ME 628**

**Unit I:** Introduction, position and orientation of objects, objects coordinate frame Rotation matrix, Euler angles Roll, pitch and yaw angles coordinate Transformations, Joint variables and position of end effectors.

**Unit II:** Dot and cross products, coordinate frames, Rotations, Homogeneous coordinates, link coordinates D-H Representation, The ARM equation. Direct kinematic analysis for Four axis, SCARA Robot and six axis Articulated Robots.

**Unit III:** The inverse kinematics problem, General properties of solutions. Tool configuration, Inverse kinematics of four axis SCARA robot and six axis Articulated robot.

**Unit IV:** Workspace Analysis, work envelope of a Four axis SCARA robot and five axis articulated robot workspace fixtures, the pick and place operations, continuous path motion, Interpolated motion, straight line motion.


**Practice:**
1. Robot Analyzer Platform Experiments,
2. Simulation Softwares for Robotics,
3. Case studies etc.

**Text/References:**


**Course Name:** SoC AND EMBEDDED SYSTEM  
**Course Code:** EE620

**UNIT-I: INTRODUCTION:** Definition and Classification, Overview of Processors and hardware units in an embedded system, Software embedded into the system, Exemplary Embedded Systems, Embedded Systems on a Chip (SoC) and the use of VLSI designed circuits.

**UNIT-II: DEVICES AND BUSES FOR DEVICES NETWORK:** I/O Devices, Device I/O Types and Examples, Synchronous, I/o synchronous and Asynchronous Communications from Serial Devices, Examples of Internal Serial-Communication Devices, UART, Parallel Port Devices, Sophisticated interfacing features in Devices/Ports, Timer and Counting Devices, I2C, USB, CAN and advanced I/O Serial high speed buses, ISA, PCI, PCI-X and advanced buses.

**UNIT-III: EMBEDDED COMPUTING:** Embedded processors, ARM processor, Architecture, Instruction sets and programming Case Studies, Parallel Computing, CUDA Language for radar Application.


**TEXT BOOKS:**
3. An Embedded software primer David E Simon,Pearson Education Twelfth India reprint,2005

**REFERENCE BOOKS:**
2. DSP Architecture, Programming and Application- B Venkataramani, M Bhaskar.
LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Experiment</th>
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<tbody>
<tr>
<td>1</td>
<td>Simulation of ALP using 8086 Emulator</td>
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<td>2</td>
<td>FPGA programming using VHDL.</td>
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<tr>
<td>3</td>
<td>Radar signal generation using FPGA.</td>
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<tr>
<td>4</td>
<td>Creating a custom IP core using the IP Integrator in Vivado IDE</td>
</tr>
<tr>
<td>5</td>
<td>Recording and play back of audio signal using Zedboard DMA</td>
</tr>
<tr>
<td>6</td>
<td>Peripheral Module Interface using soft core processor Microblaze</td>
</tr>
<tr>
<td>7</td>
<td>PWM Applications using PSoC</td>
</tr>
<tr>
<td>8</td>
<td>Introduction to CUDA programming and Tesla Processors</td>
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</table>

Course Name - Robot Sensors and Instrumentation
Course Code – ME 656
Unit I: Basic Concepts of Measurements and characteristics of an Instrumentation System:
System configuration – Problem analysis – Basic characteristics of measuring devices –
Calibration - Generalized measurements – Zero order, First order, Second order system – Dead
time element - Electromechanical sensors – Resistance type – Potentiometer – Strain gauge –
Resistance thermometer – RTD – Inductance type – Capacitance type – Piezo Electric type -
Force and Pressure Sensors - Microwave sensors - Magnetic sensors – NMR – MRI – Fiber optic
sensors – Opto electronic sensors – CCD - Digital transducers - Analog and Digital
Instrumentation:

Unit II: Operational Amplifiers – Signal generation – Signal processing – Filtering and signal
analysis - Data Acquisition, Conversion, Transmission and Processing: Signal Conditioning of
the inputs – Single channel and Multichannel data acquisition – Data conversion – Multiplexers
– Sample and hold circuits – Data transmission systems – Pulse code formats – Modulation
techniques – Telemetry system - Inertial sensors, Laser Scanners 2D and 3D, Robot Vision, 3D
cameras, filters for removal of noise and the concept of sensor fusion - Kalman filter,
Localization and Mapping techniques, INS, gyroscopes,2D,3D Scanner platforms.

Text Books:

LIST OF ELECTIVES

Course Name - Product Design and Development

Course Code - ME 631

Unit I: Introduction- Significance of product design, product design and development process, sequential engineering design method, the challenges of product development,

Unit II: Product Planning and Project Selection- Identifying opportunities, evaluate and prioritize projects, allocation of resources Identifying Customer Needs: Interpret raw data in terms of customers need, organize needs in hierarchy and establish the relative importance of needs.,

Unit III: Product Specifications- Establish target specifications, setting final specifications, Concept Generation: Activities of concept generation, clarifying problem, search both internally and externally, explore the output.

Unit IV: Industrial Design-Assessing need for industrial design, industrial design process, management, assessing quality of industrial design, Concept Selection: Overview, concept screening and concept scoring, methods of selection.

Unit V: Theory of inventive problem solving (TRIZ)- Fundamentals, methods and techniques, General Theory of Innovation and TRIZ, Value engineering Applications in Product development and design, Model-based technology for generating innovative ideas

Unit VI: Concept Testing- Elements of testing: qualitative and quantitative methods including survey, measurement of customers’ response. Intellectual Property- Elements and outline, patenting procedures, claim procedure, Design for Environment- Impact, regulations from government, ISO system.,

Text books and references:


**Course Name - Nonlinear and Robust Control**

**Course Code - AE 616**

**Unit I:** Introduction to Nonlinear Systems, Stability analysis, Feedback linearization, Input-State and Input-Output Linearization, Robust Feedback Linearization. Sliding Mode Control and Sliding Mode Observers. Uncertainties, variation and unmodelled lags.

**Unit II:** Robust control based on Uncertainty and Disturbance Estimation. Time Delay Control, Inertial Delay Control. Disturbance Observer. State and Disturbance Observers. Applications in missile and aircraft autopilot design.

**Texts/ References:**


**Course Name - Digital Image Processing**

**Course Code - AM 625**

**Unit I:** Digital image fundamentals: Simple image model, Sampling, Quantization, Introduction to colour images. Image enhancement in spatial domain: Basic gray level transformations, Histogram processing, Spatial filters.

**Unit II:** Image enhancement in frequency domain: Frequency domain filters, Ideal, Butterworth and Gaussian filters.

**Unit III:** Image restoration: Noise models, Noise reduction using spatial filters, Noise reduction using frequency domain filters. Morphological image processing: Dilation, Erosion, Opening, Closing, Applications to; Boundary extraction, Region filling, Extraction of connected components.

**Unit IV:** Image segmentation: Discontinuity detection, Edge linking and boundary detection, Thresholding, Region based segmentation, Segmentation by morphological watershed.
Unit V: Object recognition: Decision-theoretic methods.

Unit VI: Image Compression.

Text/References
6. Sing-Tze Bow, Marcel Dekker, *Pattern Recognition, Applications to Large Data-Set Problems*, 1984

Course Name - Secure Wireless Sensor Network

Course Code - CE 691

Unit I: Introduction, WSN Resources & constraints, Relevance to Cyber-Physical Systems, Relevance to Network Centric Operations, Relevance to Data Stream Management Systems, Relevance to the increasing demand of high performance computations, SCADA, battle sensor - WSN Network Architecture, MAC Layer protocols, Naming and Addressing, Synchronization, Location & positioning, Topology control, Connected Dominating Sets, Routing Protocols, Data-Centric & Content-based networking

Unit II: Data-Centric querying - Vulnerabilities, threats, attacks & safeguards in WSN, key distribution methods & protocols, multi-party computations inclusion, RF-Id communications, open source hardware concept, Security goals for WSNs, Attacks on WSNs: Passive & Active Attacks, Security Mechanisms, Security Models for WSNs, Challenges in WSNs: with respect to wireless medium, resource scarcity, ad-hoc deployments, hostile environments, immense scale, etc. Application oriented: Secure Wireless Networks.

Reference Text Books:


19. WSN Security Models: Refer 4 papers: 
   - **Paper 1**: Wireless sensor network security model using zero knowledge protocol, ICC 2011;
   - **Paper 2**: An energy efficient link-layer security protocol for wireless sensor networks, EIT 2007;
   - **Paper 3**: Toward resilient security in wireless sensor networks, MobiHoc 2005;

**Course Name - Field and service Robots**

**Course Code - ME 638**

**Unit I: Introduction to Field and service robots**: History of service robotics – Present status and future trends – Need for service robots – applications examples and Specifications of service and field Robots. Non conventional Industrial robots. Classification, applications, sensing and perception, social and ethical implications of robotics.

**Unit II: Autonomous Mobile robots**: Kinematics, locomotion, perception, motion planning and control, localization and mapping. Road map path planning, intelligent unmanned vehicles. Wheeled and legged, Legged locomotion and balance, Arm movement, Gaze and auditory orientation control, Facial expression, Hands and manipulation, Sound and speech generation, Motion capture/Learning from demonstration, Human activity recognition using vision, touch,

**Unit III: Field Robots:** Collision Avoidance-Robots for agriculture, mining, exploration, underwater, civilian and military applications, nuclear applications, Space applications. Industrial applications like cleaning robots, wall painting robots, wall plastering robots, vehicle equipment and building robots etc Load carrying robots. IDE detection and diffusion robots –

**Unit IV: Underwater robots:** Kinematics and dynamics, modeling and simulation, navigation, guidance and control. Marine data collection (Temperature, other environment parameters) –

**Unit V: Aerial robots:** Basics of aerial robots, sensors and actuators, modelling and control of small Unmanned Aerial vehicles, guidance and navigation of small range aerial robots, Autonomous indoor flight control Air defence robots.

**Text Books:**


**Reference books:**


**Course Name - Digital Communication**

**Course Code - EE602**


**Unit II: Digital Modulation Techniques:** Introduction, Pulse amplitude modulation (binary and M-ary, QAM), Pulse position modulation (binary and M-ary), Carrier modulation (M-ary ASK,
PSK, FSK, DPSK), Continuous phase modulation (QPSK and variants, MSK, GMSK), Trellis Code Modulation, Probability of Error & Bit Error Rate, Error Performance.


**Unit IV: Coding Techniques:** Matrix description of Linear Block Codes, Error detection and error Correction capabilities of linear block codes, Cyclic Codes: Algebraic structure, encoding, syndrome calculation, Decoding Convolution Codes: Convolution Codes: Encoding. Decoding using State, tree and trellis diagrams. Decoding using Viterbi algorithm. Comparison of Error Rates in Coded and Uncoded Transmission.

**Unit V: Spread Spectrum & Multi User Communication:** Model of a Spread Spectrum Communications System, Direct Sequence Spread Spectrum Signals, Frequency Hopped Spread Spectrum Signals, Other types of Spread Spectrum Signals, Spread Spectrum in multipath channels, Multiple Access Techniques (CDMA, TDMA, FDMA, SDMA, PDMA), Capacity of Multiple Access Systems, Multichannel and Multicarrier System, Multichannel Digital Communications in AWGN Multicarrier Communications

**Text books:**

**Reference books:**
Course Name - Machine Vision System
Course Code - CE 670


Unit III: Lighting system: Importance of Illumination – Light and light perception – light characteristics – Light sources – monochromatic light, white light, UV, IR LED and Laser – polarized lighting, filtered lighting - types of illuminators – illumination techniques factor to be considered in design of Lighting of a MVS.

Unit IV: Image Analysis and Image Processing: Introduction to digital images – Image analysis – Basic, scalar, arithmetic - Image enhancement – Thresholding, Histogram, line profile, intensity measurement – Image processing – lookup tables(LUT), Morphology, spatial filters, Frequency domain processing - Blob analysis, Particle measurement, Dimension measurement – Edge detection, alignment, Pattern matching.


References:


**Course Name - Digital Interface Design**

**Course Code - EE 621**

**Unit I: Introduction:** Definition and Classification, Overview of Robots and hardware units in Robotics, Introduction to Zed Board Embedded Systems on a Chip (SoC) and the use of FPGA in Robotics Application. State Machines and applications.

**Unit II: Sensor and actuator interfacing:** Sophisticated interfacing features in Devices/Ports, Timer and Counting Devices, ‘I2C’, ‘USB’, ‘CAN’. PWM in HW for robot control. LCD interfacing with FPGA.

**Unit III: Data converters interfacing:** Introduction to ADC and DAC. Various Types and specification. SPI interfacing in FPGA.

**Unit IV: Wireless and GPS interfacing:** Introduction to Bluetooth - Zig Bee Interface. Introduction to Gyro and accelerometer – Gyro accelerometer interface using Complementary Filter - Case study: Underwater Glider motion controller. NI CompactRIO embedded control hardware for rapid prototyping.

**Text Books:**


**Course Name - Machine Learning**

**Course Code - CE 671**

**Unit I: Introduction:** Definition of learning systems. Goals and applications of machine learning. Aspects of developing a learning system: training data, concept representation, function approximation. Inductive Classification: The concept learning task. Concept learning as search


information extraction. Conditional random fields (CRF's). Probabilistic context-free grammars (PCFG). Parsing and learning with PCFGs. Lexicalized PCFGs.

Textbooks:


Course Name - *Industrial Automation*

Course Code - *ME 629*

**Unit I:** Production operations and Automation strategies - Types of production, Functions in manufacturing, Plant Layout, Production concepts and Mathematical models, Automation strategies. Production Economics.

**Unit II:** Cost in manufacturing, break even analysis, Unit cost of production, Cost of manufacturing lead time and work-in-progress - Detroit - Type automation - Automated flow line, workpart transport, Transfer mechanism, Buffer storage, Control functions, Automation for machining operations, Design and fabrication consideration. Analysis of Automated Flow lines. General terminology and analysis.

**Unit III:** Analysis of transfer lines without storage, partial automation, Automated flow lines, with storage buffer, simulation of automation flow lines - Numerical Control, Types of NC Systems, Machine tool applications, other applications of NC Systems, Components of NC System, Introduction to NC part programming, Types of part programming, Direct Numerical Control, Computer Numerical Control, Adaptive Control Machining - The assembly process, assembly systems, manual assembly lines.

**Unit IV:** The line balancing problem, Methods of line balancing, Computerised line balancing method, flexible manual assembly lines. Design for automated assembly, types of automated assembly system, parts feeding devices, Analysis of single station and multistation assembly
machine - Automated materials handling: Types of material handling equipment, analysis for material handling systems, design of the system, conveyor system, automated guided vehicle systems. Automated storage systems: Automated storage / Retrieval systems, Carousel storage systems, work-in-process storage, interfacing handling and storage with manufacturing.

References/Texts


Course Name - CAD/CAM
Course Code - ME 635

Unit I: Criteria for selection of CAD workstations, Shigle Design Process, Design criteria, Geometric modeling, entities, 2D & 3D Primitives. 2D & 3D Geometric Transformations: Translation, Scaling, Rotation, Reflection and Shearing, concatenation.


Unit III: Synthetic Surface-Cubic, Bezier, Bspline, Coons - Graph Based Model, Boolean Models, Instances, Cell Decomposition & Spatial – Occupancy Enumeration, Boundary Representation (B-rep) & Constructive Solid Geometry (CSG).


Text/Reference:

Course Name - Flexible Manufacturing Systems
Course Code – ME 634

Unit I: Definition of an FMS-need for FMS, types and configuration, types of flexibilities and performance measures. Economic justification of FMS. Development and implementation of FMS- planning phases, integration, system configuration, FMS layouts, simulation - Functions - types - analysis of material handling systems, primary and secondary material handling systems-conveyors, Automated Guided Vehicles-working principle, types, traffic control of AGVs. Role of robots in material handling.

Unit II: Automated storage systems- storage system performance - AS/RS-carousel storage system, WIP storage systems, interfacing handling and storage with manufacturing - Planning, scheduling and computer control of FMS, Hierarchy of computer control, supervisory computer. DNC system- communication between DNC computer and machine control unit, features of DNC systems - System issues, types of software - specification and selection- trends-application of simulation and its software.

Unit III: Manufacturing Data systems- planning FMS data base. Modelling of FMS- analytical, heuristics, queuing, simulation and petrinets modeling techniques - Scheduling of operations on a single machine- two machine flow shop scheduling, two machine job shop scheduling - three machine flow shop scheduling- scheduling 'n' operations on 'n' machines, knowledge based scheduling, scheduling rules, tool management of FMS, material handling system schedule.

References/ Texts:


Course Name - System Engineering
Course Code – TM 609

Unit I: Large scale systems, Generic systems, System Engineering(SE) frame work, SE dimentions, SE Matrix, tools of SE.

Unit II: Words, graph, mathematics, Structural Modelling, Flexible imperative structure modelling, Algorithms of FISM, Cross impact models, Deterministic models- Kane simulations and weighted graph models, Monte Carlo models

References:


**Course Name - Introduction to Mobile Robotics**

**Course Code – ME 653**

**Unit I:** Linear Algebra, Robot Control Paradigms, Wheeled Locomotion, Proximity Sensors, Probabilistic Robotics, Probabilistic Motion Models, Probabilistic Sensor Models, Bayes Filter.

**Unit II:** Discrete Filter, Particle Filter and MCL, Kalman Filter, Extended Kalman Filter, Grid Maps and Mapping with Known Poses, SLAM - Simultaneous Localization and Mapping, SLAM - Graph-based SLAM, Techniques for 3D Mapping, Iterative Closest Point Algorithm, Path and Motion Planning, Multi-Robot Exploration, Information Driven Exploration.

**Text Books:**


**Course Name - Inertial Navigation Systems**

**Course Code – EE662**

**Unit I:** Frames of references and inertial navigation fundamentals Concept of frames of references: inertial frames, non-inertial frames, geographic frame, geocentric frame, body frame; Principles of inertial navigation: types of inertial navigation, stabilized platform and strapdown systems, comparison; Earth models: ellipsoid geometry, ellipsoid gravity, earth gravity field, gravitational potential, gravity and gravitation, plumbob gravity; Concepts of coordinate transformations: direction cosine matrix(DCM), Euler angles, quaternion; relation between DCM, Euler angles & quaternion.
Unit II: Concepts of strapdown inertial navigation

Inertial measurements: concept of specific force, basic principles of accelerometer: pendulous and vibrating beam, basic principle of gyroscope: mechanical and optical; Navigation equations formulation: forces in inertial & non-inertial frames, navigation equations in inertial & non-inertial frames, choice of reference frame, strapdown system mechanization for different frames: inertial frames, earth fixed frames, geographic frames –

Unit III: Strapdown inertial navigation computations

Sensor geometry: measurement model, concepts of DOP, failure detectability, optimal sensor geometry for different number of sensors; sensor modeling & compensation algorithms (scale factor, bias, misalignment etc.), practical constraints; Failure detection and isolation: concepts of parity vectors, generalized likelihood test; Attitude propagation algorithm: using Euler angle, DCM and quaternion; quaternion in terms of rotation vector, first and second order orientation vector algorithms for quaternion propagation, acceleration transformations, velocity & position update algorithms, numerical integration methods, comparison - Inertial navigation system alignment.

Unit IV: Initialization of inertial navigation system,

Principle of alignment: alignment on a fixed platform: azimuth and level alignment, alignment on a moving platform: in-flight alignment and shipboard alignment: one shot transfer alignment, measurement matching, methods of measurement matching; gyro-compassing; self corrective alignment scheme - Navigation System Simulation and Error Analysis: Error Analysis: development of perturbation models, attitude response under angular vibration, velocity response under combined angular and linear vibration, size effect errors, modeling of sensor assembly response to system level vibration; specialized error analysis for strapdown mechanization.

Unit V: INS Simulation:

simulation of sensors, measurement electronics and navigation algorithm; Navigation algorithm validation: comparison testing, closed loop simulations using NGC software together, hardware in-loop simulations; static navigation test, Monte Carlo & covariance analysis; General strapdown algorithm validation: spin-cone, spin-accel, spin-rock-
Advanced navigation concepts: Fundamentals of screw theory; fundamentals of Clifford algebra; dual quaternion and its applications in navigation.

References:
2. Kenneth R Britting; Inertial navigation system analysis, Wiley & Sons Canada, Limited, 1971

Course Name - Advanced Wireless Communication

Course Code – EE 607


Unit III: Wireless network security Overview of wireless technology: threats, vulnerabilities and safeguards, Cellular and PCS network security, secure wireless encrypted e-mail solution, Wireless handheld device security, Personal Area Networks security (e.g. Bluetooth), Wireless LAN security (IEEE 802.11).

Unit IV: Spread spectrum Multicarrier Modulation, Spread Spectrum, DSSS, FHSS, CDMA, Block diagram, Multiuser Communications & Wireless Networks, MIMO Systems Sensor
Networks Sensor Networks, Ad-hoc Networks, Sensor nodes (Motes), architecture, Applications of Sensor Networks, Routing protocols, Localization OS for sensor networks: Tiny OS.

**Unit V: Mobile devices** PDAs, Cellphones, Smart Phones, OS for Mobile Devices: Symbian, iOS, Embedded Linux Platforms: Android platform, Virtual Machines, Applications development, SDK, SyncML, Sim toolkit, SMS/MMS.

**Texts:**

**References:**

**Course Name - Navigation, Guidance & Control**
**Course Code – AE 603**

**Unit I: Navigation:** Navigation systems and principles of operation, Continuous waves and frequency modulated radars, MTI and Doppler radars; types of navigation; LORAN, Decca, Omega, VOR, INS, and GPS.

**Unit II: Guidance:** Classification and phases of missile guidance. Guidance laws: pursuit, LOS, CLOS, BR and PN laws. Advance Guidance Systems such as Imaging, Scene Correlation, Millimeteric wave, Non-LOS Guidance Systems, Laser Based Guidance Systems.

**Unit III: Control:** Classical linear time invariant control systems, transfer function representations, stability, Time domain characteristics, Frequency domain characteristics, Root Locus, Nyquist and Bode plots, Introduction to state space analysis.

**Reference Books:**

**Course Name - Computational Intelligence**

**Course Code – CE 604**

**Unit I:** Preliminaries in Computational Intelligence, Overview of Neural Networks, Learning in NN, The Perceptron Convergence Theorem Multi-Layer Perceptron, Data Pre-Processing, Regression, Universal Approximation, Classification, Time-Series Prediction, Unsupervised Learning: $k$-Means.

**Unit II:** SOM, Evolutionary Learning, Genetic Algorithms, Dimensionality Reduction & Feature Selection, Radial Basis Function Network, Support Vector Machines (SVM), Swarm Intelligence & Ant Colony Optimization, Simulated Annealing.


**Text Books:**


**Reference Books:**

M. Tech. in Mechanical Engineering (Mechanical System Design)

Brief Description: M. Tech. in Mechanical Engineering (Mechanical System Design) plays a vital role in the field of Mechanical Engineering discipline from the fundamentals to applications in industrial/Defence practices. The importance of this program is vivid from understanding basics, design, development and implementation of mechanical system.
The objective of entire program is to impart knowledge to Engineers/Scientists pertaining to Mechanical system design from the basics of engineering to final machine or equipment design ready to use in engineering system. This can be achieved by teaching a candidate different range of subjects for enhancing their analytical skills related to Machine design. Other objective of the program is to produce quality design engineers to cater to the needs of the relevant industry. The programme is conducted by well-versed faculty, invited experts from reputed institutions and industries.

**Eligibility:**

1. The eligibility for the postgraduate programme will be Bachelor’s Degree in Mechanical / Production Engineering disciplines from recognized university.

2. This programme is open for civilian GATE qualified candidates, DRDO Scientists/Officers and Officers from Tri-services. This programme is also open to foreign nationals from the countries approved by GOI.

**Organization:** M. Tech Mechanical Engineering with specialisation in Mechanical System Design is a four-semester programme. In the first semester there are six courses, in second semester, there are six courses and in the third semester there are two electives. In each of these semesters, there will be three tests and a final semester examination for every course. In third semester, M. Tech. (phase I) dissertation is there and in fourth semester, Phase-II dissertation work is to be completed. Half yearly evaluation of the project takes place at the end of the third semester. At the end of the final semester, student submits a thesis and makes a presentation about the M. Tech. project, which is evaluated by the Internal and External examiners. The details of the courses offered are:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Course Code</th>
<th>Course</th>
<th>Credits</th>
<th>Total Credits(*)</th>
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<tr>
<td>1</td>
<td>ME 602</td>
<td>Advanced Mechanics of Materials</td>
<td>3</td>
<td>1</td>
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<tr>
<td>2</td>
<td>ME 603</td>
<td>Advanced Fluid Mechanics</td>
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<td>3</td>
<td>ME 609</td>
<td>Mechanical Vibrations</td>
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<td>4</td>
<td>AM607</td>
<td>Mathematics for Engineers</td>
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<td>5</td>
<td>ME 631</td>
<td>Product Design and Development</td>
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### Semester- II

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<tr>
<td>1</td>
<td>ME 607</td>
<td>Computational Fluid Dynamics</td>
<td>L 3</td>
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<td>2</td>
<td>ME 630</td>
<td>Design of Machinery</td>
<td>L 3</td>
<td>T/P 1</td>
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<tr>
<td>3</td>
<td>ME 608</td>
<td>Finite Element Methods</td>
<td>L 3</td>
<td>T/P 1</td>
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<tr>
<td>4</td>
<td>ME 627</td>
<td>Fatigue, Fracture and Failure Analysis</td>
<td>L 3</td>
<td>T/P 1</td>
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<td>Elective – I</td>
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<td>Elective – II</td>
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Note: 04 weeks industrial practice school during summer vacation for scholarship students.

### Semester- III

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<th>S. No.</th>
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<tr>
<td>1</td>
<td>ME 651</td>
<td>M.Tech. Dissertation Phase I</td>
<td>L 28**</td>
<td>T/P 14</td>
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### Semester-IV

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<tbody>
<tr>
<td>1</td>
<td>ME 652</td>
<td>M.Tech. Dissertation Phase II</td>
<td>L 28**</td>
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<td><strong>Total</strong></td>
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* 1 credit in Theory/ Tutorial means one contact hour and 1 credit in Practice/Project Thesis means two contact hours.

**Contact Hours/ week

### List of Electives

<table>
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<tbody>
<tr>
<td>1</td>
<td>AM 602</td>
<td>Mathematical Modeling and System Analysis</td>
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<td>2</td>
<td>AM 603</td>
<td>Operations Research</td>
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<td>3</td>
<td>ME 604</td>
<td>Advanced Materials and processing</td>
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<tr>
<td>4</td>
<td>ME 611</td>
<td>Design for manufacturability</td>
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<tr>
<td>5</td>
<td>ME 617</td>
<td>Kinematics and dynamics of Machinery</td>
</tr>
<tr>
<td>6</td>
<td>ME 618</td>
<td>Composite Structures</td>
</tr>
</tbody>
</table>
Detailed Contents

Course Name- Advanced Mechanics of Materials
Course Code- ME 602

Unit I: Theory of Elasticity-Introduction, Stress. Differential equations of equilibrium, strain, compatibility conditions, plane problems of elasticity, stress strain relations, stress functions and applications in 2D problems. Pressurized cylinders & rotating disks, Governing equations, Stresses in thick walled cylinder under internal and external pressures. Introduction to experimental stress analysis.

Unit II: Energy Methods-Work done by forces and strain energy, reciprocal relations, Castigliano’s theorems, Fictitious load method, statically indeterminate structures, theorem of virtual work, generalization of castigliano’s theorem.

Unit III: Asymmetrical Bending of beams-Bending of prismatic bars and unsymmetrical bending. Concept of shear centre in symmetric and un-symmetric bending, Plate bending, bending of curved beams.

Unit IV: Torsion of non-circular sections-Introduction, torsion of general prismatic solid section like circular, elliptical, rectangular, triangular shafts, membrane analogy, torsion of thin walled tubes, torsion of thin walled multiple cell closed sections.

Text/References:

Course Name- Advanced Fluid Mechanics
Course Code- ME 603

Unit II: Dynamics of Ideal Fluid Motion, Applications, Integration of Euler’s equations of motion. Governing Equations of fluid flow in differential form, Navier-Stokes Equations and exact solutions, Energy Equation and solution of fluid flow with thermal effects.

Unit III: Dimensional Analysis. Prandtl’s Boundary Layer equations, Laminar Boundary Layer over a Flat Plate, Blasius solution. Turbulent flows in two-dimensional channels and pipes, Velocity field, Smooth and Rough pipes, Drag reduction in pipes, Turbulent Boundary Layer over a Flat Plate, Laws of wall over Flat Plates, Effect of Pressure gradient, Boundary Layer control.

Unit IV: Speed of sound and Mach number, Basic equations for one dimensional flows, Isentropic relations, Normal-shock wave, Rankine-Hugoniot relations, Fanno and Rayleigh curve, Mach waves, Oblique shock wave, Prandtl-Meyer expansion waves, Quasi-one dimensional flows, Compressible viscous flows, Compressible boundary layers.

Practice:
- Steady State Determination of heat transfer temperature difference and surface heat transfer coefficient for a single tube in a transversely flowing air stream.
- Determination of the Relationship between Nusselt and Reynolds Number for the forward stagnation point on a cylinder in cross flow using the Direct Heat Transfer Cylinder.
- Investigation of the effect of external fins on the heat transfer watt density of plain tube bundles in cross flow.
- Determination of the heat transfer rate and the exchanger effectiveness.
- Measure the distribution of Total pressure and Static Pressure along the duct and to compare these with the predictions of Bernoulli’s equation.
- Measure the Temperature of Furnace by using the thermal Image Camera.

Text/References:
2. Boundary Layer Theory, 8th ed, 2000, Herrmann Schlichting, Springer

Course Name- Mechanical Vibrations
Course Code- ME 609

Unit I: Single Degree of Freedom Systems- Free and forced vibrations of damped and undamped systems; Simple harmonic excitation; steady state response; torsional vibrations.

Unit II: Vibration of Systems with Two Degrees of Freedom- Free and forced vibration of spring-mass-damper systems; torsional vibrations; modal analysis of undamped and damped systems; numerical methods: Matrix iteration, Holzer’s method, Dunkerley’s lower and Rayleigh’s upper bound approximations; Dynamic vibration absorbers

Unit III: Vibration of Multi-degree of Freedom and Continuous Systems: Vibrating string; Longitudinal and torsional vibration of rods; Free and forced vibration of beams; Properties of vibrating systems: Flexibility and stiffness influence coefficients; Reciprocity theorem; Eigenvalue analysis; Orthogonality of eigenvectors; Modal matrix
Unit IV: Experimental methods in vibration analysis: Vibration instruments: exciters, transducers, analysers, measurement devices: vibrometers, velocity meters and accelerometers; Signal analysis techniques: time domain analysis, frequency domain analysis, amplitude and power spectra, coherence, auto and cross correlations, amplitude and frequency modulations; Tests for free and forced vibrations

Unit V: Case studies - Vehicle dynamics: introduction to nonlinear and random vibrations, vehicle subjected to random vibrations (for example an uneven road); Fluid-structure interaction problems: vibration of suspension bridges, Noise control and acoustics.

Practice:
Any four experiments on topics under unit I, II and III on Vibration Fundamental Trainer.

Text Books:
1. Introductory Course on Theory and Practice of Mechanical Vibrations, J.S.Rao, K.Gupta, Revised second edition, New Age International Publishers

Reference Books:

Course Name - Product Design and Development
Course Code - ME 631

Unit I: Introduction - Significance of product design, product design and development process, sequential engineering design method, the challenges of product development,

Unit II: Product Planning and Project Selection - Identifying opportunities, evaluate and prioritize projects, allocation of resources Identifying Customer Needs: Interpret raw data in terms of customers need, organize needs in hierarchy and establish the relative importance of needs.,

Unit III: Product Specifications - Establish target specifications, setting final specifications, Concept Generation: Activities of concept generation, clarifying problem, search both internally and externally, explore the output.

Unit IV: Industrial Design - Assessing need for industrial design, industrial design process, management, assessing quality of industrial design, Concept Selection: Overview, concept screening and concept scoring, methods of selection.

Unit V: Theory of inventive problem solving (TRIZ) - Fundamentals, methods and techniques, General Theory of Innovation and TRIZ, Value engineering Applications in Product development and design, Model-based technology for generating innovative ideas
Unit VI: Concept Testing - Elements of testing: qualitative and quantitative methods including survey, measurement of customers’ response. Intellectual Property- Elements and outline, patenting procedures, claim procedure, Design for Environment- Impact, regulations from government, ISO system.,

Text/References:
4. Inventive thinking through TRIZ: a practical guide, By Michael A. Orloff, Springer
5. Systematic innovation: an introduction to TRIZ ; (theory of inventive Problem Solving), By John Terninko, Alla Zusman, CRC Press.

Course Name- Tribology for Design
Course Code- ME 619

Unit I: Introduction-Defining Tribology, Tribology in Design - Mechanical design of oil seals and gasket
- Tribological design of oil seals and gasket, Tribology in Industry (Maintenance), Defining Lubrication, Basic Modes of Lubrication, Properties of Lubricants, Lubricant Additives, Defining Bearing, Terminology - Sliding contact bearings -Rolling contact bearings, Comparison between Sliding and Rolling Contact Bearings


Unit IV: Hydrodynamic Thrust Bearing-Introduction - Flat plate thrust bearing - Tilting pad thrust bearing, Pressure Equation - Flat plate thrust bearing - Tilting pad thrust bearing, Load - Flat plate thrust bearing - Tilting pad thrust bearing, Center of Pressure - Flat plate thrust bearing - Tilting pad thrust bearing, Friction - Flat plate thrust bearing - Tilting pad thrust bearing

Unit V: Hydrostatic and Squeeze Film Lubrication-Hydrostatic Lubrication - Basic concept - Advantages and limitations - Viscous flow through rectangular slot – Load carrying capacity and flow requirement - Energy losses - Optimum design, Squeeze Film Lubrication - Basic concept - Squeeze action between circular and rectangular plates - Squeeze action under variable and alternating loads, Application to journal bearings, Piston Pin Lubrications.

Unit VII: Gas (Air) Lubricated Bearings - Introduction, Merits, Demerits and Applications, Tilting pad bearings, Magnetic recording, discs with flying head, Hydrostatic bearings with air lubrication, Hydrodynamic bearings with air lubrication, Thrust bearings with air lubrication.


Practice:
1. Surface roughness test,
2. Friction & Wear test on Pin on disc Machine
3. Case studies etc.

Text/References:

Course Name: Computational Fluid Dynamics (CFD)
Course Code: ME 607

Unit I: Basic of Computational Fluid Dynamics. Governing Equations of fluid mechanics and heat transfer, physical boundary conditions, basic aspects of Discretization.

Unit II: Finite Difference and Finite Volume formulation of steady/transient one-dimensional conduction equation, Finite Volume formulation of steady one-dimensional convection and diffusion problems

Unit III: Solution algorithms for pressure-velocity coupling in steady and unsteady flows. discretization equations for two dimensional convection and diffusion.


Practice:
1. Turbulent Flow in a 2D elbow. (use water)
2. Laminar Flow in a 2D Pipe. (use water)
3. Flow over an Airfoil. (use air)
4. Laminar flow over a flat plate.

Text/References:
2. Introduction to Computational Fluid Dynamics, 2005, Anil W Date, Cambridge University Press, NY, USA.

Course Name- Design of Machinery
Course Code- ME 630


Unit III: Dynamics of mechanisms/machineries- Dynamics Fundamentals, Dynamic Force Analysis, Balancing, Engine Dynamics, Multi cylinder Engines.


Outcomes:
Upon completion of this course, the students can able to apply fundamentals of mechanism/machines for the design of new mechanisms/machines and analyse them for optimum design.

Text/References:

Course Name- Finite Element Methods
Course Code- ME 608

Unit I: Prerequisites to FEM-Application of FEM, Strain- displacement relations, Stress-strain relations, Differential equations of equilibrium, Co-ordinates, basic element shapes, interpolation function, Minimum potential energy. Properties of stiffness matrix, treatment of boundary conditions, solution of system of equations, shape functions and characteristics.


Unit IV: Scalar field problems-1-D Heat conduction through composite walls, fins of uniform cross section, 2-D heat conduction problems, Torsional problems.


Practice:
(vii) Stress Analysis of Plate With Cut-outs using ANSYS/ABAQUS Software
(viii) Modal Analysis Of Cantilever Beam using ANSYS/ABAQUS Software
(ix) Case Studies etc.

Text /References:
3. A First Course in the Finite Element Method by Daryl L. Logan.
**Course Name: Fatigue, Fracture and Failure Analysis**  
**Course Code: ME 627**

**Unit I: Fatigue of Structures**  

**Unit II: Statistical Aspects of Fatigue Behaviour**  
Low cycle and high cycle fatigue - Coffin-Manson’s relation - Transition life - cyclic strain hardening and softening - Analysis of load histories - Cycle counting techniques - Cumulative damage - Miner’s theory - Other theories.

**Unit III: Physical Aspects of Fatigue**  
Phase in fatigue life - Crack initiation - Crack growth - Final Fracture - Dislocations - fatigue fracture surfaces.

**Unit IV: Fracture Mechanics**  
Strength of cracked bodies - Potential energy and surface energy - Griffith’s theory - Irwin - Orwin extension of Griffith’s theory to ductile materials - stress analysis of cracked bodies - Effect of thickness on fracture toughness - stress intensity factors for typical geometries.

**Unit V: Fatigue Design and Testing**  
Safe life and Fail-safe design philosophies - Importance of Fracture Mechanics in aerospace structures - Application to composite materials and structures.

**Text /References:**

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**Electives**

**Course Name: Mathematical Modelling and System Analysis**  
**Course Code: AM 602**

**Unit I: Mathematical Modelling:** Introduction to modelling and simulation, Classification of systems into continuous and discrete, Structural characterization of mathematical model and validation techniques.

**Unit II: Modelling Techniques:** Dimensional analysis: Concept behind dimensional approach, Buckingham Pi theorem, Models using dimensional approach.

**Unit III: Continuous approach:** Models based on physical laws.

**Unit IV: Discrete Approach:** Models based on discrete approach. Prey - Predator models.

**Unit V: Combat Modelling:** Modelling the Lanchester laws with System Dynamics.

**Unit VI: System Analysis:** The state of a system, mathematical models of continuous linear lumped parameter, time invariant systems, Discrete time systems, Linear approximation of non-linear systems, Topological models of system, Block diagram representation, Signal flow graph, and Mason’s rule. A generalized approach to modelling. Principles of conservation and continuity and Applications. Basics of simulator technology.

**Text / References:**

**Course Name- Operations Research**  
**Course Code- AM 603**  
**Unit I:** Introduction to OR, Linear programming (Simplex Method, Revised Simplex Method, Dual simplex, Duality theory), Transportation Models, Integer linear Programming, Dynamic Programming,  
**Unit II:** Introduction to Game Theory. Classical optimization techniques, one dimensional nonlinear optimization, unconstrained optimization using calculus (Taylor's theorem, convex functions, Coercive functions).  
**Unit III:** Unconstrained optimization via iterative methods (Newton's method, Gradient/ conjugate gradient based methods, Quasi- Newton methods). Constrained optimization (Penalty methods, Lagrange multipliers, Kuhn-Tucker conditions). Genetic Algorithms. Note: Relevant practicals to be taught while teaching module.  
**Text/References:**  

**Course Name- Advanced Materials and Processing**  
**Course Code- ME 604**  
**Unit I:** Introduction of advanced materials and its manufacturing processes for engineering applications.  
**Piezoelectric materials (PZT)-** Piezoelectric effect, Di-electric hysterisis, piezoelectric constants, piezoelectric charge constants, dynamic behaviour of PZT transducers, piezoelectric materials and manufacturing techniques (stability, poling and depolarisation).  
**Unit II: Shape memory alloys (SMA)-** Shape memory effect and the metallurgical phenomenon of SMA. Temperature assisted shape memory effect, Visco-elastic behaviour, magnetic shape memory effect. Various shape memory alloys. Manufacturing technology of SMAs.  
**Unit III: Electro rheological (ER) and magneto-rheological (MR) materials-** Characteristics of ER and EM fluids. ER and EM materials.
Unit IV: Composite materials- Design and manufacturing of polymer matrix, metal matrix and ceramic matrix composites. Various forms and type of reinforcements, fillers and additives. Design of composites for structural, wear resistance and high temperature applications.


Text/References:

Course Name- Design for Manufacturability
Course Code- ME 611

Unit I: Manufacturing Considerations in Design- Design for manufacture, Tolerencing and tolerance analysis. Processing techniques and limitations for metals, polymers and ceramics. Influence of materials in processing and tooling on the design of components. Finishing, surface coatings and surface modifications of materials.


Unit III: Machining considerations- Design for accuracy, locating pins and registers, machining in assembly, adjustment. Backlash and clearance adjustment. Examples illustrating the various principles. Available design variants for some of the common basic functional requirements.

Text/References:

Course Name- Kinematics and Dynamics of Machinery
Course Code- ME 617

Unit I: Machine kinematics- Overview, Degrees of freedom, Links and joints, Grashof condition, 4-bar linkage, slider-crank, and inverted slider crank

Unit II: Machine Dynamics- Newtonian solution method, Force analysis of linkage, Shaking force and torque, Balancing linkage, Flywheels

Unit III: Gears and gear trains- Terminologies of gears and gear trains, Interface, undercutting, contact ratio, Simple gears and compound gear trains, Planetary gear trains

Unit IV: Cam systems- Cam terminologies, Cam function design and sizing

Unit V: Programmable mechanisms- Introduction to industrial manipulators, Kinematic chains and classifications, Coordinate transformation, Forward and inverse kinematics

Text/References:

Course Name- Composite Structures
Course Code- ME 618

Unit I: Introduction composite materials-Classification and characteristics, mechanical behavior of composite materials, basic terminology, and manufacture of laminated fiber-reinforced composite materials, current and potential advantages of fiber –reinforced composite materials, applications of composite materials.

Unit II: Macro-mechanical behavior of lamina-Introduction, stress-strain relations for anisotropic materials, stiffnesses, compliances , and engineering constants for orthotropic materials, restrictions on engineering constants, stress train relation for plane stress in an orthotropic material, stress-train relations for lamina of arbitrary orientation, invariant properties of an orthotropic lamina, strengths of an orthographic lamina, biaxial strength criteria for an orthotropic lamina.

Unit III: Micro-mechanical behavior of lamina-Introduction, mechanics of materials approach to stiffness, elasticity approach to stiffness, comparison of approaches to stiffness, mechanics of materials approach to strength.

Unit IV: Macro-mechanical behavior of laminates-Introduction, Classical Lamination Theory, Special Cases Of Laminate Stiffness, Theoretical Versus Measured Stiffness, Strength Of Laminates, Inter-Laminar Stress.
Unit V: Introduction to design of composites structures - Introduction to structural design, material selection, configuration selection, laminate joints design requirements and design failure criteria, optimization concepts, design analysis philosophy for composite structures.


Unit VII: Testing and characterisation of composites - Lamina strength characterization, tensile testing, compression testing, in-plane shear testing, short beam test, double cantilever beam test. Physical properties characterisation void content evaluation, fibre Volume Fraction Evaluation, DMA, DSC FOR Tg, Wet Properties Of Lamina, NDE Methods, Ultrasonic A-scan and CT-Scan Methods For Characterisation Of Composites.

Text books:

Reference books:
7. Liquid moulding technologies, c d Rudd, a c long, k n Kendall and c g e Mangin, woodhead publishing limited, Cambridge England.

Course Name- Design of Hydraulic and Pneumatic Systems
Course Code- ME 628


circuit, Penumo hydraulic circuit, Sequential circuit design for simple applications using cascade method.

Unit IV: Design of Pneumatic Circuits-Servo systems – Hydro Mechanical servo systems, Electro hydraulic servo systems and proportional valves. Fluidics – Introduction to fluidic devices, simple circuits, Introduction to Electro Hydraulic Pneumatic logic circuits, ladder diagrams, PLC applications in fluid power control. Fluid power circuits; failure and troubleshooting.

Text Books:

Reference Books:

Course Name- Design of Experiments
Course Code- ME 629
Unit I: Overview and Basic Principles, Simple Designs and Analysis of Variance,
Unit II: Block Designs, Latin Squares and Related Designs, Full Factorial Designs, 2-level Full Factorial and Fractional Factorial Designs.
Unit III: Response surface methods and designs, Designs with Random Factors, Nested Designs, and split-plot Designs.

Text/ References:

Course Name- Design Optimization
Course Code- ME 632
Unit II: Single Variable Optimization Techniques-Optimality Criteria - Bracketing Methods - Exhaustive search method - Bounding phase method – Region Elimination Methods - Interval
halving method - Fibonacci search method - Golden section search method - Gradient based

**Unit III: Multi Variable and Constrained Optimization Techniques**
Optimality criteria - Direct search Method - Simplex search methods - Hooke-Jeeve’s pattern search method - Powell’s conjugate direction method - Gradient based method - Cauchy’s method - Newton’s method - Conjugate gradient method. Kuhn - Tucker conditions - Penalty Function - Concept of
Lagrangian multiplier - Complex search method - Random search method

**Unit IV: Intelligent Optimization Techniques**
Introduction to Intelligent Optimization - Soft Computing - Working principles of Genetic Algorithm Types of reproduction operators,
crossover & mutation, - Simulated Annealing Algorithm - Particle Swarm Optimization (PSO) -
Graph Grammer Approach - Example Problems

**Unit V: Engineering Applications**
Structural applications - Design of simple truss members. Design applications - Optimum design of simple axial, transverse loaded members - Optimum
design of shafts - Optimum design of springs. Dynamic applications - Optimum design of single,
two degree of freedom systems and gear vibration absorbers. Mechanisms applications - Optimum design of simple linkage mechanisms

**Text/References:**

**Course Name** - *Mechanical Behavior of Materials*
**Course Code** - *ME 633*

**Unit I: Introduction to deformation behaviour**- Concept of stresses and strains, engineering stresses and strains, Different types of loading and temperature encountered in applications, Tensile Test - stress – strain response for metal, ceramic and polymer, elastic region, yield point, plastic deformation, necking and fracture, Bonding and Material Behaviour, theoretical estimates of yield strength in metals and ceramics.

**Unit II: Elasticity Theory**- The State of Stress and strain, stress and strain tensor, tensor transformation, principal stress and strain, elastic stress-strain relation, anisotropy, elastic behaviour of metals, ceramics and polymers.

**Unit III: Yielding and Plastic Deformation**- Hydrostatic and Deviatoric stress, Octahedral stress, yield criteria and yield surface, texture and distortion of yield surface, Limitation of engineering strain at large deformation, true stress and true strain, effective stress, effective strain, flow rules, strain hardening, Ramberg- Osgood equation, stress - strain relation in plasticity, plastic deformation of metals and polymers.
Unit IV: Microscopic view of plastic deformation - crystals and defects, classification of defects, thermodynamics of defects, geometry of dislocations, slip and glide, dislocation generation - Frank Read and grain boundary sources, stress and strain field around dislocations, force on dislocation - self-stress, dislocation interactions, partial dislocations, twinning, dislocation movement and strain rate, deformation behavior of single crystal, critical resolved shear stress (CRSS), deformation of poly-crystals - Hall-Petch and other hardening mechanisms, grain size effect - source limited plasticity, Hall-Petch breakdown, dislocations in ceramics and glasses.

Unit V: Fracture - Fracture in ceramics, polymers and metals, different types of fractures in metals, fracture mechanics - Linear fracture mechanics - KIC, elasto-plastic fracture mechanics - JIC, Measurement and ASTM standards, Design based on fracture mechanics, effect of environment, effect of microstructure on KIC and JIC, application of fracture mechanics in the design of metals, ceramics and polymers.

Unit VI: Deformation under cyclic load - Fatigue - S-N curves, Low and high cycle fatigue, Life cycle prediction, Fatigue in metals, ceramics and polymers.

Unit VII: Deformation at High temperature - Time dependent deformation - creep, different stages of creep, creep and stress rupture, creep mechanisms and creep mechanism maps, creep under multi-axial loading, microstructural aspects of creep and design of creep resistant alloys, high temperature deformation of ceramics and polymers.

Text/References:

Course Name- Experimental Stress Analysis
Course Code- ME 634

Unit I: Measurements & Extensometer - Principles of measurements, Accuracy, Sensitivity and range of measurements. Mechanical, Optical Acoustical and Electrical extensometers and their uses, Advantages and disadvantages.

Unit II: Electrical Resistance Strain Gauges - Principle of operation and requirements, Types and their uses, Materials for strain gauge. Calibration and temperature compensation, cross sensitivity, Rosette analysis, Wheatstone bridge and potentiometer circuits for static and dynamic strain measurements, strain indicators.

Unit III: Photoelasticity - Two dimensional photo elasticity, Concept of light – photoelastic effects, stress optic law, Interpretation of fringe pattern, Compensation and separation techniques, Photo elastic materials. Introduction to three dimensional photo elasticity.
Unit IV: Brittle Coating and Moire Methods- Introduction to Moire techniques, brittle coating methods and holography.

Unit V: Non-Destructive Testing- Fundamentals of N DT, Radiography, ultrasonic, magnetic particle inspection, Fluorescent penetrant technique, Eddy current testing, Acoustic Emission Technique.

Text Books:

Reference Books:

Course Name- CAD/CAM
Course Code- ME 635
Unit I: Criteria for selection of CAD workstations, Shigle Design Process, Design criteria, Geometric modeling, entities, 2D & 3D Primitives.
Text/References:

Course Name- MEMS - Design, Fabrication, and Characterization
Course Code- ME 636
**Unit I: MEMS Fabrication**-Conventional MEMS fabrication using VLSI technology: lithography, chemical etching: isotropic and anisotropic, Plasma etching, reactive ion etching (RIE), oxidation, chemical vapour deposition (CVD), LPCVD, PECVD, surface micromachining, LIGA, single layer and higher layer fabrication. Non-conventional MEMS fabrication: laser micromachining and welding, processing of metals and nonmetals with laser, Electro Discharge and Electro Chemical micromachining (EDM and ECM), Microstereolithography: scanning process, dynamic mask process. Electronic packaging.

**Unit II: MEMS: Design and Analysis**-Basic concepts of design of MEMS devices and processes, Design for fabrication, Other design considerations, Analysis of MEMS devices, FEM and Multiphysics analysis, Modeling and simulation, connection between molecular and continuum mechanics, MEM system level analysis from perspective of control theory.


**Text/References:**


**Course Name- Design of Pressure Vessel**

**Course Code- ME 637**


**Unit III: Design of Vessels**-Design of Tall cylindrical self-supporting process columns – Supports for short, vertical and horizontal vessels – stress concentration – at a variable Thickness
transition section in a cylindrical vessel, about a circular hole, elliptical openings. Theory of Reinforcement – pressure vessel Design. Introduction to ASME pressure vessel codes

Unit III: Buckling Of Vessels - Buckling phenomenon – Elastic Buckling of circular ring and cylinders under external pressure – collapse of thick walled cylinders or tubes under external pressure – Effect of supports on Elastic Buckling of Cylinders – Buckling under combined External pressure and axial loading.

Text/References:

Course Name- Advanced Heat & Mass Transfer
Course Code- ME 654

Unit I: Conduction Heat Transfer - Fourier's law, 1-D heat diffusion equation, 3-D form (Laplacian), Solution, Thermal resistance concept - electrical analogy, Fick's and Ohm's laws, Radial heat conduction, critical radius of insulation, Heat diffusion equation - general form, Transient conduction, extended surface heat transfer

Unit II: Convective Heat Transfer - Applications, Forced, free and mixed convection, Internal and external flow, Heat transfer coefficient and its physical significance, Dimensional analysis in convective heat transfer, Conservation equations - mass, momentum and energy, boundary condition

Unit III: External laminar forced convection - Boundary layer equation, Energy equation and similarity solution for flow over flat plate for various boundary conditions and Prandtl numbers, Scale analysis, Approximate method, Viscous dissipation effect of laminar boundary layer

Unit IV: Internal laminar forced convection - Developing and developed flow and heat transfer in a duct and circular pipe having various boundary conditions

Unit V: Mass convection - Various non-dimensional numbers and their analogy to those of heat transfer, Analogy friction, heat transfer and mass transfer coefficients, Species equations, Examples of simultaneous heat and mass transfer

Unit VI: Heat transfer in phase change - Boiling, Condensation and Radiation - Kirchhoff's law, Black and grey bodies, Gaseous radiation, Solar energy

Text/References:
1. Convective Heat Transfer by L. C. Burmeister (John Wiley and Sons)
2. Convective Heat Transfer by Adrian Bejan (John Wiley and Sons)
3. Boundary Layer Theory by H Sctllichting (McGraw-Hill)
5. Introduction to Convective Heat Transfer Analysis by Patrick H. Oosthuizen and David Laylor (McGraw-Hill)
The department of Computer Science and Engineering was established in 1987. The department of Computer Engineering offers M. Tech., M.Sc.(by Research) and Ph.D. programs for DRDO scientists, tri-services and GATE qualified students. Currently, there are 06 faculty members in the department. Five faculty members have PhD degrees and one is pursuing the PhD programs in DIAT. Currently, the department has 20 PhD research scholars and 47 M.Tech. students.


The department has successfully organized NCECE 2016 (National Conference on Electronics and Computer Science – Theme: Defence Applications) Sponsored by BEL and NCSDAQC 2017 (National Cyber Security Seminar, Debate and Quiz Contest) during July 2017 sponsored by DRDO. The Department has also conducted several workshops on Ethical Hacking, Cyber Security, Nine Algorithms, IT and Defence etc. The department had received NVIDIA academic research grant, 2018 for deep learning based research activities.

The department of Computer Engineering is associated with the data center activities to facilitate the email, WiFi, internet, web hosting, etc. to the DIAT campus. The establishment of
M.Tech. in Computer Science and Engineering
(Cyber Security)

Brief Description:
Communication networks and information systems have become an essential factor in economic, social development and almost in every facet of our daily lives. Information systems are vulnerable to one or more types of cyber attacks. The security of communication networks and information systems and their availability in particular, is therefore of increasing concern. In general, cyber security threats are increasing rapidly, the incidents range from defaced websites to theft of large volumes of intellectual property and money, to even Internet crimes. Cyber security is now a prominent field of study. Professionals who are trained in this field are highly regarded and contribute to strengthening the social, political and financial fabric of modern society.

The domain of cyber security refers to the collection of tools, policies, security concepts, guidelines, risk management approaches, actions, training, best practices, assurance and technologies that can be used to protect the cyber environment, organization and user’s assets.

To survive in an Information Centric Warfare scenario, the tools and techniques of cyber security will provide mechanisms to safeguard the critical systems against related threats & attacks. In this context, new information centric complex systems require highly skilled manpower, not only to research, design, develop and test reliable secure systems but also to: install, deploy, utilize & maintain them throughout their lifespan.

The M.Tech(Cyber Security) programme aims at developing Human Resources in the field of Cyber Security with a thrust on defence related problems. The present programme is conceived to understand, assimilate & use the advanced technologies to design and develop secure systems, comprehend different types of cyber attacks, methods and technologies to develop secure IT infrastructure. Advanced technologies from domains such as Network security, Cryptography, Ethical Hacking, Digital Forensic, Malware Analysis, Information Security Management and Trusted Computing techniques have been selected. After completing this course, students are expected to understand and practice the essential
concepts related to Information Security, Incident Responses, Digital Evidence Analysis, Cyber Attacks, Design and Development of secure systems, Penetration Testing etc.

Eligibility: Fulltime BE/B.Tech. in Computer Science / Electronics / Electrical / Communication / Telecommunication/ Information Technology or Fulltime M.Sc./MCA in Computer Science with valid gate score in CS/ECE.

Organization: The Programme curriculum has been designed considering the cyber security requirements of Industry and Defence research and development. It is designed and reviewed by panel of experts chosen from various DRDO labs and leading academic institutions. Each subject of 4 credits is delivered by subject experts through the duration of 16 weeks approximately. It consists of 3 hrs of class room interaction and 2 hrs of lab sessions per week. The evaluations follow continuous assessment process that includes – 3 monthly evaluation exams (10 Marks each), internal assessment (20 Marks) and final examination (50 Marks). The lab focuses on practical exposure to the cyber security tools and techniques in form of mini projects and lab assignments. The 3rd and 4th semesters have a major component of MTech project dissertation, where the students work under close supervision and guidance of their project guide. The students present their work at the end of 3rd and 4th semester. The MTech thesis is submitted and evaluated by the panel of expert examiners at the end of 4th semester.

<table>
<thead>
<tr>
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<td>Applied Cryptography</td>
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<td>Security Standards &amp; Audits</td>
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<td>CE680</td>
<td>Data Mining Techniques</td>
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<td>Secure Software Engineering</td>
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<td>Ethical Hacking and Penetration Testing</td>
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* 04 week industrial practice school during summer vacation for scholarship students.

Semester III

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### Semester IV

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<td>Mobile Computing</td>
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<td>Fault Tolerant Computing Systems</td>
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<td>Big data Analysis &amp; Algorithms</td>
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<td>BitCoins and Cryptocurrency</td>
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<td>CE 70A</td>
<td>Formal Specification and Verification of Programs</td>
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<td>28</td>
<td>CE 70D</td>
<td>Computer Network Audit &amp; Forensics</td>
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**CE 660 Advanced Computer Networks**

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Course Objective:
To meet end-user, Network-Administrator & Network-Designer perspectives, develop skill sets to be resourceful in the area of Cyber-Security. Enhance analytical capabilities to evaluate a Network and Network Enabled Operations to analyze Network Centric Operations.

Prerequisites:
Preliminary knowledge Electronic Communications (Graduation Level), Computer Networks (Graduation Level) & IPV4, Networking Devices, Finite State Automata, Socket Programming, Algorithms

Teaching Method:
Class room instructions, learning through assignments, learning through hands-on sessions, learning through online recommended courses to complement the class room instructions

Short Recapitulation on topics before the start of the Course: Architecture of Computer Networks, ISO/OSI and TCP/IP model, IP protocol, transport protocols (TCP, UDP), basic services of computer networks (short recapitulation)

Course Contents:

Unit I
Basic Network-Application Architectures: n-tier, Peer-to-peer networks; Routing in Structured and Unstructured P2P systems and hybrid P2P networks

Unit II
Packet Analysis, Packet Analysis Tools, Network Audit & tools, Network Traffic Engineering, Network Forensics, Network-Audit, Network Analysis and Analytics

Unit III
Advanced features of IPv6 protocol: Mobility and Security, ICMPv6, IPv6 support in applications

Unit IV
Advanced Routing Mechanisms: distance vector, link state and path vector routing; Router Architecture; MPLS, MPLS labels assignment and distribution, MPLS routing

Unit V
AI-Enabled Network Environments, Network Virtualization, SDNs, Sensor Networks, IoT, Evolution in Computing Environments like Cloud, Edge, Fog, Ubiquitous, Pervasive; Futuristic Networks

Text Book:
2. Wireshark Tool Notes, Packet Analysis.

Recommended Readings:


4. Topic based Research Papers assigned during classroom discussions

References

1. RFCs and Internet Drafts, available from Internet Engineering Task Force.
6. TCP/IP Illustrated, Volume 1: The protocols by W. R. Stevens, Addison Wesley, 2005

CE 662 Operating System Security

Objectives:
This course examines what it takes to build a secure operating system and explores the major systems development approaches applied towards building secure OS’s including virtualization.

From this course, students will learn:
- Theoretical concepts of operating system security
- Security architectures of current operating systems
- Details of security implementation
- Concept of virtualization
- Security mechanisms in virtual machines

Prerequisites: Operating System Concepts

Syllabus:
**Operating System Fundamentals:** Process management – Process states, runtime environment, IPC; Memory management – Memory organization, virtual memory concept; File System; OS kernel architecture. **Introduction to Secure Operating Systems:** Security goals, Trust model, Threat model. **Access Control Fundamentals:** Protection system, Reference monitor concept, Discretionary protection system, Mandatory protection system, Rule-based access control, Role-based access control. **Multics:** Multics security fundamentals, protection system models, vulnerability analysis. **Security in Unix-like and Windows OS:** protection system,
authorization, security analysis. **Verifiable Security Goals:** Information flow models, secrecy models, integrity models. **Secure Capability Systems:** Capability system fundamentals, Building secure capability systems. **Security Kernels:** Scomp architecture, Kernel data structure analysis. **Security in Commercial Operating Systems:** Security in Commercial Operating Systems - Microkernel systems, UNIX systems. **Kernel level attack vectors:** Memory exploits, code based attacks. **Case Studies:** Solaris Trusted Extensions, SE Linux, Android security features. **Secure Virtual Machine Systems:** Separation kernels, sandboxing, Multiple Independent Levels of Security, VAX/VMM security kernel architecture.

**Text Book:**

**Reference Material:**
1. Morrie Gasser: "Building a Secure Computer System"

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**CE 663 Applied Cryptography**

**Course Objectives:** Understanding of basic encryption schemes and issue related to cryptanalysis
- Private keys encryption schemes
- Public keys encryption schemes
- Elliptic Curve Cryptography
- Hash algorithms

Be able to determine the strength and weakness of the encryption schemes.

**Course Prerequisites:** Basic understanding of Mathematics concept like Prime numbers, Group, Ring and Fields

**Syllabus:**

**New Additions:** AES and Quantum Cryptography

**Text Book:**

**Reference Books**

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**CE 665 Security Standards & Audits**

**Course Objectives:**
This course examines the methods for securing information existing in different forms. This course will provide an introduction to the different technical and administrative aspects of Information Security and Assurance. Student will learn various countermeasures/tools/mechanisms/best practices used for implementing and managing information security. Students will also learn to design, implement, integrate and manage various security infrastructure components through hands-on activities in Information Security Laboratory.

1. To facilitate individual in gaining knowledge on information security management systems,.
2. To facilitate individual in gaining knowledge on security standards like ISO-27001 standards, TCSEC, ITSEC, Secure coding and cyberlaws.

**Prerequisites:** Basic computer networking, operating systems and computer programming knowledge is required.

**Syllabus:**


**Text Book:**

**Reference Books:**

Research paper for study (if any) - White papers on information security assurance from IEEE/ACM/IBM sources. Important website for reference & Study (if any) - ISACA website.

**CE 680  Data Mining Techniques**

**Course Objectives:**
- To learn the advanced techniques w.r.t. the applications in different fields
- To implement those techniques using MATLAB/C/C++ and test them on bench-marked datasets.
- To validate their understanding in terms of developing atleast 2/3 functionalities in Cyber Security domain using Open-Source Tool

**Pre- Requisites:**
Knowledge of Statistical Techniques, Probability Theory, Data Structures and Algorithms.

**Syllabus:**
**Unit I:** Introduction to Data Mining and Pattern Recognition Systems.

**Unit II:** Classification: Linear Classifiers and Non-Linear Classifiers, Bayes Decision Theory, Decision Trees, Random Forest Trees, Neural Networks, Support Vector Machines

**Unit III:** Association Rules and Pattern Mining: Apriori algorithm, Frequent Pattern Mining using FP growth algorithm, Basic concepts of Temporal Data Mining.

**Unit IV:** Clustering Algorithms: Partitioning Methods, Hierarchical Methods, Density based Methods, Grid Based Methods, Model Based Methods, Clustering high dimension data.

**Unit V: Data Mining for Cyber Security:** Adversarial Learning methods for Intrusion detection, Fraud Detection, Anomaly detection, Spam detection, Malware Detection.

**Text Book:**
1. Jiawei Han, Micheline Kamber, and Jian Pei, Data Mining: Concepts and Techniques, 3rd Edition, Morgan Kaufmann, 2011.

**Reference Books:**


**CE664 Network Security**

**Course Objectives:** Understanding of basic issues, concepts, principles, and mechanisms in network security.
- Basic security concepts
- Authentication
- Access control
- IPsec and Internet key management
- SSL/TLS
- Firewall
- Malicious Software
- Intruder Detection Systems

Be able to determine appropriate mechanisms for protecting networked systems.

**Course Prerequisites:** Basic understanding of Computer Networking and Cryptography


**Text Books:**

**Reference Books:**

**CE682 Secure Software Engineering**

**Course Objectives:**
Students will acquire an understanding of the fundamental concepts for developing secure systems
- Introduce security requirements, Security Policies, Architecture of Secure Software and Boot Integrity
- Attacker models
- Fundamentals of data protection and privacy.

**Course Prerequisites:**
C programming and debugging. Basic concept of Operating Systems.


**Text / Reference Books:**
3. The security Development Lifecycle, by Michael Howard and Steve Lipner
CE 69C Ethical Hacking & Penetration Testing

Course Objectives:

The threats from hackers, spies, terrorists, and criminal organizations against our information assets are undeniable. The serious consequences like identity theft, theft of sensitive/proprietary information/trade secrets or loss of reputation/credibility in the market; may result from these attacks. A single malicious attempt by your enemies can bring down any reputed organization or financial institution to a halt, by causing a great damage may be costing in millions of dollars per hour. One cannot protect his information assets if he doesn’t know how attackers think and what techniques attackers use to exploit systems. Hence, learning offensive security techniques like Ethical Hacking is becoming a need of future cyber security world. The objective of course will be as:

1. To facilitate individual in gaining ethical hacking knowledge base in order to promote a more secure cyberspace interactions.
2. To learn how intruders escalate privilege, how various kinds of attacks like Network Intrusion, DDOS, Malware attacks, Session Hijacking are carried out successfully by attackers.
3. To train individual to become a competent information security professional by learning both theoretical as well as practical ethical hacking knowledge base.

Prerequisites: Basic computer networking, operating systems and computer programming knowledge is required.

Syllabus:


Text Book:
4. CEH official Certified Ethical Hacking Review Guide, Wiley India Edition

**Reference Books:**
3. Certified Ethical Hacker: Michael Gregg, Pearson Education
4. Certified Ethical Hacker: Matt Walker, TMH.
5. Rich Annings, Himanshu Dwivedi, Zane Lackey, ”Hacking Exponsed Web 2.0”, Tata Mcgraw hill Edition

Research paper for study (if any) - White papers on multimedia from IEEE/ACM/Elsevier/Spinger/IBM/EC-Council sources.

**CE 684 Digital Forensics**

**Course Objectives:**
- To get into the depth of different domains of digital crimes
- Practically able to detect digital attacks using Commercial/Open -source/Freeware tools
- To build the case-oriented procedures for new-scenerios.

**Prerequisites:** Knowledge of OS, Assembly Languages like Python, Number System and their Conversions, Internal Structure of CD/DVD.

**Syllabus:**
**Unit I :** Introduction to legal issues, context, and digital forensics; Stages of Forensic: acquisition or imaging of exhibits, Preservation, Analysis and reporting standards.
**Unit II :** Introduction to Computer Forensics: Digital Devices with rudimentary computing power. Acquisition or imaging of Onboard Memory and Static Memory. Online and Live Forensics
**Unit V :** Media Analysis: disk structure, file systems (NTFS, EXT 2/3, HFS), and physical layer issues; Tools for digital forensics;
**Unit III :** Database forensics: forensic study of databases and their metadata. Investigative use of database contents, log files and in-RAM data in order to build a time-line or recover relevant information;
**Unit IV :** Network forensics: Evidence or Intrusion detection from internet logs, monitoring and analysis of network traffic. Introduction to IoT Forensics.
**Unit VI :** Mobile device forensics: recovery of digital evidence or data from a mobile device.

**List of Experiments:**
1. Perform Imaging and Analysis of Non-Volatile Memory using Open Source Tools in the absence of Write-Blockers.
2. Perform Imaging and Analysis of Non-Volatile Memory using EnCase/Other Open Source
Tools With and Without Write Blockers.
3. Perform Imaging and Analysis of Volatile Memory using EnCase/Other Open Source Tools
4. MFT & Registry Hives Extraction from Windows OS through Tools and Scripts.
5. Data Carving Using Open Source Tools
6. Data Recovery and Secure deletion on Storage media.
7. Hiding Data into Slack Space.
8. Information gathering and network traffic analysis using TCP DUMP and WIN DUMP
9. Attacks and Forensics using IoT devices
10. Explore the Phases of Ethical Hacking in terms of implementing some attack.
11. Solving Case Study using online datasets from digitalcorpora.org

Text Books:

Reference Books:

Elective-I/II

CE669  Reverse Engineering and Malware Analysis

Course Objectives: The course introduces reverse engineering techniques and explores the techniques for detecting, analyzing, reverse engineering and eradicating malware. Upon completion of the course, students should be able to:

- Have a good understanding of reverse engineering techniques and tools
- Identify the different types of malware analysis methods
- Setup an environment for malware analysis
- Recognize common malware characteristics

Prerequisites: Assembly language programming, OS fundamentals.

Syllabus:
Introduction to reverse engineering, Low level software, Assembly language primer, Compilers, Execution Environments, Windows OS fundamentals, Executable file formats, Static & Dynamic reverse engineering, Reversing tools, Disassemblers, Debuggers, Decompilers, System monitoring tools, Reversing program binaries, Anti-reversing techniques, Breaking protections, Reversing ‘.NET’, De-compilation, Introduction to malware, Software vulnerabilities – buffer overflow, integer overflow, vulnerabilities exploitation, mitigation; Return oriented
programming; Reversing malware – Static & Dynamic malware analysis techniques, Packers & compression, Sandboxing executables& runtime analysis; Malware classification.

Text Book:

Reference Books:
1. Michael Ligh, Steven Adair, “Malware Analyst’s cookbook & DVD”, Wiley publishing

CE 681 Mobile Computing

Course Objectives: Course provides introduction to the fundamentals of mobile computing, mobile application development as well as wireless communication and security. Students will gain a sound understanding of the core concepts of mobile networks and the design of cellular networks including approaches to maximize the available capacity. The course will look at some current research in mobile computing security and wireless security. Students will learn android application development framework and use it to implement their assignments.

Course Prerequisites: Students are required to gain knowledge of basics of computer networking.

Syllabus:

Text/Reference Books:
CE 683  Information Warfare

Prerequisites to study the subject - Students are required to gain knowledge of computer networking and basic concepts of Cyber Security.

Objective of the course/subject - This course will help students in gaining the knowledge of information warfare domain concepts including principles of information warfare (IW), Cyber warfare (CW), Offensive and defensive IW, military espionage, economic espionage, communications eavesdropping, computer break-ins, Open source intelligence, Covert Communication, Surveillance, ethical and legal concepts in the context of CW, Command and Control, Psyops and perception management. They will learn about different countermeasures, ethical hacking tools and techniques. They will form two teams (Red and Blue). One team carries out offensive operations against the; while other team will carry out defensive operations to protect the same information systems.

Syllabus:

Text Books –

Reference Books –
6. Research paper for study (if any) - White papers on cyberwarfare from IEEE/ACM/IBM sources.
7. Important website for reference & Study (if any) - ISACA website.

CE 689  Fault Tolerant Computing System

Syllabus
1. Introduction: Motivation, System view of high availability design, Terminology
3. Error detection techniques: Watchdog processors, Heartbeats, Consistency and capability checking, Data audits, Assertions, Control-flow checking Application: DHCP
5. Network fault tolerance: Reliable communication protocols, Agreement protocols, Database commit protocols Application: Distributed SQL server
6. Practical steps in design of high availability networked systems Application: Web services, Highly available clusters
7. Checkpointing & Recovery Application: Microcheckpointing
8. Attack dimension to failures, byzantine generals problem, in context of side-channel attacks study fault induced leads to catastrophic failure
9. Case Studies

Text Book:

Reference Book:

CE 690 Parallel and Distributed Systems

Course Objective

To meet end-user, Administrator & Designer perspectives. Enhance analytical capabilities to evaluate a system.

About the Course: The study of Parallel and Distributed Systems investigates software architectures to support flexible parallel and distributed applications, which can adapt themselves for execution in dynamically changing, heterogeneous environments. The study targets the diverse environments ranging from scalable clusters of commodity workstations to dynamic aggregations of computing and information resources, emphasizing the interactions between hardware, operating systems, and applications. The study includes efforts to build fault-tolerant programming systems, compiler-assisted object caching systems, application-structuring mechanisms for adaptation in dynamic environments, and transparent secure distribution
middleware for general-purpose applications. These projects encompass a gamut of approaches from fundamental research through prototypes, up to working usable systems.

**Pre-requisites:** CSE, IT, ECE, EE, Robotics, Instrumentation Engg, Industrial Engineering, Modelling & Simulations, Fundamental Computer architecture, programming environments, computer networks

**Syllabus:**

**Unit I:** Introduction to various Network Enabled Operations, Network Centric Operations, n-tier, P2P Systems; State of Art Examples and their types: GIS systems, MIS systems, Nature of Parallelism and Distributed Environment Models.

**Unit I: Unit II:** Parallel Architecture, Parallel Algorithms, Parallel Databases, Distributed Architecture, Distributed Systems, Distributed Databases

**Unit III:** Systems modeling and Virtualization, Clusters for Scalable Parallel Computing, Virtual Machines, Virtualization Of Clusters

**Unit IV:** Data Centers, Computing Clouds, Service-Oriented Architectures, Service-Oriented Architectures for Distributed Computing

**Unit V:** Cloud Programming and Software Environment, Grids, P2P, Future Internet, Peer-To-Peer Computing and Overlay Networks, Ubiquitous Cloud and Internet of Things. Fog and Edge Computing.

**Unit VI:** Adhoc Distributed & Self-Organising Environments, Pervasive and Ubiquitous Computations, Environments

**Text book:**


**Papers:**

3. Research Papers discussed in the classroom discussions.

**CE 691 SECURE WIRELESS SENSOR NETWORKS

**Background:** Wireless Sensor networks (WSN) is an emerging technology and have great potential to be employed in critical situations like battlefields and commercial applications such as building, traffic surveillance, habitat monitoring and smart homes and many more scenarios. One of the major challenges wireless sensor networks face today is security. While the deployment of sensor nodes in an unattended environment makes the networks vulnerable to a
variety of potential attacks, the inherent power and memory limitations of sensor nodes makes conventional security solutions unfeasible. The sensing technology combined with processing power and wireless communication makes it profitable for being exploited in great quantity in future. The wireless communication technology also acquires various types of security threats.

Objective: To meet End-User, Network-Administrator and Network-Designer perspectives

Basic Revision Mandatory: Computer Networks Fundamentals, Programming,

Subject Contents:

Part I: Introduction, WSN Resources & constraints, Relevance to IoTs, Relevance to Cyber-Physical Systems, Relevance to Network Centric Operations, Relevance to Data Stream Management Systems, Relevance to the increasing demand of high performance computations, SCADA, battle sensor.

Part II: WSN Network Architecture, MAC Layer protocols, Naming and Addressing, Synchronization, Location & positioning, Topology control, Connected Dominating Sets, Routing Protocols, Data-Centric & Content-based networking, Data-Centric querying, WSNs versus IoTs


Text Book:


Research Paper References:


Tutorials:

a. Routing techniques: Overview of Proactive and reactive routing protocols, significance of a hop in adhoc networks
b. Flooding, Gossiping, Zonal Routing Protocols ZRP, Hybrid Routing, TTL significance with respect to routing protocols
c. Impact of hardware and software on Battery Performances/Utilisation
d. IEEE 802.15.4: A study, Features, Types of Devices FFD (PAN coordinators, Coordinators), RFDs Reduced Function Devices, Network Setup process & parameters in Consideration, Programming Strategies to suit the standards, MAC and PHY structure
e. Demo 1: Controlling DIOs. Demonstrate the usage of DIO using LEDs. Learning how to handle data sampling period.

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f. Demo 2. Reading data from a single IoT device. Interpretation of data.
g. Demo 3: Create a broadcast wireless network and capture the traffic generated by the participating nodes.
i. Understanding MBR & LBR (MAC Based Routing and LBR Level-Based Routing)
j. Understanding existing API, Libraries & its association with pre-existing demonstration codes.

CE 667  Trustworthy Computing

Course Objectives: Understanding of TPM capabilities, as well as other trusted computing standards and technologies
- Secure/Trusted/Verified Boot
- Remote Attestation
- Use of open source tools for development of trusted process

Be able to maintain and to develop trusted systems.

Course Prerequisites: Basic understanding of Boot Process, Shell Programming and Formal Methods, Fundamentals of OS.

Syllabus:

Text Books:

Reference Books:

CE 688  Game Theory

Course Objectives: To understand the concepts of Game Theory and get an overview. To learn and appreciate the applications of game theory in Network Security.

Prerequisites: Basic understanding of Computer Networking and Network Security

Syllabus:

Text Books:

Reference Books:

CE 692 Computational Geometry and Applications

Pre-requisites: The students are assumed to have a basic knowledge of the design and analysis of algorithms and data structures. No knowledge of the application domains is required, and
hardly any knowledge of geometry. The analysis of the randomized algorithms requires very elementary knowledge of probability theory.

**Syllabus:** Geometric primitives, Line intersection, randomized incremental concepts, Triangulation and visibility, Linear programming in two and three dimensions, Orthogonal range searching, Point location and Binary Space Partitions, Voronoi diagrams and Delaunay triangulation, Convex hulls, Non-orthogonal range searching

**Text Book:**
1. “Computational Geometry: Algorithms and Applications”, Third Edition (March 2008), Mark de Berg, TU Eindhoven (the Netherlands), Otfried Cheong, KAIST (Korea), Marc van Kreveld, Mark Overmars, Utrecht University (the Netherlands), Springer-Verlag

### CE 694 Big Data Analysis & Algorithms

**Course Objective**
To meet end-user, Administrator & Designer perspectives, develop skill sets to be resourceful in the area of knowledge, information systems. Enhance analytical capabilities to evaluate a domain specific technical and expertise areas. Multi-Disciplinary Course useful to any engineering discipline who use a computer.

**About the Course:** The use of Big Data is becoming a crucial way for leading companies to outperform their peers. In most industries, established competitors and new entrants alike will leverage data-driven strategies to innovate, compete, and capture value. Early adopters of Big Data are using data from sensors embedded in products from children’s toys to industrial goods to determine how these products are actually used in the real world. Such knowledge then informs the creation of new service offerings and the design of future products. Big Data will help to create new growth opportunities and entirely new categories of companies. With everything going digital, data is pouring in from all kinds of sources imaginable. Organisations are getting inundated with terabytes and petabytes of data in different formats from sources like operational and transactional systems, customer service points, and mobile and web media. The problem of such huge data is storage and with no proper utilisation of the data, collecting and storing is a waste of resource. Earlier it had been difficult to process such data without relevant technology. Big data analytics is becoming an integral part of organisations who want to grow in this age of innovation and is being done by most of the big companies. There is huge scope of big data analytics professionals as this is going to be an essential part of companies in the future.

**The Need:**

(a) **Cyber-Security Perspective:** As the complexity of IT networks has grown, the inventiveness and sophistication of cyber security threats and attacks has grown just as quickly. As malware attacks increase in volume and complexity, it’s becoming more difficult for traditional analytic tooling and infrastructure to keep up thanks to the **Data volume**, For example, every day at SophosLabs, over 300,000 new potentially malicious files that require analysis are reported. **Scalability:** SQL-based tooling and infrastructure doesn’t scale well and is costly to maintain. Big Data Analytics is a Path Forward to Cyber Security.

(b) **AI / Intelligent Systems Perspective:** Centre for Big Data Analytics and Intelligent Systems focuses on the theory development, novel techniques and smart solutions of big data analytics in broad domains, along with theories and techniques of building computer
systems, which capture the intelligent behaviours in complex environments. AI dwells on Big Data.

(c) Multi-Disciplinary Course useful to any engineering discipline who use a computer.

Intended Audience: CSE, IT, ECE, EE, Robotics, Instrumentation Engg, Industrial Engineering, Modelling & Simulations

Pre-Requisites: Basic programming knowledge, Data Structure, Programming, Statistical Techniques

Course Contents:

Unit I: Introduction to big data analysis: Evolution of data, data streams, structured & unstructured data, database models, graph data, normalizations

Unit II: Big data analytics platforms: Architectures, Frameworks that enable big data analytics

Unit III: Big data analytics storage & processing: Data Preprocessing, Multi-Dimensional Data Models, Data Warehousing OLTPS, OLAPS, Data Warehouse Architectures, Datacube Computations, Big Data Mining Frequent Patterns, Big Data Associations & Correlations, Classifications & Predictions, Clustering Techniques & Analysis, Mining Data Streams, Graph Mining Mining Spatial & Temporal Objects, Predictive Analysis, Ad Hoc Queries, Web Analytics

Unit IV: Algorithms for massive data sets, Algorithms for SISD, SIMD environments, Linked Big Data Analysis – Graph Computing and Network Science, Big Data Visualization, Big Data Mobile Applications, Large-Scale Machine Learning, Big Data Analytics on Specific Processors, Hardware and Cluster Platforms for Big Data Analytics, Big Data Next Challenges – IoT, Cognition, and Beyond

Unit V: Big data analytics tools, HDFS, NOSQL, SQL environments

Text Book:


References:

1. Data Mining, Jiawei Han & Micheline Kamber, 2nd edition, Elsevier, 2006
3. Research Papers discussed in the classroom discussions.

Course links & References:

Brief About the Subject: This course examines a new class of computational systems called Cyber-Physical Systems CPS. Such systems have the potential to provide far-reaching benefits in addressing some of the toughest problems we face as a society, such as: reducing healthcare costs, minimizing traffic congestion, and constructing zero-net energy buildings. Four important features characterize CPS: their ability monitors the underlying physical environment, reason about the monitored data, control the physical environment through actuation, in a coordinated manner using a communication medium. It can be seen immediately that in CPS, the computational element (cyber) and the environment (physical) are tightly coupled, with one influencing the other. CPS sits at the confluence of several traditional disciplines, such as: embedded systems, real-time systems, sensor networks, control and hybrid systems, and security. It presents many challenging problems and opportunities for research. With guidance from the professor, students will survey recent CPS publications, develop an aptitude. Readings will include papers on CPS applications (e.g., Body Area Networks, smart automobiles, and energy-efficient buildings), issues involved in designing CPS (e.g., monitoring, communication, and control), and how to ensure that the designed systems satisfy certain essential properties (e.g., safety and security).

CPS combine cyber capabilities (computation and/or communication) with physical capabilities (motion or other physical processes). Cars, aircraft, and robots are prime examples, because they move physically in space in a way that is determined by discrete computerized control algorithms. Designing these algorithms to control CPSs is challenging due to their tight coupling with physical behavior. At the same time, it is vital that these algorithms be correct, since we rely on CPSs for safety-critical tasks like keeping aircraft from colliding; its role in Command and Control environments.

Pre-requisites: CSE, IT, ECE, EE, Robotics, Instrumentation Engg, Industrial Engineering, Modelling & Simulations, Theoretical knowledge of Computer Science and Engineering

Syllabus:

Unit I: CPS: Introduction Main Concepts, Challenges; Background role of Computer Networks, Data, Algorithms

Unit II: Self-organising Systems, Self-organisation in Natural Systems Inspiring Self-organising Software,

Unit III: Agents and Multi-Agent Systems Computing trends, Data device proliferation, Confluence of trends

Unit V: Engineering Self-organising Systems, Middleware Infrastructures for Self-organising Pervasive Computing Systems


Text Books:
3. Research Papers discussed in the classroom discussions.

Reading assignments:
1. Introduction: Brief history of CPS. Motivating problems in CPS.

Modeling: Continuous systems and discrete event systems.
6. Lygeros, Sastry, and Tomlin, Chapter 2

Control over networks

Stability of Hybrid and Switched Systems
CE 69F Theory of Computation

Syllabus:

1. **Introduction**: Motivation, Terminology, History
2. **Computers and Science of Computing**: Computability, Undecidability, Intractability, and Intelligence
3. **Automata**: Construction, Finite Automata, Limitations of Finite Automata
4. **Non-Deterministic Finite Automata**: Moore Machine, Mealy Machine
5. **Regular Languages and Expressions**: Equivalence, Regular expressions in practice
6. **Grammars**: Parsing and Derivation, Grammar for regular languages, Converting Regular grammar to Automata
7. **Nature of Regular Languages**: Closure properties, Pigeonhole principle, Pumping Lemma, Adversarial Game
8. **Context Free Languages and Grammars**: Context Free Behaviour, CFGs, Ambiguity, Chomsky Normal Form, Simple, Linear and other grammars
9. **Pushdown Automata**: Stack Behaviour, Constructing PDAs, CFGs to PDAs, CFL-CFG-PDA Triad
10. **Nature of Context Free Languages**: Closure properties
11. **Turing Machines**: Construction, Definition, Complex Turing Machines, Church Turing Thesis, Universal Turing Machines
12. **The Chomsky Hierarchy**: Languages, Grammars and Machines, Recursive Languages, Idea of Context
13. **Computability and Undecidability**: Halting Problem, $P = NP$?

Text Book:


Reference Book:

Course Objectives:

Biometrics has emerged as a specialized field in criminal forensics, public safety surveillance, user authentication and identification. Expansions of biometric modalities are ranged from fingerprint, face and other traits to multimodal biometric traits. Objectives of this course to introduce the students different modality based biometric identification systems, to help them to understand the difference between advanced biometric techniques with respect to traditional authentication mechanisms. Students after learning this course would be able to design and develop biometric systems by utilizing inter-disciplinary knowledge related to fields like Pattern Recognition, Image Processing and Machine Learning etc.

Syllabus:

1. **Introduction:** History of Biometrics, Multimodal Biometric Systems, Recent Advances
2. Authentication Technologies, Access Control
3. **Finger Print Biometrics:** Sensors, Dactyloscopy, Types, Algorithms
4. **Handwriting biometrics:** Static and Dynamic Recognition
5. **Iris Biometrics:** Retinal Scanning, Visible and Near Infra red Imaging, Operating Principle, Advantages and Shortcomings
6. **Voice Biometrics:** Verification versus Identification, Text Dependent and Text Independent, Technology, Applications
7. **Face Recognition:** Techniques for Face Acquisition/Recognition, Advantages and Disadvantages, History, Anti-facial recognition
8. **DNA fingerprint/ Profiling:** Process, DNA Database, DNA evidence,
9. **Statistical Measures for Biometrics:**
10. **Biometric Devices:** Personal, Handheld, Biometric spoofing, Accuracy

Text Book:


Reference Book:

Course Objectives:

1. To facilitate individual in gaining knowledge on digital watermarking, steganographic and encryption techniques on multimedia signals like image, audio and video for digital rights management applications.
2. To facilitate individual in gaining knowledge on forensics on multimedia signals like image, audio and video for multimedia tamper/forgery detection applications.
3. To teach biometric security concepts. Student will learn and implement various algorithms using MATLAB, Python during hands-on activities carried in the Laboratory.

Prerequisites: Basic computer programming knowledge is required.

Syllabus:


Text Book:

Reference Books:

Research paper for study (if any) - White papers on multimedia from IEEE/ACM/Elsevier/Spinger/IBM sources.

CE 699 : Internet of Things

Objective

To meet end-user, Network-Administrator & Designer perspectives, develop skill sets to be resourceful in the area of Cyber-Security. Enhance analytical capabilities to evaluate a deployment and realisation.

About the Course:

The Internet of Things (IoT) is predicted to be the single most important factor impacting fundamental business logic in the coming decades. Government, academia, and industry are involved in different aspects of research, implementation, and business with IoT. IoT cuts across different application domain verticals ranging from civilian to defence sectors. These domains include agriculture, space, healthcare, manufacturing, construction, water, and mining, which are presently transitioning their legacy infrastructure to support IoT. Today it is possible to envision pervasive connectivity, storage, and computation, which, in turn, gives rise to building different IoT solutions. IoT-based applications such as innovative shopping system, infrastructure management in both urban and rural areas, remote health monitoring and emergency notification systems, and transportation systems, are gradually relying on IoT based systems. Therefore, it is very important to learn the fundamentals of this emerging technology & enable the students to anticipate and acknowledge the security concerns and vulnerabilities in the cyberspace. The impact of poor IoT security is being felt like a monsoon as these devices are compromised and then used to flood targets with DDOS traffic. As we move forward into this IoT era, it is imperative that we take steps as individuals to protect our Networks.

Intended Audience:

CSE, IT, ECE, EE, Robotics, Instrumentation Engg, Industrial Engineering, Modelling & Simulations Pre-Requisites : Basic programming knowledge

Course Contents:

Unit I:
Introduction to Internet of Things, Definition and Characteristics of IoT, Physical Design of IoT, IoT Protocols, IoT communication models, IoT Communication APIs

Unit II


Unit III

IoT and M2M, Software defined networks, network function virtualization, difference between SDN and NFV for IoT, Basics of IoT System Management with NETCOZF, YANG, NETCONF, YANG, SNMP NETOPEER

Unit IV

IoT physical end devices & end points, IoT Physical Servers & Cloud offerings, Software environments, NEO, Security

Text Book


References

4. Research Papers discussed in the classroom discussions.

CE 69A BitCoins and CryptoCurrency

About this course: To understand what is special about Bitcoin, we need to understand how it works at a technical level. The course will address the important questions about Bitcoin, such as: How does Bitcoin work? What makes Bitcoin different? How secure are your Bitcoins? How anonymous are Bitcoin users? What determines the price of Bitcoins? Can cryptocurrencies be regulated? What might the future hold? After this course, students will know the need to be able to separate fact from fiction when reading claims about Bitcoin and other cryptocurrencies. Students will have the conceptual foundations to engineer secure software that interacts with the Bitcoin network. And students will be able to integrate ideas from Bitcoin in their own projects.
Intended Audience: CSE, IT, ECE, EE, Robotics, Instrumentation Engg, Industrial Engineering, Modelling & Simulations Pre-Requisites: Basic programming knowledge, Basic Cryptography, Web Applications, Computer Networks

Course Contents:

Unit I: Introduction to Crypto and Cryptocurrencies Objective: Learn about cryptographic building blocks ("primitives") and reason about their security. Work through how these primitives can be used to construct simple cryptocurrencies.

Unit II How Bitcoin Achieves Decentralization Objective: Learn Bitcoin's consensus mechanism and reason about its security. Appreciate how security comes from a combination of technical methods and clever incentive engineering.

Unit III Mechanics of Bitcoin Objective: Learn how the individual components of the Bitcoin protocol make the whole system tick: transactions, script, blocks, and the peer-to-peer network.

Unit IV How to Store and Use Bitcoins Objective: Learn how using Bitcoins works in practice: different ways of storing Bitcoin keys, security measures, and various types of services that allow you to trade and transact with bitcoins.

Unit V Bitcoin Mining Objective: Bitcoin relies crucially on mining. But who are the miners? How did they get into this? How do they operate? What's the business model like for miners? What impact do they have on the environment?

Unit VI Bitcoin and Anonymity Objective: Is Bitcoin anonymous? What does that statement even mean—can we define it rigorously? We'll learn about the various ways to improve Bitcoin's anonymity and privacy and learn about Bitcoin's role in Silk Road and other hidden marketplaces.

Unit VII Community, Politics, and Regulation Objective: Look at all the ways that the world of Bitcoin and cryptocurrency technology touches the world of people. Discuss the community, politics within Bitcoin and the way that Bitcoin interacts with politics, and law enforcement and regulation issues.

Unit VIII Alternative Mining Puzzles Not everyone is happy about how Bitcoin mining works: its energy consumption and the fact that it requires specialized hardware are major sticking points. This week we'll look at how mining can be redesigned in alternative cryptocurrencies.

Unit IX Bitcoin as a Platform, One of the most exciting things about Bitcoin technology is its potential to support applications other than currency. We'll study several of these and study the properties of Bitcoin that makes this possible.

Unit X Altcoins and the Cryptocurrency Ecosystem Hundreds of altcoins, or alternative cryptocurrencies, have been started, either to fix Bitcoin's perceived flaws or to pursue different goals and properties. We'll look at everything that goes into an altcoin and how they interact with Bitcoin.
Unit XI The Future of Bitcoin? The use of Bitcoin technology for decentralizing property, markets, and so on has been hailed as a recipe for economic and political disruption. The technological underpinnings of these proposals and the potential impact on society.

Text Book:


2. Research Papers discussed in the classroom discussions.

**CE 69B Network Forensics**

Course Objective To meet end-user, Network-Administrator & Network-Designer perspectives, develop skill sets to be resourceful in investigating the crimes in the area of Cyber-Security. Enhance analytical capabilities to evaluate a network.

About the Course: Computer and Network Forensics studies cyber-attack prevention, planning, detection, response, and investigation with the goals of counteracting cybercrimes, and making the responsible persons/groups accountable. The topics covered in this course include fundamentals of Network forensics, Network forensic duplication and analysis, Network Surveillance, Network Intrusion Detection and Response, Incident Response, Anti-Forensics Techniques, Anonymity and Pseudonymity, Network Cyber Law, Computer Security Policies and Guidelines, Court Report Writing and Presentation, and Case Studies. Pre-requisites: Computer Networks, Basics of OS

**Syllabus:**

Unit I: Forensics: An Overview, Scope of Network Forensic, Network Forensics Basics

Unit II: Network Enabled Operations, Network Controlled Operations, Network Offences, Network Criminalistics

Unit III: Basics of host devices on networks: Inter-Network Devices, OS and Networking: A Review


Unit V: Intrusion and Online Frauds Detection

Unit VI: Peer-2-Peer Networks, Cryptocurrency and Blockchain
Unit VII: Network Traffic & Traffic engineering, Network Traffic & Traffic engineering for the Steganography & Steganalysis

Unit VIII: Anonymity/Pseudonymity/P2P environments, Network Forensic Challenges in adhoc environments, Network Forensic challenges in IoTs

Unit IX: Legal Perspective: Cyber Law, Security and Privacy Policies and Guidelines

Unit X: Case Studies, and ethical issues Unit XI: Court Testimony and Report Writing Skills

Course Materials

There will be no textbooks. Most readings are from the lecture notes and papers published in recent years from top security/forensics conferences/workshops or journals, reference books, and related Internet web sites. Two reading lists will be given. The required readings are 30-35 papers and a suggested reading list includes 130+ papers published within the last 10 years.

Reference books:


CE 70A Formal Specification and Verification of Programs

Objectives:
To study methods and techniques for stating and proving the correctness statements. Studying Mathematical Logic (Symbolic Logic), Mathematical models for programs. (Programming Language Semantics) and Justification of the verification techniques.

On successful completion of the module, the students
- should have a good knowledge and understanding of soundness, correctness of static analysis.
- should be able to understand the use of logic as a formal language for the specification of systems.
- understand the use of symbolic execution, and the main verification techniques used in symbolic model checking, and be able to verify simple systems.
- study some of the issues that arise in deploying these techniques in practice, and solution strategies for them.

**Syllabus**
Reasoning about sequential programs: Programs as (possibly infinite) state transition systems; Specifying program correctness using pre- and post-conditions; partial and total correctness semantics; Hoare logic and its rules for a simple imperative sequential language; weakest pre-condition and strongest post-condition semantics; central importance of invariants in program verification. Brief introduction to lattices and the theory of abstract interpretation; some numerical abstract domains: intervals, difference bound matrices, octagons, polyhedra; computing abstract post-conditions and abstract loop invariants; refining abstractions and counterexample-guided abstraction refinement; Predicate abstraction and boolean programs; converting assertion to a location reachability problem; location reachability using predicate abstraction for simple programs and for programs with (possibly recursive) function calls; Introduction to temporal logics: LTL and CTL; Kripke structures as models of reactive (hardware and software) systems; LTL and CTL model checking algorithms and some applications.

**Text Reference:**
3. Research papers and survey articles to be announced in class

**CE 70B Advanced Algorithms**

**Syllabus:**

**Unit I: Basics**
Data Structures, Abstract Data Types, Dictionaries, Parameters of Algorithms, Growth Functions, Asymptotic Notations & Complexity analysis, Complexity measures.

**Unit II: Algorithms**
Classic Algorithms, Purpose (S, S, SM, PF, Opti, Prob, Rand), Examples of each, Types of Algorithms, P Type, NP Type, Open Problems, Examples of Algorithms for Internet Search, Web Contents Organization and retrieval

**Unit III: Soft-Computing Based Algorithms**
Need, Modularity, Sequential, PRAM models, Classic Vs Soft Computing Algorithms, AI enabled Examples of Algorithms for Internet Search, Web Contents Organization and retrieval


**Unit V: Futuristic Trend:** Computations in Cyber Physical Systems CPS, CPS based parallel & distributed Algorithms, Quantum Computing, Concepts of Qubits, Quantum Algorithms, Quantum Search-Space optimization

**Laboratory Work:**
Total V Practical Assignments. Lab Assignment based on each Unit.

**Text Books:**

**Reference Books:**
3. Recommended Research papers during instruction

**CE 700 Quantum Computing**

**About this Course**
"Quantum Computing" is among those terms that are widely discussed but often poorly understood. The reasons of this state of affairs may be numerous, but possibly the most significant among them is that it is a relatively new scientific area, and its clear interpretations are not yet widely spread. The main obstacle here is the word "quantum", which refers to quantum mechanics - one of the most counter-intuitive ways to describe our world. But fear not! This is not a course on quantum mechanics. We will gently touch it in the beginning and then leave it apart, concentrating on the mathematical model of quantum computer, generously developed for us by physicists. This doesn't mean that the whole course is mathematics either (however there will be enough of it). We will build a simple working quantum computer with
our bare hands, and we will consider some algorithms, designed for bigger quantum computers which are not yet developed. The course material is designed for those computer scientists, engineers and programmers who believe, that there's something else than just HLL programming, that will move our computing power further into infinity.

**Prerequisites** are complex numbers and linear algebra

**Course Contents:**

1. **Unit I:** Introduction, Information and Computations, Characteristics of Computational Systems, Computability and Algorithms, Computational Complexity, Quantum Computing parameters and units, The Multiverse Interpretation of Quantum Mechanics

2. **Unit II:** Mathematical Model of Quantum Computing, Qubit, Qubit Measurement, Systems with Multiple Qubits, Measuring the Multiple Qubits Systems, Quantum System Evolution & Computations

3. **Unit III:** Quantum Computer and Quantum Algorithms, Deutsch's Problem, Quantum Computer Prototype, Suitable Algorithms

4. **Unit IV:** Shor's Algorithm, Factoring and the RSA, Factoring and Period Finding, Quantum Fourier Transform

5. **Unit V:** Grover's Algorithm. A Quantum Computer Application Boundaries, Grover's Algorithm, Challenges

6. **Unit VI:** Quantum environments, Search Spaces, Search Optimisation, Storage Optimisation, Quantum Resources, Future, Challenges

**Text Book:**


2. **References:** Research Papers as discussed in the class room.

**CE 70D Computer Network Audit & Forensics**

**Course Objective:**
To meet end-user, Network-Administrator & Network-Designer perspectives, develop skill sets to be resourceful in the area of Cyber-Security. Enhance analytical capabilities to evaluate a Network and Network Enabled Operations to analyze Network Centric Operations.

**Prerequisites:**
Preliminary knowledge Electronic Communications (Graduation Level), Computer Networks (Graduation Level) & IPV4, Networking Devices, Finite State Automata, Socket Programming, Algorithms

**Teaching Method:**
Class room instructions, learning through assignments, learning through hands-on sessions, learning through online recommended courses to complement the class room instructions
Short Recapitulation on topics before the start of the Course: Architecture of Computer Networks, ISO/OSI and TCP/IP model, IP protocol, transport protocols (TCP, UDP), basic services of computer networks (short recapitulation)

Course Contents

Unit I: Basics of host devices on networks: Inter-Network Devices, OS and Networking: A Review, n-tier, peer-to-peer Network architectures

Unit II: Network Protocols, Network Enabled Operations, Network Controlled Operations, Network Offences, Network Criminalities

Unit III: Packet Analysis, Packet Analysis Tools, Network Audit & tools, Network Traffic Engineering, Network Analysis and Analytics

Unit IV: Network Forensics: An Overview, Scope of Network Forensic, Network Forensics Basics


Unit V: Futuristic Networks, Dependable Networks, AI-Enabled Network Environments, Network Virtualization, SDNs, Sensor Networks, IoT, Evolution in Computing Environments like Cloud, Edge, Fog, Ubiquitous, Pervasive

Text Books:

2. Packet Analysis Tools, Network Audit Tools and Courseware

Recommended Mandatory Readings:

4. Topic based Research Papers assigned during classroom discussions

**Reference books:**

M Tech in Computer Science and Engineering
(Software Engineering)

Eligibility: BE/B.Tech. in any branch of Engineering or M.Sc./MCA in Computer Science.

### Semester I

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<td>CE682</td>
<td>Secure Software Engineering</td>
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<td>2</td>
<td>CE694</td>
<td>Big Data Analytics</td>
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<td>Elective I</td>
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<td>Elective III</td>
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<td>Elective IV</td>
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### Semester III

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<tr>
<th>Sr. No.</th>
<th>Course Code</th>
<th>Course</th>
<th>Contact Hours / Week</th>
<th>Credits</th>
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<td>CE 651</td>
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### Semester IV

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<th>Course</th>
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<th>Credits</th>
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<td>CE 652</td>
<td>MTech Dissertation Phase II</td>
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### Elective Subjects for Semester II:

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<tr>
<th>Sr. No.</th>
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<tbody>
<tr>
<td>1.</td>
<td>CE607</td>
<td>Decision Support Systems</td>
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<tr>
<td>2.</td>
<td>CE 669</td>
<td>Reverse Engineering &amp; Malware Analysis</td>
</tr>
<tr>
<td>3.</td>
<td>CE 681</td>
<td>Mobile Computing</td>
</tr>
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<td>4.</td>
<td>CE 683</td>
<td>Information Warfare</td>
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<tr>
<td>5.</td>
<td>CE608</td>
<td>Semantic based System &amp; Web Intelligence</td>
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<tr>
<td>6.</td>
<td>CE 609</td>
<td>Principle of Compiler Design &amp; OS</td>
</tr>
<tr>
<td>7.</td>
<td>CE 689</td>
<td>Fault Tolerant Computing Systems</td>
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<td>8.</td>
<td>CE 690</td>
<td>Parallel &amp; Distributed Systems</td>
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<td>9.</td>
<td>CE 691</td>
<td>Secure Wireless Sensor Networks</td>
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<tr>
<td>10.</td>
<td>CE 610</td>
<td>Information Retrieval Systems</td>
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<td>11.</td>
<td>AM 625</td>
<td>Digital Image Processing</td>
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<td>12.</td>
<td>AM 628</td>
<td>Computational Number Theory and Cryptography</td>
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<td>13.</td>
<td>EE 607</td>
<td>Advanced Wireless Communication</td>
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<td>14.</td>
<td>EE 613</td>
<td>Electronic Warfare</td>
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<td>15.</td>
<td>EE 618</td>
<td>DSP System Design</td>
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<td>16.</td>
<td>TM 609</td>
<td>System Engineering</td>
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<td>17.</td>
<td>TM 611</td>
<td>Software Projects Management</td>
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<td>18.</td>
<td>EE 609</td>
<td>SoC and Embedded Systems</td>
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<td>19.</td>
<td>CE 667</td>
<td>Trustworthy Computing</td>
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<td>20.</td>
<td>CE 611</td>
<td>Genetic Algorithm &amp; Artificial Neural Networks</td>
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<td>21.</td>
<td>CE 688</td>
<td>Game Theory</td>
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<td>22.</td>
<td>CE 612</td>
<td>Soft Computing</td>
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<td>23.</td>
<td>CE 692</td>
<td>Computational Geometry &amp; Applications</td>
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<td>24.</td>
<td>CE 694</td>
<td>Big data Analysis &amp; Algorithms</td>
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<tr>
<td>25.</td>
<td>CE 695</td>
<td>Cyber-Physical &amp; Self-Organising Systems</td>
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<td>26.</td>
<td>CE 662</td>
<td>Operating System Security</td>
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<td>27.</td>
<td>CE 613</td>
<td>Software Architecture &amp; Design Patterns</td>
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<tr>
<td>28.</td>
<td>CE614</td>
<td>Principles of Programming Languages</td>
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<td>29.</td>
<td>CE615</td>
<td>Advanced Algorithms</td>
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<td>30.</td>
<td>CE69D</td>
<td>Lean Six Sigma</td>
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<td>31.</td>
<td>CE69E</td>
<td>Flight Simulators and Game Programming</td>
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<tr>
<td>32.</td>
<td>CE 69F</td>
<td>Theory of Computation</td>
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<td>33.</td>
<td>CE 697</td>
<td>Biometric Security</td>
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<td>34.</td>
<td>CE698</td>
<td>Multimedia Security</td>
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<td>35.</td>
<td>CE699</td>
<td>Internet of Things</td>
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<td>36.</td>
<td>CE69A</td>
<td>BitCoins and CryptoCurrency</td>
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<td>37.</td>
<td>CE69B</td>
<td>Network Forensics</td>
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<tr>
<td>38.</td>
<td>CE 70A</td>
<td>Formal Specification and Verification of Programs</td>
</tr>
<tr>
<td>39.</td>
<td>CE 70B</td>
<td>Advanced Algorithms</td>
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<tr>
<td>40.</td>
<td>CE 70C</td>
<td>Semantic Web</td>
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<tr>
<td>41.</td>
<td>CE 700</td>
<td>Quantum Computing</td>
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<tr>
<td>42.</td>
<td>CE 70D</td>
<td>Computer Network Audit &amp; Forensics</td>
</tr>
</tbody>
</table>
CE601 Advanced Software Engineering

- Introduction: FAQs about Software Engineering; Professional and ethical responsibility; Software process models; Process iteration; Process activities; Computer-Aided Software Engineering.
- Rapid Software Development, Software Reuse: Agile methods; Extreme programming; Rapid application development. Reuse landscape; Design patterns; Generator-based reuse; Application frameworks; Application system reuse.
- CBSE: Components and component models; Component-Based Software Engineering (CBSE).
- Software Evolution: Program evolution dynamics; Software maintenance; Evolution processes; Legacy system evolution.
- Verification and Validation: Planning verification and validation; Software inspections; System testing; Component testing; Test case design; Test automation.
- Critical Systems Development, Validation: Dependable processes; Dependable programming; Fault tolerance and fault tolerant architectures.
- Reliability validation; Safety assurance; Security assessment; Safety and dependability cases.
- Distributed Systems Architecture: Multiprocessor architectures; Client-Server architectures; Distributed object architectures; Inter-Organizational distributed computing.
- Real-Time Software Design: Real-time systems; System design; Monitoring and control systems; Data acquisition systems.
- Capability Maturity Model (CMM): 5 levels of maturity, KPAs, CMM in Software
- SWEBOK: Software Engineering Body of Knowledge

Text Books:
3. SWEBOK, IEEE Computer Society

Reference Books:

CE 71A Software Testing & Reliability Standards

Objectives:
On successful completion of the module
- The students should have a good knowledge and understanding of correctness, consistency, faults and failures, static analysis and testing.
• The students should have a good understanding of the range of approaches to testing that can be applied to software systems and be able to undertake both black-box and white-box (unit-level) testing.
• The students will be able to appreciate the limitations of the current tools and have insights in ongoing research topics to overcome them.

**Syllabus:**
**Basic concepts:** Software engineering lifecycle context; Correctness; Soundness and completeness; Faults; Errors; Failures; Static and dynamic analysis
**Validation:** Kinds of testing (unit, functional, integration, system, acceptance, regression); Black Box Testing; Mutation Testing; Regression Testing
**Software Reliability standards:** IEEE standards for software reliability, Reliability standards followed in software industry, DRDO labs.

**Reference Texts:**

**CE 606 Object-Oriented Modelling & Design**

**Objectives:**
1. To learn basic OO Modelling and design skills
2. To use the UML design diagrams and to apply the appropriate design patterns

**Prerequisites:** Software Engineering

**Syllabus:**
**Unit 1:** Introduction to UML : Importance of modelling, object oriented modelling, conceptual model of the UML, Architecture, Software Development Life Cycle. **Unit II:** Inception – Introduction of Inception, Artifacts in Inception, Use case Modeling - Relating Use cases – include, extend and generalization. Finding conceptual classes, Associations, Attributes. **Unit III:** Classes, Relationships, common Mechanisms, and diagrams. Class Associations - hierarchies- Aggregation and Composition- UML modelling for Class & Object Diagrams. System sequence diagram-Relationship between sequence diagram and Use Cases. **Unit IV:** Designing objects with responsibilities – Creator – Information expert – Low Coupling – High Cohesion – Controller. Applying GoF design patterns. **Unit IV:** UML interaction diagrams, Events and signals, State Diagrams and Modelling- Processes and Threads, Time and space.

**Text Book:**

Reference Books:

CE 680  Data Mining Techniques

Course Objectives:
- To learn the advanced techniques w.r.t. the applications in different fields
- To implement those techniques using MATLAB/C/C++ and test them on bench-marked datasets.
- To validate their understanding in terms of developing atleast 2/3 functionalities in Cyber Security domain using Open-Source Tool

Pre- Requisites:
Knowledge of Statistical Techniques, Probability Theory, Data Structures and Algorithms.

Syllabus:

Unit I: Introduction to Data Mining and Pattern Recognition Systems.
Unit II: Classification: Linear Classifiers and Non-Linear Classifiers, Bayes Decision Theory, Decision Trees, Random Forest Trees, Neural Networks, Support Vector Machines
Unit III: Association Rules and Pattern Mining: Apriori algorithm, Frequent Pattern Mining using FP growth algorithm, Basic concepts of Temporal Data Mining.
Unit IV: Clustering Algorithms: Partitioning Methods, Hierarchical Methods, Density based Methods, Grid Based Methods, Model Based Methods, Clustering high dimension data.
Unit V: Data Mining for Cyber Security: Adversarial Learning methods for Intrusion detection, Fraud Detection, Anomaly detection, Spam detection, Malware Detection.

Text Book:
2. JiaweiHan, MichelineKamber, and Jian Pei, Data Mining: Concepts and Techniques, 3rd Edition, Morgan Kaufmann, 2011.

Reference Books:
CE682  Secure Software Engineering

Course Objectives:
Students will acquire an understanding of the fundamental concepts for developing secure systems
- Introduce security requirements, Security Policies, Architecture of Secure Software and Boot Integrity
- Attacker models
- Fundamentals of data protection and privacy.

Course Prerequisites:
C programming and debugging. Basic concept of Operating Systems.

Syllabus:

Text / Reference Books:
9. The security Development Lifecycle, by Michael Howard and Steve Lipner
**Course Objective**
To meet end-user, Administrator & Designer perspectives, develop skill sets to be resourceful in the area of knowledge, information systems. Enhance analytical capabilities to evaluate a domain specific technical and expertise areas.

**About the Course:** The use of Big Data is becoming a crucial way for leading companies to outperform their peers. In most industries, established competitors and new entrants alike will leverage data-driven strategies to innovate, compete, and capture value. Early adopters of Big Data are using data from sensors embedded in products from children’s toys to industrial goods to determine how these products are actually used in the real world. Such knowledge then informs the creation of new service offerings and the design of future products. Big Data will help to create new growth opportunities and entirely new categories of companies. With everything going digital, data is pouring in from all kinds of sources imaginable. Organisations are getting inundated with terabytes and petabytes of data in different formats from sources like operational and transactional systems, customer service points, and mobile and web media. The problem of such huge data is storage and with no proper utilisation of the data, collecting and storing is a waste of resource. Earlier it had been difficult to process such data without relevant technology. Big data analytics is becoming an integral part of organisations who want to grow in this age of innovation and is being done by most of the big companies. There is huge scope of big data analytics professionals as this is going to be an essential part of companies in the future.

**The Need:** Cyber-Security Perspective: As the complexity of IT networks has grown, the inventiveness and sophistication of cyber security threats and attacks has grown just as quickly. As malware attacks increase in volume and complexity, it’s becoming more difficult for traditional analytic tooling and infrastructure to keep up thanks to the Data volume, For example, every day at SophosLabs, over 300,000 new potentially malicious files that require analysis are reported. Scalability: SQL-based tooling and infrastructure doesn’t scale well and is costly to maintain. Big Data Analytics is a Path Forward to Cyber Security.

Intelligent Systems Perspective: Centre for Big Data Analytics and Intelligent Systems focuses on the theory development, novel techniques and smart solutions of big data analytics in broad domains, along with theories and techniques of building computer systems, which capture the intelligent behaviours in complex environments.

**Intended Audience:** CSE, IT, ECE, EE, Robotics, Instrumentation Engg, Industrial Engineering, Modelling & Simulations

**Pre-Requisites:** Basic programming knowledge, Data Structure, Programming, Statistical Techniques

**Course Contents:**

Unit I : Introduction to big data analysis: Evolution of data, data streams, structured & unstructured data, database models, graph data, normalizations

Unit II: Big data analytics platforms: Architectures, Frameworks that enable big data analytics
Unit III: Big data analytics storage & processing: Data Preprocessing, Multi-Dimensional Data Models, Data Warehousing OLTPS, OLAPS, Data Warehouse Architectures, Datacube Computations, Big Data Mining Frequent Patterns, Big Data Associations & Correlations, Classifications & Predictions, Clustering Techniques & Analysis, Mining Data Streams, Graph Mining Mining Spatial & Temporal Objects, Predictive Analysis, Ad Hoc Queries, Web Analytics

Unit IV: Algorithms for massive data sets, Algorithms for SISD, SIMD environments, Linked Big Data Analysis – Graph Computing and Network Science, Big Data Visualization, Big Data Mobile Applications, Large-Scale Machine Learning, Big Data Analytics on Specific Processors, Hardware and Cluster Platforms for Big Data Analytics, Big Data Next Challenges – IoT, Cognition, and Beyond

Unit V: Big data analytics tools

Text Book:

References:
4. Data Mining, Jiawei Han & Micheline Kamber, 2nd edition, Elsevier, 2006
6. Research Papers discussed in the classroom discussions.

Course links & References:

CE 607 Decision Support Systems


Text Book:

Reference Book:

CE669 Reverse Engineering and Malware Analysis

Course Objectives: The course introduces reverse engineering techniques and explores the techniques for detecting, analyzing, reverse engineering and eradicating malware. Upon completion of the course, students should be able to:
- Have a good understanding of reverse engineering techniques and tools
- Identify the different types of malware analysis methods
- Setup an environment for malware analysis
- Recognize common malware characteristics

Prerequisites: Assembly language programming, OS fundamentals.

Syllabus:
Introduction to reverse engineering, Low level software, Assembly language primer, Compilers, Execution Environments, Windows OS fundamentals, Executable file formats, Static & Dynamic reverse engineering, Reversing tools, Disassemblers, Debuggers, Decompilers, System monitoring tools, Reversing program binaries, Anti-reversing techniques, Breaking protections, Reversing ‘.NET’, De-compilation, Introduction to malware, Software vulnerabilities – buffer overflow, integer overflow, vulnerabilities exploitation, mitigation; Return oriented programming; Reversing malware – Static & Dynamic malware analysis techniques, Packers & compression, Sandboxing executables & runtime analysis; Malware classification.

Text Book:

Reference Books:
4. Michael Ligh, Steven Adair, “Malware Analysts’s cookbook & DVD”, Wiley publishing

CE 681 Mobile Computing

Course Objectives: Course provides introduction to the fundamentals of mobile computing, mobile application development as well as wireless communication and security. Students will gain a sound understanding of the core concepts of mobile networks and the design of cellular networks including approaches to maximize the available capacity. The course will look at some current research in mobile computing security and wireless security. Students will learn android application development framework and use it to implement their assignments.

Course Prerequisites: Students are required to gain knowledge of basics of computer networking.
Syllabus:

Text/Reference Books:

CE 683 Information Warfare

Prerequisites to study the subject - Students are required to gain knowledge of computer networking and basic concepts of Cyber Security.
Objective of the course/subject - This course will help students in gaining the knowledge of information warfare domain concepts including principles of information warfare (IW), Cyber warfare (CW), Offensive and defensive IW, military espionage, economic espionage, communications eavesdropping, computer break-ins, Open source intelligence, Covert Communication, Surveillance, ethical and legal concepts in the context of CW, Command and Control, Psyops and perception management. They will learn about different countermeasures, ethical hacking tools and techniques. They will form two teams (Red and Blue). One team carries out offensive operations against the; while other team will carry out defensive operations to protect the same information systems.

Syllabus:

Text Books –

Reference Books –
13. Research paper for study (if any) - White papers on cyberwarfare from IEEE/ACM/IBM sources.

Important website for reference & Study (if any) - ISACA website.

CE 608 Semantic Based System & Web Intelligence

Objectives:
- To learn Web Intelligence
- To learn Knowledge Representation for the Semantic Web
- To learn Ontology Engineering
- To learn Semantic Web Applications, Services and Technology
- To learn Social Network Analysis and semantic web

Contents:

**References:**

(Ref: [http://jntuh.ac.in/](http://jntuh.ac.in/), [http://mnnit.ac.in](http://mnnit.ac.in))

**CE 609 Principles of Compiler Design & Operating System**

**Objectives:**
- To apply Structure and functions of OS
- To apply Processes and Threads, Scheduling algorithms
- The student needs to understand the Principles of concurrency and Memory management
- The student will learn the fundamentals of I/O management and File systems
- To understand, design and implement Lexical analyzer & parser

**Contents:**
**UNIT I - INTRODUCTION TO COMPILER DESIGN:**

**UNIT II - PARSER & SYNTAX ANALYSIS:**

**UNIT III - INTRODUCTION TO OPERATING SYSTEM:**

**UNIT IV - CONCURRENCY & MEMORY MANAGEMENT:**

UNIT V - INPUT/OUTPUT AND FILE SYSTEMS:
I/O management and disk scheduling – I/O devices, organization of I/O functions; OS design issues, I/O buffering, disk scheduling, Disk cache. File management – Organization, Directories, File sharing, and Record blocking, secondary storage management.

References:

(CRef: http://www.srmuniv.ac.in/ )

CE 689 Fault Tolerant Computing System

Syllabus
10. Introduction: Motivation, System view of high availability design, Terminology
12. Error detection techniques: Watchdog processors, Heartbeats, Consistency and capability checking, Data audits, Assertions, Control-flow checking Application: DHCP
14. Network fault tolerance: Reliable communication protocols, Agreement protocols, Database commit protocols Application: Distributed SQL server
15. Practical steps in design of high availability networked systems Application: Web services, Highly available clusters
16. Check pointing& Recovery Application: Microcheckpointing
17. Attack dimension to failures, byzantine generals problem, in context of side-channel attacks study fault induced leads to catastrophic failure
18. Case Studies

Text Book:

Reference Book:
**Course Objective**

To meet end-user, Administrator & Designer perspectives. Enhance analytical capabilities to evaluate a system.

**About the Course**: The study of Parallel and Distributed Systems investigates software architectures to support flexible parallel and distributed applications, which can adapt themselves for execution in dynamically changing, heterogeneous environments. The study targets the diverse environments ranging from scalable clusters of commodity workstations to dynamic aggregations of computing and information resources, emphasizing the interactions between hardware, operating systems, and applications. The study includes efforts to build fault-tolerant programming systems, compiler-assisted object caching systems, application-structuring mechanisms for adaptation in dynamic environments, and transparent secure distribution middleware for general-purpose applications. These projects encompass a gamut of approaches from fundamental research through prototypes, up to working usable systems.

**Pre-requisites**: CSE, IT, ECE, EE, Robotics, Instrumentation Engg, Industrial Engineering, Modelling & Simulations, Fundamental Computer architecture, programming environments, computer networks

**Syllabus:**


**Unit I: Unit II**: Parallel Architecture, Parallel Algorithms, Parallel Databases, Distributed Architecture, Distributed Systems, Distributed Databases

**Unit III**: Systems modeling and Virtualization, Clusters for Scalable Parallel Computing, Virtual Machines, Virtualization Of Clusters

**Unit IV**: Data Centers, Computing Clouds, Service-Oriented Architectures, Service-Oriented Architectures for Distributed Computing

**Unit V**: Cloud Programming and Software Environment, Grids, P2P, Future Internet, Peer-To-Peer Computing and Overlay Networks, Ubiquitous Cloud and Internet of Things. Fog and Edge Computing.

**Unit VI**: Adhoc Distributed & Self-Organising Environments, Pervasive and Ubiquitous Computations, Environments

**Text book:**

Background: Wireless Sensor networks (WSN) is an emerging technology and have great potential to be employed in critical situations like battlefields and commercial applications such as building, traffic surveillance, habitat monitoring and smart homes and many more scenarios. One of the major challenges wireless sensor networks face today is security. While the deployment of sensor nodes in an unattended environment makes the networks vulnerable to a variety of potential attacks, the inherent power and memory limitations of sensor nodes makes conventional security solutions unfeasible. The sensing technology combined with processing power and wireless communication makes it profitable for being exploited in great quantity in future. The wireless communication technology also acquires various types of security threats.

Objective: To meet End-User, Network-Administrator and Network-Designer perspectives

Basic Revision Mandatory: Computer Networks Fundamentals, Programming,

Subject Contents:

Part I: Introduction, WSN Resources & constraints, Relevance to IoTs, Relevance to Cyber-Physical Systems, Relevance to Network Centric Operations, Relevance to Data Stream Management Systems, Relevance to the increasing demand of high performance computations, SCADA, battle sensor.

Part II: WSN Network Architecture, MAC Layer protocols, Naming and Addressing, Synchronization, Location & positioning, Topology control, Connected Dominating Sets, Routing Protocols, Data-Centric & Content-based networking, Data-Centric querying, WSNs versus IoTs


Text Book:

Research Paper References:


Tutorials:

k. Routing techniques: Overview of Proactive and reactive routing protocols, significance of a hop in adhoc networks
l. Flooding, Gossiping, Zonal Routing Protocols ZRP, Hybrid Routing, TTL significance with respect to routing protocols
m. Impact of hardware and software on Battery Performances/Utilisation
n. IEEE 802.15.4: A study, Features, Types of Devices FFD (PAN coordinators, Coordinators), RFDs Reduced Function Devices, Network Setup process & parameters in Consideration, Programming Strategies to suit the standards, MAC and PHY structure
o. Demo 1: Controlling DIOs. Demonstrate the usage of DIO using LEDs. Learning how to handle data sampling period.
p. Demo 2. Reading data from a single IoT device. Interpretation of data.
q. Demo 3: Create a broadcast wireless network and capture the traffic generated by the participating nodes.
s. Understanding MBR & LBR (MAC Based Routing and LBR Level-Based Routing)
t. Understanding exiting API, Libraries & its association with pre-existing demonstration codes.

CE610 Information Retrieval Systems


Text Book:

Reference Books:
Course Objectives: Understanding of TPM capabilities, as well as other trusted computing standards and technologies
- Secure/Trusted/Verified Boot
- Remote Attestation
- Use of open source tools for development of trusted process
Be able to maintain and to develop trusted systems.

Course Prerequisites: Basic understanding of Boot Process, Shell Programming and Formal Methods, Fundamentals of OS.

Syllabus:

Text Books:

Reference Books:

CE 611 Genetic Algorithm & Artificial Neural Networks


Text Books:

Reference Books:
Course Objectives: To understand the concepts of Game Theory and get an overview. To learn and appreciate the applications of game theory in Network Security.

Prerequisites: Basic understanding of Computer Networking and Network Security

Syllabus:


Text Books:

Reference Books:

Text Book:

Reference Books:
3. J. Yen and R. Langari, “Fuzzy Logic, Intelligence, Control and Information”, Pearson Education.

CE 692 Computational Geometry and Applications

Pre-requisites: The students are assumed to have a basic knowledge of the design and analysis of algorithms and data structures. No knowledge of the application domains is required, and hardly any knowledge of geometry. The analysis of the randomized algorithms requires very elementary knowledge of probability theory.

Syllabus: Geometric primitives, Line intersection, randomized incremental concepts, Triangulation and visibility, Linear programming in two and three dimensions, Orthogonal range searching, Point location and Binary Space Partitions, Voronoi diagrams and Delaunay triangulation, Convex hulls, Non-orthogonal range searching

Text Book:
2. “Computational Geometry: Algorithms and Applications”, Third Edition (March 2008), Mark de Berg, TU Eindhoven (the Netherlands), Otfried Cheong, KAIST (Korea), Marc van Kreveld, Mark Overmars, Utrecht University (the Netherlands), Springer-Verlag

CE 694 Big Data Analysis & Algorithms

Course Objective
To meet end-user, Administrator & Designer perspectives, develop skill sets to be resourceful in the area of knowledge, information systems. Enhance analytical capabilities to evaluate a domain specific technical and expertise areas. Multi-Disciplinary Course useful to any engineering discipline who use a computer.

About the Course: The use of Big Data is becoming a crucial way for leading companies to outperform their peers. In most industries, established competitors and new entrants alike will leverage data-driven strategies to innovate, compete, and capture value. Early adopters of Big Data are using data from sensors embedded in products from children’s toys to industrial goods

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to determine how these products are actually used in the real world. Such knowledge then informs the creation of new service offerings and the design of future products. Big Data will help to create new growth opportunities and entirely new categories of companies. With everything going digital, data is pouring in from all kinds of sources imaginable. Organisations are getting inundated with terabytes and petabytes of data in different formats from sources like operational and transactional systems, customer service points, and mobile and web media. The problem of such huge data is storage and with no proper utilisation of the data, collecting and storing is a waste of resource. Earlier it had been difficult to process such data without relevant technology. Big data analytics is becoming an integral part of organisations who want to grow in this age of innovation and is being done by most of the big companies. There is huge scope of big data analytics professionals as this is going to be an essential part of companies in the future.

The Need:

(d) Cyber-Security Perspective: As the complexity of IT networks has grown, the inventiveness and sophistication of cyber security threats and attacks has grown just as quickly. As malware attacks increase in volume and complexity, it’s becoming more difficult for traditional analytic tooling and infrastructure to keep up thanks to the Data volume, For example, every day at SophosLabs, over 300,000 new potentially malicious files that require analysis are reported. Scalability: SQL-based tooling and infrastructure doesn’t scale well and is costly to maintain. Big Data Analytics is a Path Forward to Cyber Security.

(e) AI / Intelligent Systems Perspective: Centre for Big Data Analytics and Intelligent Systems focuses on the theory development, novel techniques and smart solutions of big data analytics in broad domains, along with theories and techniques of building computer systems, which capture the intelligent behaviours in complex environments. AI dwells on Big Data.

(f) Multi-Disciplinary Course useful to any engineering discipline who use a computer.

Intended Audience: CSE, IT, ECE, EE, Robotics, Instrumentation Engg, Industrial Engineering, Modelling & Simulations

Pre-Requisites: Basic programming knowledge, Data Structure, Programming, Statistical Techniques

Course Contents:

Unit I : Introduction to big data analysis: Evolution of data, data streams, structured & unstructured data, database models, graph data, normalizations

Unit II: Big data analytics platforms: Architectures, Frameworks that enable big data analytics

Unit III: Big data analytics storage & processing: Data Preprocessing, , Multi-Dimensional Data Models, Data Warehousing OLTPS, OLAPS, Data Warehouse Architectures, Datacube Computations, Big Data Mining Frequent Patterns, Big Data Associations & Correlations, Classifications & Predictions, Clustering Techniques & Analysis, Mining Data Streams, Graph Mining Mining Spatial & Temporal Objects, Predictive Analysis, Ad Hoc Queries, Web Analytics
Unit IV: Algorithms for massive data sets. Algorithms for SISD, SIMD environments, Linked Big Data Analysis – Graph Computing and Network Science, Big Data Visualization, Big Data Mobile Applications, Large-Scale Machine Learning, Big Data Analytics on Specific Processors, Hardware and Cluster Platforms for Big Data Analytics, Big Data Next Challenges – IoT, Cognition, and Beyond

Unit V: Big data analytics tools, HDFS. NOSQL, SQL environments

Text Book:

References:
7. Data Mining, Jiawei Han & Micheline Kamber, 2nd edition, Elsevier, 2006
9. Research Papers discussed in the classroom discussions.

Course links & References:

CE 695 Cyber-Physical & Self-Organising Systems

Brief About the Subject: This course examines a new class of computational systems called Cyber-Physical Systems CPS. Such systems have the potential to provide far-reaching benefits in addressing some of the toughest problems we face as a society, such as: reducing healthcare costs, minimizing traffic congestion, and constructing zero-net energy buildings. Four important features characterize CPS: their ability monitors the underlying physical environment, reason about the monitored data, control the physical environment through actuation, in a coordinated manner using a communication medium. It can be seen immediately that in CPS, the computational element (cyber) and the environment (physical) are tightly coupled, with one influencing the other. CPS sits at the confluence of several traditional disciplines, such as: embedded systems, real-time systems, sensor networks, control and hybrid systems, and security. It presents many challenging problems and opportunities for research. With guidance from the professor, students will survey recent CPS publications, develop an aptitude. Readings will include papers on CPS applications (e.g., Body Area Networks, smart automobiles, and energy-efficient buildings), issues involved in designing CPS (e.g., monitoring, communication, and control), and how to ensure that the designed systems satisfy certain essential properties (e.g., safety and security).
CPS combine cyber capabilities (computation and/or communication) with physical capabilities (motion or other physical processes). Cars, aircraft, and robots are prime examples, because they move physically in space in a way that is determined by discrete computerized control algorithms. Designing these algorithms to control CPSs is challenging due to their tight coupling with physical behavior. At the same time, it is vital that these algorithms be correct, since we rely on CPSs for safety-critical tasks like keeping aircraft from colliding; its role in Command and Control environments.

Pre-requisites: CSE, IT, ECE, EE, Robotics, Instrumentation Engg, Industrial Engineering, Modelling & Simulations, Theoretical knowledge of Computer Science and Engineering

**Syllabus:**

**Unit I:** CPS: Introduction Main Concepts, Challenges; Background role of Computer Networks, Data, Algorithms

**Unit II:** Self-organising Systems, Self-organisation in Natural Systems Inspiring Self-organising Software,

**Unit III:** Agents and Multi-Agent Systems Computing trends, Data device proliferation, Confluence of trends

**Unit IV:** Technological and economic drivers Self-organisation Mechanisms, Stigmergy, Gossip, Trust and Reputation for Successful Software Self-organisation, Cooperation, Immune Systems, Holonic Multi-Agent Systems Engineering Artificial Self-organising Systems,

**Unit V:** Engineering Self-organising Systems, Middleware Infrastructures for Self-organising Pervasive Computing Systems

**Unit VI:** Applications of Self-organising Software, Self-organisation in Constraint Problem Solving, Adaptive Trust Management, Security in Artificial Systems

**Text Books:**

6. Research Papers discussed in the classroom discussions.

**Reading assignments:**

16. *Introduction*: Brief history of CPS. Motivating problems in CPS.
Objectives:
This course examines what it takes to build a secure operating system and explores the major systems development approaches applied towards building secure OS’s including virtualization.

From this course, students will learn:
- Theoretical concepts of operating system security
- Security architectures of current operating systems
- Details of security implementation
- Concept of virtualization
- Security mechanisms in virtual machines

Prerequisites: Operating System Concepts

Syllabus:

Text Book:

Reference Material:
4. Morrie Gasser: "Building a Secure Computer System"

CE 613 Software Architecture & Design Patterns

Objective:
1. To apply the appropriate design patterns

Prerequisite: Knowledge of C++ and OOAD

What is Software Architecture, Architectural patterns, reference models, reference architectures, architectural structures and views. Introduction to Patterns and UML • Software Design Patterns From GoF • Creational Patterns • Structural Patterns • Behavioral Patterns • Software Architectural Patterns • Layer, Pipe and Filters and Black Board

Text Book:
2. Design Patterns: Elements of Reusable Object-Oriented Software, Erich Gamma, Richard Helm, Ralph Johnson, and John Vlissides, Addison-Wesley.

Reference books:
1. Object-Oriented Design with Applications (Second Edition) by Grady Booch
2. UML Distilled – Third Edition by Martine Fowler, Addison Wesley

CE 614 Principles of Programming Language

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Introduction: Programming Languages, Programming linguistics, Concepts and paradigms, Syntax, semantics, and pragmatics, Language processors, Historical development

**Basic Concepts:** Values and Types Types: Primitive types, Built-in primitive types, Defined primitive types, Discrete primitive types, Composite types, Cartesian products, structures, and records, Mappings, arrays, and functions, Disjoint unions, discriminated records, and objects, Recursive types, Lists, Strings, Recursive types in general, Type systems, Static vs dynamic typing, Type equivalence, The Type Completeness Principle, Expressions, Literals, Constructions, Function calls, Conditional expressions, Iterative expressions

**Variables and Storage:** Variables and storage, Simple variables, Composite variables, Total vs selective update, Static vs dynamic vs flexible arrays, Copy semantics vs reference semantics, Lifetime, Global and local variables, Heap variables, Persistent variables, Pointers, Pointers and recursive types, Dangling pointers, Commands, Skips, Assignments, Procedure calls, Sequential commands, Collateral commands,

**Bindings and Scope:** Bindings and environments, Scope, Block structure, Scope and visibility, Static vs dynamic scoping, Declarations, Type declaration, Constant declarations, Variable declarations, Procedure definitions, Collateral declarations, Sequential declarations, Recursive declarations, Scopes of declarations, Blocks, Block commands, Block expressions, The Qualification Principle

**Procedural Abstraction:** Function procedures and proper procedures, Function procedures, Proper procedures, The Abstraction Principle, Parameters and arguments, Copy parameter mechanisms, Reference parameter mechanisms, The Correspondence Principle, Implementation notes, Implementation of procedure calls, Implementation of parameter passing

**Advanced Concepts**
Data Abstraction; Program units, packages, and encapsulation, Packages, Encapsulation, Abstract types, Objects and classes, Classes, Subclasses and inheritance, Abstract classes, Single vs multiple inheritance, Interfaces
Generic Abstraction: Generic units and instantiation, Generic classes in C++, Type and class parameters, Type parameters in C++, Class parameters in Java
Type Systems: Inclusion polymorphism, Types and subtypes, Classes and subclasses, Parametric polymorphism, Polymorphic procedures, Parameterized types, Type inference, Overloading, Type conversions
Control Flow: Sequencers, Jumps, Escapes, Exceptions
Concurrency : Why concurrency?, Programs and processes, Problems with concurrency, Nondeterminism, Speed dependence, Deadlock, Starvation, Process interactions

**Paradigms**

**Imperative Programming:** Key concepts, Pragmatics, A simple spellchecker, Case study: C, Values and types, Variables, storage, and control, Bindings and scope, Procedural abstraction, Independent compilation, Preprocessor directives, Function library, A simple spellchecker

**Object-Oriented Programming:** Key concepts, Pragmatics, Case study: C++, Values and types, Variables, storage, and control, Bindings and scope, Procedural abstraction, Data abstraction, Generic abstraction, Independent compilation and preprocessor directives, Class and template library, A simple spellchecker

Case study: Java, Values and types, Variables, storage, and control, Bindings and scope, Procedural abstraction, Data abstraction, Generic abstraction, Separate compilation and dynamic linking, Class library, A simple spellchecker

**Concurrent Programming:** Key concepts, Pragmatics, Case study: Ada95, Process creation and termination, Mutual exclusion, Admission control, Scheduling away deadlock, Case study: Java, Process creation and termination, Mutual exclusion, Admission control
**Functional Programming:** Key concepts, Eager vs normal-order vs lazy evaluation, Pragmatics, Case study: Haskell, Values and types, Bindings and scope, Procedural abstraction, Lazy evaluation, Data abstraction, Generic abstraction, Modeling state, A simple spellchecker

**Logic Programming:** Key concepts, Pragmatics, Case study: Prolog, Values, variables, and terms, Assertions and clauses, Relations, The closed-world assumption, Bindings and scope, Control, Input/output, A simple spellchecker

**Scripting:** Pragmatics, Key concepts, Regular expressions Case study: Python, Values and types, Variables, storage, and control, Bindings and scope, Procedural abstraction, Data abstraction, Separate compilation, Module library

**Language Selection:** Criteria, Evaluation

**Language Design:** Selection of concepts, Regularity, Simplicity, Efficiency, Syntax, Language life cycles

**Text Books:**

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**CE615 Advanced Algorithms**

2. **Graph Algorithms:** Bellman - Ford Algorithm; Single source shortest paths in a DAG; Johnson’s Algorithm for sparse graphs; Flow networks and Ford-Fulkerson method; Maximum bipartite matching.
3. **Internet Algorithms:** Search engines; Ranking web pages; Hashing; Caching, content delivery, and consistent hashing.
4. **Number-Theoretic Algorithms:** Elementary notions; GCD; Modular Arithmetic; Solving modular linear equations; The Chinese remainder theorem; Powers of an element; RSA cryptosystem; Primality testing; Integer factorization.
5. **String-Matching Algorithms:** Naïve string Matching; Rabin - Karp algorithm; String matching with finite automata; Knuth-Morris-Pratt algorithm; Boyer – Moore algorithms.
6. **Probabilistic and Randomized Algorithms:** Probabilistic algorithms; Randomizing deterministic algorithms, Monte Carlo and Las Vegas algorithms; Probabilistic numeric algorithms.

**Laboratory Work:**
1. Design, develop, and run a program in any language to implement the Bellman-Ford algorithm and determine its performance.
2. Design, develop, and run a program in any language to implement Johnson’s algorithm and determine its performance.
3. Design, develop, and run a program in any language to implement a Monte Carlo algorithm to test the primality of a given integer and determine its performance.
4. Design, develop, and run a program in any language to solve the string matching problem using naïve approach and the KMP algorithm and compare their performances.
5. Design, develop, and run a program in any language to solve modular linear equations.
6. Design, develop, and run a program in any language to implement a Page Ranking algorithm.
Text Books:

Reference Books:

CE 69D Lean Six Sigma

Syllabus:


Text Book:

Reference Book:

CE 69E Flight Simulators and Game Programming

Syllabus:


Text Book:
Reference Book:


CE 69F Theory of Computation

Syllabus:

14. **Introduction**: Motivation, Terminology, History
15. **Computers and Science of Computing**: Computability, Undecidability, Intractability, and Intelligence
16. **Automata**: Construction, Finite Automata, Limitations of Finite Automata
18. **Regular Languages and Expressions**: Equivalence, Regular expressions in practice
19. **Grammars**: Parsing and Derivation, Grammar for regular languages, Converting Regular grammar to Automata
20. **Nature of Regular Languages**: Closure properties, Peigeonhole principle, Pumping Lemma, Adversarial Game
21. **Context Free Languages and Grammars**: Context Free Behaviour, CFGs, Ambiguity, Chomsky Normal Form, Simple, Linear and other grammars
22. **Pushdown Automata**: Stack Behaviour, Constructing PDAs, CFGs to PDAs, CFL-CFG-PDA Triad
23. **Nature of Context Free Languages**: Closure properties
24. **Turing Machines**: Construction, Definition, Complex Turing Machines, Church Turing Thesis, Universal Turing Machines
25. **The Chomsky Hierarchy**: Languages, Grammars and Machines, Recursive Languages, Idea of Context
26. **Computability and Undecidability**: Halting Problem, P = NP?

Text Book:


Reference Book:

Course Objectives:

Biometrics has emerged as a specialized field in criminal forensics, public safety surveillance, user authentication and identification. Expansions of biometric modalities are ranged from fingerprint, face and other traits to multimodal biometric traits. Objectives of this course to introduce the students different modality based biometric identification systems, to help them to understand the difference between advanced biometric techniques with respect to traditional authentication mechanisms. Students after learning this course would be able to design and develop biometric systems by utilizing inter-disciplinary knowledge related to fields like Pattern Recognition, Image Processing and Machine Learning etc.

Syllabus:

11. **Introduction**: History of Biometrics, Multimodal Biometric Systems, Recent Advances

12. Authentication Technologies, Access Control

13. **Finger Print Biometrics**: Sensors, Dactyloscopy, Types, Algorithms

14. **Handwriting biometrics**: Static and Dynamic Recognition

15. **Iris Biometrics**: Retinal Scanning, Visible and Near Infra red Imaging, Operating Principle, Advantages and Shortcomings

16. **Voice Biometrics**: Verification versus Identification, Text Dependent and Text Independent, Technology, Applications

17. **Face Recognition**: Techniques for Face Acquisition/Recognition, Advantages and Disadvantages, History, Anti-facial recognition

18. **DNA finger printing/ Profiling**: Process, DNA Database, DNA evidence,

19. **Statistical Measures for Biometrics**:

20. **Biometric Devices**: Personal, Handheld, Biometric spoofing, Accuracy

Text Book:


Reference Book:


**CE 698 Multimedia Security**

Course Objectives:
1. To facilitate individual in gaining knowledge on digital watermarking, steganographic and encryption techniques on multimedia signals like image, audio and video for digital rights management applications.
2. To facilitate individual in gaining knowledge on forensics on multimedia signals like image, audio and video for multimedia tamper/forgery detection applications.
3. To teach biometric security concepts. Student will learn and implement various algorithms using MATLAB, Python during hands-on activities carried in the Laboratory.

**Prerequisites:** Basic computer programming knowledge is required.

**Syllabus:**


**Text Book:**

**Reference Books:**

Research paper for study (if any) - White papers on multimedia from IEEE/ACM/Elsevier/Spinger/IBM sources.

CE 699 : Internet of Things

Objective

To meet end-user, Network-Administrator & Designer perspectives, develop skill sets to be resourceful in the area of Cyber-Security. Enhance analytical capabilities to evaluate a deployment and realisation.

About the Course:

The Internet of Things (IoT) is predicted to be the single most important factor impacting fundamental business logic in the coming decades. Government, academia, and industry are involved in different aspects of research, implementation, and business with IoT. IoT cuts across different application domain verticals ranging from civilian to defence sectors. These domains include agriculture, space, healthcare, manufacturing, construction, water, and mining, which are presently transitioning their legacy infrastructure to support IoT. Today it is possible to envision pervasive connectivity, storage, and computation, which, in turn, gives rise to building different IoT solutions. IoT-based applications such as innovative shopping system, infrastructure management in both urban and rural areas, remote health monitoring and emergency notification systems, and transportation systems, are gradually relying on IoT based systems. Therefore, it is very important to learn the fundamentals of this emerging technology & enable the students to anticipate and acknowledge the security concerns and vulnerabilities in the cyberspace. The impact of poor IoT security is being felt like a monsoon as these devices are compromised and then used to flood targets with DDOS traffic. As we move forward into this IoT era, it is imperative that we take steps as individuals to protect our Networks.

Intended Audience:

CSE, IT, ECE, EE, Robotics, Instrumentation Engg, Industrial Engineering, Modelling & Simulations Pre-Requisites : Basic programming knowledge

Course Contents:

Unit I:
Introduction to Internet of Things, Definition and Characteristics of IoT, Physical Design of IoT, IoT Protocols, IoT communication models, IoT Communication APIs

Unit II


Unit III

IoT and M2M, Software defined networks, network function virtualization, difference between SDN and NFV for IoT, Basics of IoT System Management with NETCOZF, YANG, NETCONF, YANG, SNMP NETOPEER

Unit IV

IoT physical end devices & end points, IoT Physical Servers & Cloud offerings, Software environments, NEO, Security

Text Book


References

8. Research Papers discussed in the classroom discussions.

CE 69A BitCoins and CryptoCurrency

About this course: To understand what is special about Bitcoin, we need to understand how it works at a technical level. The course will address the important questions about Bitcoin, such as: How does Bitcoin work? What makes Bitcoin different? How secure are your Bitcoins? How anonymous are Bitcoin users? What determines the price of Bitcoins? Can cryptocurrencies be regulated? What might the future hold? After this course, students will know the need to be able to separate fact from fiction when reading claims about Bitcoin and other cryptocurrencies. Students will have the conceptual foundations to engineer secure software that interacts with the Bitcoin network. And students will be able to integrate ideas from Bitcoin in their own projects.
Intended Audience: CSE, IT, ECE, EE, Robotics, Instrumentation Engg, Industrial Engineering, Modelling & Simulations Pre-Requisites: Basic programming knowledge, Basic Cryptography, Web Applications, Computer Networks

Course Contents:

Unit I: Introduction to Crypto and Cryptocurrencies Objective: Learn about cryptographic building blocks ("primitives") and reason about their security. Work through how these primitives can be used to construct simple cryptocurrencies.

Unit II How Bitcoin Achieves Decentralization Objective: Learn Bitcoin's consensus mechanism and reason about its security. Appreciate how security comes from a combination of technical methods and clever incentive engineering.

Unit III Mechanics of Bitcoin Objective: Learn how the individual components of the Bitcoin protocol make the whole system tick: transactions, script, blocks, and the peer-to-peer network.

Unit IV How to Store and Use Bitcoins Objective: Learn how using Bitcoins works in practice: different ways of storing Bitcoin keys, security measures, and various types of services that allow you to trade and transact with bitcoins.

Unit V Bitcoin Mining Objective: Bitcoin relies crucially on mining. But who are the miners? How did they get into this? How do they operate? What's the business model like for miners? What impact do they have on the environment?

Unit VI Bitcoin and Anonymity Objective: Is Bitcoin anonymous? What does that statement even mean—can we define it rigorously? We'll learn about the various ways to improve Bitcoin's anonymity and privacy and learn about Bitcoin's role in Silk Road and other hidden marketplaces.

Unit VII Community, Politics, and Regulation Objective: Look at all the ways that the world of Bitcoin and cryptocurrency technology touches the world of people. Discuss the community, politics within Bitcoin and the way that Bitcoin interacts with politics, and law enforcement and regulation issues.

Unit VIII Alternative Mining Puzzles Not everyone is happy about how Bitcoin mining works: its energy consumption and the fact that it requires specialized hardware are major sticking points. This week we'll look at how mining can be redesigned in alternative cryptocurrencies.

Unit IX Bitcoin as a Platform, One of the most exciting things about Bitcoin technology is its potential to support applications other than currency. We'll study several of these and study the properties of Bitcoin that makes this possible.

Unit X Altcoins and the Cryptocurrency Ecosystem Hundreds of altcoins, or alternative cryptocurrencies, have been started, either to fix Bitcoin's perceived flaws or to pursue different goals and properties. We'll look at everything that goes into an altcoin and how they interact with Bitcoin.
Unit XI: The Future of Bitcoin? The use of Bitcoin technology for decentralizing property, markets, and so on has been hailed as a recipe for economic and political disruption. The technological underpinnings of these proposals and the potential impact on society.

Text Book:


2. Research Papers discussed in the classroom discussions.

**CE 69B Network Forensics**

Course Objective: To meet end-user, Network-Administrator & Network-Designer perspectives, develop skill sets to be resourceful in investigating the crimes in the area of Cyber-Security. Enhance analytical capabilities to evaluate a network.

About the Course: Computer and Network Forensics studies cyber-attack prevention, planning, detection, response, and investigation with the goals of counteracting cybercrimes, and making the responsible persons/groups accountable. The topics covered in this course include fundamentals of Network forensics, Network forensic duplication and analysis, Network Surveillance, Network Intrusion Detection and Response, Incident Response, Anti-Forensics Techniques, Anonymity and Pseudonymity, Network Cyber Law, Computer Security Policies and Guidelines, Court Report Writing and Presentation, and Case Studies. Pre-requisites: Computer Networks, Basics of OS

Syllabus:

Unit I: Forensics: An Overview, Scope of Network Forensic, Network Forensics Basics

Unit II: Network Enabled Operations, Network Controlled Operations, Network Offences, Network Criminalistics

Unit III: Basics of host devices on networks: Inter-Network Devices, OS and Networking: A Review


Unit V: Intrusion and Online Frauds Detection

Unit VI: Peer-2-Peer Networks, Cryptocurrency and Blockchain

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Unit VII: Network Traffic & Traffic engineering, Network Traffic & Traffic engineering for the Steganography & Steganalysis

Unit VIII: Anonymity/Pseudonymity/P2P environments, Network Forensic Challenges in adhoc environments, Network Forensic challenges in IOTs

Unit IX: Legal Perspective: Cyber Law, Security and Privacy Policies and Guidelines

Unit X: Case Studies, and ethical issues Unit XI: Court Testimony and Report Writing Skills

Course Materials

There will be no textbooks. Most readings are from the lecture notes and papers published in recent years from top security/forensics conferences/workshops or journals, reference books, and related Internet web sites. Two reading lists will be given. The required readings are 30-35 papers and a suggested reading list includes 130+ papers published within the last 10 years.

Reference books:


CE 70A Formal Specification and Verification of Programs

Objectives:
To study methods and techniques for stating and proving the correctness statements. Studying Mathematical Logic (Symbolic Logic), Mathematical models for programs. (Programming Language Semantics) and Justification of the verification techniques.

On successful completion of the module, the students
- should have a good knowledge and understanding of soundness, correctness of static analysis.
- should be able to understand the use of logic as a formal language for the specification of systems.
- understand the use of symbolic execution, and the main verification techniques used in symbolic model checking, and be able to verify simple systems
- study some of the issues that arise in deploying these techniques in practice, and solution strategies for them.

**Syllabus**
Reasoning about sequential programs: Programs as (possibly infinite) state transition systems; Specifying program correctness using pre- and post-conditions; partial and total correctness semantics; Hoare logic and its rules for a simple imperative sequential language; weakest pre-condition and strongest post-condition semantics; central importance of invariants in program verification. Brief introduction to lattices and the theory of abstract interpretation; some numerical abstract domains: intervals, difference bound matrices, octagons, polyhedra; computing abstract post-conditions and abstract loop invariants; refining abstractions and counterexample-guided abstraction refinement; Predicate abstraction and boolean programs; converting assertion to a location reachability problem; location reachability using predicate abstraction for simple programs and for programs with (possibly recursive) function calls; Introduction to temporal logics: LTL and CTL; Kripke structures as models of reactive (hardware and software) systems; LTL and CTL model checking algorithms and some applications

**Text Reference:**
6. Research papers and survey articles to be announced in class

**CE 70B Advanced Algorithms**

**Syllabus:**

**Unit I: Basics**
Data Structures, Abstract Data Types, Dictionaries, Parameters of Algorithms, Growth Functions, Asymptotic Notations & Complexity analysis, Complexity measures.

**Unit II: Algorithms**
Unit III: Soft-Computing Based Algorithms
Need, Modularity, Sequential, PRAM models, Classic Vs Soft Computing Algorithms, AI enabled Examples of Algorithms for Internet Search, Web Contents Organization and retrieval


Unit V: Futuristic Trend: Computations in Cyber Physical Systems CPS, CPS based parallel & distributed Algorithms, Quantum Computing, Concepts of Qubits, Quantum Algorithms, Quantum Search-Space optimization

Laboratory Work:
Total V Practical Assignments. Lab Assignment based on each Unit.

Text Books:

Reference Books:
6. Recommended Research papers during instruction

CE 70C Semantic Web

Course Objective: This course discusses fundamental concepts of information structure, representation, presentation, as well as information exchange on the World Wide Web.

Course Outline:
1. Introduction to Semantic Web Vision; Metadata and XML Schema.
2. RDF, RDF Schema.
3. Introduction to description logics, Reasoning with description logics.
4. Ontology; Ontology building methodologies.
5. Ontology Languages for the Semantic Web, From RDFS to OWL, OWL, Reasoning with OWL.

Text Books:

**CE 700 Quantum Computing**

**About this Course**
"Quantum Computing" is among those terms that are widely discussed but often poorly understood. The reasons of this state of affairs may be numerous, but possibly the most significant among them is that it is a relatively new scientific area, and it's clear interpretations are not yet widely spread. The main obstacle here is the word "quantum", which refers to quantum mechanics - one of the most counter-intuitive ways to describe our world. But fear not! This is not a course on quantum mechanics. We will gently touch it in the beginning and then leave it apart, concentrating on the mathematical model of quantum computer, generously developed for us by physicists. This doesn't mean that the whole course is mathematics either (however there will be enough of it). We will build a simple working quantum computer with our bare hands, and we will consider some algorithms, designed for bigger quantum computers which are not yet developed. The course material is designed for those computer scientists, engineers and programmers who believe, that there's something else than just HLL programming, that will move our computing power further into infinity.

**Prerequisites** are complex numbers and linear algebra

**Course Contents:**

7. **Unit I:** Introduction, Information and Computations, Characteristics of Computational Systems, Computability and Algorithms, Computational Complexity, Quantum Computing parameters and units, The Multiverse Interpretation of Quantum Mechanics

8. **Unit II:** Mathematical Model of Quantum Computing, Qubit, Qubit Measurement, Systems with Multiple Qubits, Measuring the Multiple Qubits Systems, Quantum System Evolution & Computations

9. **Unit III:** Quantum Computer and Quantum Algorithms, Deutsch's Problem, Quantum Computer Prototype, Suitable Algorithms

10. **Unit IV:** Shor's Algorithm, Factoring and the RSA, Factoring and Period Finding, Quantum Fourier Transform

11. **Unit V:** Grover's Algorithm. A Quantum Computer Application Boundaries, Grover's Algorithm, Challenges

12. **Unit VI:** Quantum environments, Search Spaces, Search Optimisation, Storage Optimisation, Quantum Resources, Future, Challenges

**Text Book:**

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4. References: Research Papers as discussed in the class room.

**CE 70D Computer Network Audit & Forensics**

**Course Objective:**
To meet end-user, Network-Administrator & Network-Designer perspectives, develop skill sets to be resourceful in the area of Cyber-Security. Enhance analytical capabilities to evaluate a Network and Network Enabled Operations to analyze Network Centric Operations.

**Prerequisites:**
Preliminary knowledge Electronic Communications (Graduation Level), Computer Networks (Graduation Level) & IPV4, Networking Devices, Finite State Automata, Socket Programming, Algorithms

**Teaching Method:**
Class room instructions, learning through assignments, learning through hands-on sessions, learning through online recommended courses to complement the class room instructions

**Short Recapitulation on topics before the start of the Course:** Architecture of Computer Networks, ISO/OSI and TCP/IP model, IP protocol, transport protocols (TCP, UDP), basic services of computer networks (short recapitulation)

**Course Contents**

**Unit I:** Basics of host devices on networks: Inter-Network Devices, OS and Networking: A Review, n-tier, peer-to-peer Network architectures

**Unit II:** Network Protocols, Network Enabled Operations, Network Controlled Operations, Network Offences, Network Criminalities

**Unit III:** Packet Analysis, Packet Analysis Tools, Network Audit & tools, Network Traffic Engineering, Network Analysis and Analytics

**Unit IV:** Network Forensics: An Overview, Scope of Network Forensic, Network Forensics Basics

**Unit IV:** Computer Network Forensic Modelling and Principles, Network Forensic Duplication, Network Forensics Analytics, Network File Carving, Network & Cyber Forensics Tools and the Testing of host devices in a network, Mobile Network Device Forensics, IPV6, Network Surveillance and Accountability
Unit V: Futuristic Networks, Dependable Networks, AI-Enabled Network Environments, Network Virtualization, SDNs, Sensor Networks, IoT, Evolution in Computing Environments like Cloud, Edge, Fog, Ubiquitous, Pervasive

Text Books:

4. Packet Analysis Tools, Network Audit Tools and Courseware

Recommended Mandatory Readings:

8. Topic based Research Papers assigned during classroom discussions

Reference books:

### Eligibility Criteria:

Bachelor’s degree in Engineering/Technology/4-year Bachelor of Science, with a valid GATE score in CS, EC, or EE.

### Course Structure 2019-2021

#### Semester I

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LIST OF ELECTIVES:

1. CE608 Semantic based System & Web Intelligence
2. CE610 Information Retrieval Systems
3. CE630 Virtual Reality
4. CE632 Computer Vision
5. CE633 Pattern Recognition
6. CE680 Data Mining Techniques
7. CE695 Cyber-Physical & Self-Organising Systems
8. CE699 Internet of Things

Open Electives from other Departments:

1. AM623: Machine Learning
2. AM625: Digital Image Processing
3. ME626: Introduction to Robotics
4. ME628: Robot Kinematics and Dynamics
CE696 AARTIFICIAL INTELLIGENCE & DECISION SUPPORT SYSTEMS

Syllabus:
Unit I: Introduction to AI, Decision Support Systems, Knowledge-based Intelligent Systems, Rule based Expert Systems;
Unit II: Uncertainty Management in rule-based expert systems: Introduction to Uncertainty, Basic Probability Theory, Bayesian reasoning, Certainty Factors;
Unit III: Learning: Overview of different forms of learning, Artificial Neural Networks: Basics of Neuron, Perceptron, Multi-layer neural networks, Back Propagation Algorithm;
Unit IV: Decision Support and Business Intelligence: Decision Support Systems and Business Intelligence, Decision Making Systems, Modeling, and Support, Knowledge Engineering and Data Mining: KDD Process, Pattern Recognition Systems, and Applications of Data Mining in Intelligent Systems.

Text Book:

Reference Books:

CE604 COMPUTATIONAL INTELLIGENCE

Syllabus:
Unit I: Introduction to Computational Intelligence: Computational Intelligence Paradigms, ANN, Evolutionary Computation, Swarm Intelligence, Artificial Immune Systems, Fuzzy Systems

Unit II: Dimensionality Reduction & Feature Selection Methods: Linear Discriminant Analysis and Principal Component Analysis; Data Pre-Processing, Regression, Universal Approximation


Unit IV: Swarm Intelligence: Particle Swarm Optimization, Ant Colony Optimization.

Unit V: Nature Inspired Algorithms for optimization: Differential Evolution, Simulated Annealing, Multi-objective Optimization, Hybrid Optimization Algorithms

Text Book:

Reference Books:

CE615A EFFICIENT ALGORITHMS

Syllabus:

Unit I: Basics
Data Structures, Abstract Data Types, Dictionaries, Parameters of Algorithms, Growth Functions, Asymptotic Notations & Complexity analysis, Complexity measures.

Unit II: Algorithms
Classic Algorithms, Purpose (S, S, SM, PF, Opti, Prob, Rand), Examples of each, Types of Algorithms, P Type, NP Type, Open Problems, Examples of Algorithms for Internet Search, Web Contents Organization and retrieval
Unit III: Soft-Computing Based Algorithms
Need, Modularity, Sequential, PRAM models, Classic Vs Soft Computing Algorithms, AI enabled Examples of Algorithms for Internet Search, Web Contents Organization and retrieval


Unit V: Efficient Algorithms: Computations in Cyber Physical Systems CPS, CPS based parallel & distributed Algorithms, Quantum Computing, Concepts of Qubits, Quantum Algorithms, Quantum Search-Space optimization

Laboratory Work:
Total V Practical Assignments. Lab Assignment based on each Unit.

Text Books:

Reference Books:
9. Recommended Research papers during instruction

CE634 NATURAL LANGUAGE PROCESSING (NLP)

Syllabus:
Introduction: Language Structures and Levels; Morphological processing; Syntactic analysis – parsing; Regular Expressions, demonstrations of use on corpus; Part of Speech Tagging, Supervised Learning, Hidden Markov Models, Unsupervised POS tagging; Grammars - CFG grammars - rule-based parsing difficulties; Discovering grammars from patterns in text; Semantic modeling: Classical ontology-driven approaches, Latent Semantic Analysis; Word discovery from real situations, Aligning unsupervised syntax with sensory structures; Machine Translation; Acquiring structures from Parallel Corpora; Spatial Language and Semantics.

Text References:
1. Dan Jurafsky, JH Martin, Speech and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech Recognition, 2nd Ed, Pearson 2009.
5. Recent papers from journals, conferences and arxiv.org

**AM604 ADVANCED STATISTICAL TECHNIQUES**

Probability and Probability Distributions: Basic concepts of Probability, Discrete Probability Distributions (Binomial, Poisson etc.), Continuous Probability Distributions (Normal, Exponential, Weibull etc.).

Inferential Statistics: Theory of Estimation, Sampling Distribution, Tests of Hypothesis (one sample t, two sample t etc.), Chi Square Test.

Introduction to Statistical modelling. Regression modeling for Normal response and quantitative explanatory: Variables, Simple and Multiple regressions, Model building and validation Comparison of regressions.


Introduction to Design and Analysis of Experiments: Need for conducting Experiments, Applications of experiments, Basic Principles of Experiments, Road Map to conduct efficient experiments Terminologies associated with experiments.

**AM607 MATHEMATICS FOR ENGINEERS**

(Common Course for all M.Tech Programmes)

**SEMESTER II CORE COURSES**

**CE631 DEEP LEARNING**

**Syllabus:**
Unit I: Introduction : Overview of machine learning, linear classifiers, loss functions
Unit II: Optimization : Stochastic gradient descent and contemporary variants, backpropagation
Unit III: Feedforward networks and training: Activation functions, initialization, regularization, batch normalization, model selection, ensembles
Unit IV: Convolutional neural networks: Fundamentals, architectures, pooling, visualization
Unit V: Deep learning for spatial localization: Transposed convolution, efficient pooling, object detection, semantic segmentation
Unit VI: Recurrent neural networks: Recurrent neural networks (RNN), long-short term memory (LSTM), language models, machine translation, image captioning, video processing, visual question answering, video processing, learning from descriptions, attention
Unit VIII: Deep reinforcement learning: Policy gradient methods, Q-Learning: Project presentations

Text/Reference Books:

CE694 BIG DATA ANALYSIS AND ALGORITHMS

Unit I: Introduction to big data analysis: Evolution of data, data streams, structured & unstructured data, database models, graph data, normalizations

Unit II: Big data analytics platforms: Architectures, Frameworks that enable big data analytics

Unit III: Big data analytics storage & processing: Data Preprocessing, Multi-Dimensional Data Models, Data Warehousing OLTPS, OLAPS, Data Warehouse Architectures, Datacube Computations, Big Data Mining Frequent Patterns, Big Data Associations & Correlations, Classifications & Predictions, Clustering Techniques & Analysis, Mining Data Streams, Graph Mining Mining Spatial & Temporal Objects, Predictive Analysis, Ad Hoc Queries, Web Analytics

Unit IV: Algorithms for massive data sets: Algorithms for SISD, SIMD environments, Linked Big Data Analysis – Graph Computing and Network Science, Big Data Visualization, Big Data Mobile Applications, Large-Scale Machine Learning, Big Data Analytics on Specific Processors, Hardware and Cluster Platforms for Big Data Analytics, Big Data Next Challenges – IoT, Cognition, and Beyond

Unit V: Big data analytics tools, HDFS, NOSQL, SQL environments

Text Book:
References:
10. Data Mining, Jiawei Han & Micheline Kamber, 2nd edition, Elsevier, 2006
12. Research Papers discussed in the classroom discussions.

Course links & References:

SEMESTER II ELECTIVE COURSES

CE608 Semantic Based System & Web Intelligence

Syllabus:
Unit V - Social Network Analysis and semantic web: What is social Networks analysis, development of the social networks analysis, Electronic Sources for Network Analysis – Electronic Discussion networks, Blogs and Online Communities, Web Based Networks. Building Semantic Web Applications with social network features.
References:
6. Programming the Semantic Web, T. Segaran, C. Evans, J. Taylor, O'Reilly, SPD.

CE610 Information Retrieval Systems

Syllabus:

Text Book:

Reference Books:

CE630 Virtual Reality

Syllabus:
Unit II: **Multiple Modals of Input and Output Interface in Virtual Reality:** Input -- Tracker, Sensor, Digital Glove, Movement Capture, Video-based Input, 3D Menus & 3DScanner etc. Output -- Visual / Auditory / Haptic Devices


Unit IV: **Environment Modeling in Virtual Reality:** Geometric Modeling, Behavior Simulation, Physically Based Simulation

Unit V: **Interactive Techniques in Virtual Reality:** Body Track, Hand Gesture, 3D Manus, Object Grasp

Unit VI: **Introduction of Augmented Reality:** System Structure of Augmented Reality, Key Technology in AR

Unit VII: **Application of VR in Digital Entertainment:** VR Technology in Film & TV Production, VR Technology in Physical Exercises and Games

Textbook(s) and other required material:

References:

**CE632 Computer Vision**

Syllabus:


Text/Reference Books:

CE633 Pattern Recognition

Syllabus:
UNIT I: Basics of Probability, Random Processes and Linear Algebra (recap):
Probability: independence of events, conditional and joint probability, Bayes theorem

UNIT II: Linear Algebra: Inner product, outer product, inverses, eigen values, eigen vectors, singular values, singular vectors.


**Unit VI: Linear discriminant functions**: Gradient descent procedures, Perceptron, Support vector machines - a brief introduction.


**Unit VIII: Non-metric methods for pattern classification**: Non-numeric data or nominal data. Decision trees: Classification and Regression Trees (CART).

**Text/Reference Books**:


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**CE680 Data Mining Techniques**

**Syllabus**:


**Text Books**:

2. Jiawei Han, Micheline Kamber, and Jian Pei, Data Mining: Concepts and Techniques, 3rd Edition, Morgan Kaufmann, 2011.

**Reference Books**:
CE695 Cyber-Physical & Self-Organising Systems

Brief Overview:
This course examines a new class of computational systems called Cyber-Physical Systems. Such systems have the potential to provide far-reaching benefits in addressing some of the toughest problems we face as a society, such as: reducing healthcare costs, minimizing traffic congestion, and constructing zero-net energy buildings. Four important features characterize Cyber-Physical Systems (CPS): their ability monitor the underlying physical environment, reason about the monitored data, control the physical environment through actuation, in a coordinated manner using a communication medium. It can be seen immediately that in CPS, the computational element (cyber) and the environment (physical) are tightly coupled, with one influencing the other. Cyber-Physical Systems sits at the confluence of several traditional disciplines, such as: embedded systems, real-time systems, sensor networks, control and hybrid systems, and security. It presents many challenging problems and opportunities for research. With guidance from the professor, students will survey recent CPS publications, develop an aptitude. Readings will include papers on CPS applications (e.g., Body Area Networks, smart automobiles, and energy-efficient buildings), issues involved in designing CPS (e.g., monitoring, communication, and control), and how to ensure that the designed systems satisfy certain essential properties (e.g., safety and security).

Syllabus:
Introduction: Brief history of CPS. Motivating problems in CPS.

Modeling: Continuous systems and discrete event systems.

Control over networks

Stability of Hybrid and Switched Systems
CE699 Internet of Things

Syllabus:
Unit I Introduction to Internet of Things, Definition and Characteristics of IoT, Physical Design of IoT, IoT Protocols, IoT communication models, IoT Communication APIs
Unit III IoT and M2M, Software defined networks, network function virtualization, difference between SDN and NFV for IoT, Basics of IoT System Management with NETCOZF, YANG, NETCONF,YANG, SNMP NETOPEER
Unit IV IoT physical end devices & end points, IoT Physical Servers & Cloud offerings, Software environments, NEO, Security

Text /Reference Books:
4. Research Papers discussed in the classroom discussions.

SEMMER II ELECTIVE COURSES: FROM OTHER DEPARTMENTS

AM623 Machine Learning

Syllabus:
Introduction - Well-posed learning problems, Designing a learning system, Perspectives and issues in machine learning

Concept learning and the general to specific ordering – Introduction, A concept learning task, Concept learning as search, Find-S: finding a maximally specific hypothesis, Version spaces and the candidate elimination algorithm, Remarks on version spaces and candidate elimination, Inductive bias

Decision Tree learning – Introduction, Decision tree representation, Appropriate problems for decision tree learning, The basic decision tree learning algorithm, Hypothesis space search in decision tree learning, Inductive bias in decision tree learning, Issues in decision tree learning

Evaluation Hypotheses – Motivation, Estimation hypothesis accuracy, Basics of sampling theory, A general approach for deriving confidence intervals, Difference in error of two hypotheses, Comparing learning algorithms
Bayesian learning – Introduction, Bayes theorem, Bayes theorem and concept learning, Maximum likelihood and least squared error hypotheses, Maximum likelihood hypotheses for predicting probabilities, Minimum description length principle, Bayes optimal classifier, Gibbs algorithm, Naïve Bayes classifier, An example learning to classify text, Bayesian belief networks The EM algorithm

Computational learning theory – Introduction, Probability learning an approximately correct hypothesis, Sample complexity for Finite Hypothesis Space, Sample Complexity for infinite Hypothesis Spaces, The mistake bound model of learning - Instance-Based Learning- Introduction, k-Nearest Neighbour Learning, Locally Weighted Regression, Radial Basis Functions, Case-Based Reasoning, Remarks on Lazy and Eager Learning


Analytical Learning - Introduction, Learning with Perfect Domain Theories: Prolog-EBG Remarks on Explanation-Based Learning, Explanation-Based Learning of Search Control Knowledge

Combining Inductive and Analytical Learning – Motivation, Inductive-Analytical Approaches to Learning, Using Prior Knowledge to Initialize the Hypothesis, Using Prior Knowledge to Alter the Search Objective, Using Prior Knowledge to Augment Search Operators,

Reinforcement Learning – Introduction, the Learning Task, Q Learning, Non-Deterministic, Rewards and Actions, Temporal Difference Learning, Generalizing from Examples, Relationship to Dynamic Programming.

Text / References:
1. Machine Learning – Tom M. Mitchell, - MGH
5. Chris Bishop, Neural Networks for Pattern Recognition, Oxford University Press, 1995

AM625 Digital Image Processing

Syllabus:
Image Sensing and Acquisition – Image Sampling and Quantization – Relationships between pixels.


**Morphological image processing:** Dilation, Erosion, Opening, Closing, Applications to; Boundary extraction, Region filling, Extraction of connected components.


**Object recognition:** Decision-theoretic methods.

**Text / References:**
6. Pattern Recognition, Applications to Large Data-Set Problems, 1984, Sing-Tze Bow, Marcel Dekker

**ME626 Introduction to Robotics**

**Syllabus:**
**Unit I:** Robot definition, Robotics and programmable automation Historical background, laws of Robotics. Robotics systems and Robot anatomy, specification of Robots. Robot geometrical configuration.

**Unit II:** Performance Definition - Accuracy / Repeatability / Precision with respect to Position & Path, payload, speed, acceleration, cycle time - Challenges, Applications and uses of Mobile and other robots: wheeled, tracked, legged, aerial, underwater robots, surgical robots, rehabilitation robots, humanoid robots, Nano Robots.
**Unit III:** Classification of end effectors, Types of Grippers Hooks, scoops and other devices, Gripper force analysis and design of Drive system for gripper – communication of robots

**Unit IV:** Euler angles for specifying orientation, Euler angles for roll-yaw-roll geometry, Gripper positioning by Euler angles for roll-yaw-roll geometry - Euler angles for roll - pitch - yaw geometry, Cylindrical Robot coordinates polar Robot coordinates, calculation of cylindrical, polar coordinates, Some applications.

**Practice:**
1. Firebird Robot Platform Experiments,
2. Languages, Simulation Softwares for Robotics,
3. Case studies etc.

**Text/References:**

**ME628 Robot Kinematics and Dynamics**

**Syllabus:**

**Unit I:** Introduction, position and orientation of objects, objects coordinate frame, Rotation matrix, Euler angles Roll, pitch and yaw angles coordinate Transformations, Joint variables and position of end effectors.

**Unit II:** Dot and cross products, coordinate frames, Rotations, Homogeneous coordinates, D-H Representation, The ARM equation. Direct kinematic analysis for Four axis, SCARA Robot and six axis Articulated Robots.

**Unit III:** The inverse kinematics problem, General properties of solutions. Tool configuration, Inverse kinematics of four axis SCARA robot and six axis Articulated robot.

**Unit IV:** Workspace Analysis, work envelope of a Four axis SCARA robot and five axis articulated robot workspace fixtures, the pick and place operations, continuous path motion, Interpolated motion, straight line motion.


**Practice:**
1. Robot Analyzer Platform Experiments,
2. Simulation Softwares for Robotics,
3. Case studies etc.

Text/References:
Department of Applied Mathematics

M. Tech in Modelling and Simulation

Brief Introduction of Department
The Department of Applied Mathematics came into existence with the inception of Institute of Armament Studies in 1953 as Faculty of Applied Mathematics. The faculty constituted of three departments: (1) Applied Mathematics (2) Ballistics (3) Statistics. In 1991 the three departments merged into one and named it as Department of Applied Mathematics.

**Department of Applied Mathematics offers a two year Multidisciplinary M. Tech. (Modelling & Simulation) programme, and also offers a Doctoral Degree programme in the areas of Applied Mathematics. This programme was provisionally accredited by NBA.**

The aim of the Department was to provide training in depth knowledge of various modelling and simulation techniques and also mathematical topics to various courses conducted at DIAT. The present faculty strength of the Department is five and one visiting faculty. The Department is also actively engaged in handling the projects from various agencies. Since then the Department members have been actively involved in the research in different fields of applied mathematics such as ballistics, flight dynamics, hydro-dynamics, hydro-ballistics, Numerical Methods and Optimization, Statistics, Probability. Recently the Department has also developed expertise in the advanced Modelling and Simulation techniques like Neural Network, Fuzzy Logic and Genetic Algorithm, Parallel Computing, Cryptography and Machine Learning.

The programme is of two years duration where the student undergoes basic training in the subjects related to mathematical modelling & simulation through classroom teaching in the first and second year. During this period the student is also exposed to various simulation tools and practicals. The second year is the dissertation phase where the student works under the guidance of a recognized guide on a problem related to modelling and simulation. Course curriculum will be updated periodically to keep pace with contemporary technological advancement.

**Research Areas**

- Mathematical Modelling & Simulation
- Finite Element Analysis in Fluid Flow through Porous Media
- Computational Fluid Dynamics
- Partial Differential Equations & its Applications
- Numerical Methods for PDEs
  - Finite Elements Method
  - Boundary Element Method
  - Domain Decomposition Method
- Boundary Layer Theory
- Bio-Mechanics
- Cryptography
- Image Processing
Vision of the Department

✓ To provide high quality education, research and training in Applied Mathematics and in the Multidisciplinary area: “Modelling and Simulation” for solving the complex problems.

Mission of the Department

✓ To build strong teaching and research environment for basic and applied research with thrust to defence related problems.
✓ To encourage and help the students community to develop mathematical and statistical models and also exploit available tools for solving real life and defence related problems.
✓ To become a premier department in the country in the area of “Modelling and Simulation” and applications of mathematics.
✓ To provide high quality education, research and customised training in the area of “Modelling and Simulation” for

DRDO Scientists, Service Officers, DPSU and other civilian community.

Programme Educational Objectives

✓ The department of Applied Mathematics is committed to impart knowledge related to Modelling & Simulation and applied mathematical techniques to students and service officers to obtain realistic and reasonable solutions for real world and defence related problems to meet the challenges of current and future requirements of nation.
✓ Being an interdisciplinary programme, such knowledge can help to solve the problem holistically and to achieve successful career and professional accomplishment.
✓ To inculcate positive attitude, professional ethics, effective communication and interpersonal skills which would facilitate them to succeed in the chosen profession exhibiting creativity and innovation through research and development both as team member and as well as leader.

Programme Outcomes (POs)

✓ The department imparts higher education and training in the field of modelling and simulation meeting the defence, industries and academic requirement of the country.
✓ Various courses offered under his programme help to develop various mathematical models cutting across the boundaries and to understand simulation techniques.
After providing the appropriate training in computation and simulation methods and imparting knowledge on contemporary issues, students are well equipped to tackle challenges in the related field.

This is a unique capability which helps the students to establish themselves as a successful professional.

An ability to function on multidisciplinary teams involving interpersonal skills.

An ability to identify, formulate and solve engineering problems of multidisciplinary nature 

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**Eligibility for admission to M.Tech programme:**

M.Sc. in Mathematics / Physics / Statistics / O.R. / Computer science (Provided mathematics is one of the subject at the graduate level), Bachelors Degree in Engineering / Technology of a recognized Institute / University. Proficiency in computer programming is essential.

**Organization of M.Tech programme:**

This programme is of four-semester duration. In first and second semester have six courses along with practical component of each course. The respective course instructor will give assignments / practical problems from the course component and these will be solved in Modelling and Simulation Lab. The practice problems can be solved by using Advanced Data structures (C / C++) / MATLAB / MATHEMATICA / Simula8 / Maplesim / SPSS / R / Extend Sim. . .etc., All these softwares are licensed version and available in the department.

In the first semester all courses are compulsory. But in the second semester 2 courses are compulsory and there is an option to choose 4 elective courses, out of which two elective courses must be chosen from the department only and rest of the two elective courses can be chosen from either department or inter department courses. In each of the course component, there will be three tests and a final semester examination of every course. Half yearly evaluation of the project takes place at the end of the third semester. After the second semester, scholarship students are encouraged do a summer internship for about one and half months at their place of choice where as the sponsored category students are encouraged to identify their project work related to their field (labs) to have collaboration a with DIAT. The third and fourthe semester will have only dissertation phase (work) – 1, and dissertation phase (work) – 2(this is in continuation of dissertation phase (work) – 1) respectively. The department faculty will encourage and help to students to take their projects from DRDO labs / premier institutes or as per student’s choice. This will be entirely based student’s own arrangements and expenses.
department will not sponsor for this; except official arrangements, like issuing no-objection certificate etc. At the end of the final semester he/she submits a thesis and makes a presentation about the project, which is evaluated by the Internal and External examiners. No credits will be counted for attending an audit course.

**Semester I:**

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* 1 Credit for Theory (or Tutorial) means 1 contact hour in a week and 1 credit for practical means 2 contact hours in a week.

**Contact Hours/ week

Note: During summer vacation (4 Weeks), Summer Internship / Industrial Tour will be accepted for all students relevant to the dissertation work especially modeling and Simulation

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<td>Tensor Analysis and Engineering Applications</td>
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<td>AM 625</td>
<td>Digital Image Processing</td>
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<td>AM 626</td>
<td>Computational Heat and Mass Transfer</td>
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<td>AM 627</td>
<td>Introduction to Non Newtonian Fluids</td>
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<td>AM 628</td>
<td>Computational Number Theory and Cryptography</td>
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<td>Calculus of Variations and Integral Equations</td>
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<td>AM 630</td>
<td>Domain Decomposition Methods</td>
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<td>AM 631</td>
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<tr>
<td>AM 633</td>
<td>Bio-Mechanics</td>
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**AM 601 Advanced Numerical Methods**


**Boundary Value Problems and Characteristic Value Problems**: The shooting method – solution through a set of equations – Derivative boundary conditions – Characteristic value problems – Eigen values of a matrix by Iteration – The power method.

Finite difference approximations for partial derivatives and finite difference schemes:


Basic concepts of finite volume method (FVM):

Gauss-divergence theorem. Four basic rules. General discretization techniques. Source term linearization and boundary conditions. Over relaxation and under relaxation techniques. Location of control volume faces. Staggered grid concept. Application of FVM. Advantage and disadvantage with the FDM.

Text / References:

AM 602 Mathematical Modelling and System Analysis

Mathematical Modelling: Introduction to modelling and simulation, Classification of systems into continuous and discrete, Structural characterization of mathematical model and validation techniques.
Modelling Techniques: Dimensional analysis: Concept behind dimensional approach, Buckingham Pi theorem, Models using dimensional approach.

Continuous approach: Models based on physical laws.


Combat Modelling: Modelling the Lanchester laws with System Dynamics.


Text Books / References


AM – 603 Advanced Optimization Techniques


Assignment problem: Hungarian’s algorithm, Degeneracy, applications, unbalanced problems, traveling salesman problem.

Numerical methods for optimization: Nelder Mead’s Simplex search method, Gradient of a function, Steepest descent method, Newton’s method, Conjugate Gradient methods for handling constraints.

Genetic algorithm (GA): Differences and similarities between conventional and evolutionary algorithms, working principle, reproduction, crossover, mutation, termination criteria, different reproduction and crossover operators, GA for constrained optimization, draw backs of GA

Genetic Programming (GP): Principles of genetic programming, terminal sets, functional sets, differences between GA & GP, random population generation, solving differential equations using GP.

CPM/PERT: Simulation of CPM/PERT network, Analysis of an activity network, Simulation of inventory system and manufacturing system

Text Books / References:

5. Introduction to Optimization, 1988, Beale, John Wiley.
7. Optimization for Engineering Design – Kalyanmoy Deb, PHI Publishers
9. Genetic Programming- Koza
10. A Field Guide to Genetic Programming, Riccardo Poli, William B. Langdon, Nicholas F. McPhee
13. Multi objective Genetic algorithms - Kalyanmoy Deb, PHI Publisher

AM 604 Advanced Statistical Techniques

254
**Probability and Probability Distributions:** Basic concepts of Probability, Discrete Probability Distributions (Binomial, Poisson etc.), Continuous Probability Distributions (Normal, Exponential, Weibull etc.).

**Inferential Statistics:** Theory of Estimation, Sampling Distribution, Tests of Hypothesis (one sample t, two sample t etc.), Chi Square Test.

**Introduction to Statistical modelling.**

**Regression modeling for Normal response and quantitative explanatory:** Variables, Simple and Multiple regressions, Model building and validation Comparison of regressions.

**Stochastic process:** Basic idea of random processes, Stationary, Markov processes, Markov chains and applications, Introduction to ergodicity.

**Introduction to Design and Analysis of Experiments:** Need for conducting Experiments, Applications of experiments, Basic Principles of Experiments, Road Map to conduct efficient experiments Terminologies associated with experiments.

**Text/References**


**AM 605  Computer Graphics**

**Introduction:** Application areas of Computer Graphics, overview of graphics systems, video-display devices, raster-scan systems, random scan systems, graphics monitors and work stations and input devices

**Output primitives:** Points and lines, line drawing algorithms, mid-point circle and ellipse algorithms. Filled area primitives: Scan line polygon fill algorithm, boundary-fill and flood-fill algorithms.
2-D Geometrical transforms: Translation, scaling, rotation, reflection and shear transformations, matrix representations and homogeneous coordinates, composite transforms, transformations between coordinate systems.

2-D Viewing: The viewing pipeline, viewing coordinate reference frame, window to view-port coordinate transformation, viewing functions, Cohen-Sutherland and Cyrus-beck line clipping algorithms, Sutherland–Hodgman polygon clipping algorithm.

3-D Object representation: Polygon surfaces, quadric surfaces, spline representation, Hermite curve, Bezier curve and B-spline curves, Bezier and B-spline surfaces. Basic illumination models, polygon rendering methods.

3-D Geometric transformations: Translation, rotation, scaling, reflection and shear transformations, composite transformations, 3-D viewing: Viewing pipeline, viewing coordinates, view volume and general projection transforms and clipping.

Visible surface detection methods: Classification, back-face detection, depth-buffer, scan-line, depth sorting, BSP-tree methods, area sub-division and octree methods

Computer animation: Design of animation sequence, general computer animation functions, raster animation, computer animation languages, key frame systems, motion specifications

Text / References:
7. Computer Graphics, with OpenGL Hearn and Baker, - Pearson

AM 606 Mathematical Methods

Law of Cooling, Free Falling Bodies. Simple Harmonic Motion, Damped Motion, Forced Motion, Other Applications in Electronics and Pendulum Problem.

**Linear Algebra:** General (real) vector spaces, Subspaces, Linear independence, Dimension, Norms, Orthogonal bases and Gram-Schmidt orthogonalization, Linear transformation, Kernel and range, Inverse transformations, Matrices of linear transformations, Change of basis, Similarity, Eigen values and eigen vectors, Diagonalization, Orthogonal diagonalization and symmetric matrices, Quadratic forms.


**Texts / References:**
5. Ordinary Differential Equations by Deo and Raghavendra
6. Fourier analysis with Applications of boundary value problems schaum series.
7. Integral Transforms by Goyal and Gupta.

**AM 607 Mathematics for Engineers**

**Elements of Probability and Statistics:** Basic concepts of Probability, Discrete Probability Distributions (Binomial, Poisson etc.), Continuous Probability Distributions (Normal, Exponential, etc.,).

**Components of Operations Research:**
Introduction to Operations Research, Linear programming (Simplex Method, Revised Simplex Method, Dual simplex, Duality theory), Transportation Models.

**Linear Algebra:**
General (real) vector spaces, Subspaces, Linear Independence of Vectors, Basis and Dimension, Linear Transformations, Span, Norms, Orthogonal basis and Gram-Schmidt Orthogonalization.

**Ordinary Differential Equations:**

**Transform Techniques:**
Overview of Laplace transforms, Fourier Transforms, Z transform.

**Numerical Methods for ODE and P.D.E.:**
Parabolic, Hyperbolic and Elliptic Equations using finite difference method

**Texts / References:**
12. S. Gupta.. Calculus of Variation, Prentice Hall of India Pvt. Ltd.

**AM 621  Advanced Modelling Techniques**

**Fuzzy logic:** Basic concepts of fuzzy set, Operation on fuzzy sets, Fuzzy numbers Fuzzy relation, Fuzzification, Fuzzy logic as generalization of two valued logic, Fuzzy system, fuzzy control, fuzzy clustering.
Artificial Neural Networks – Introduction, Neural network representation, Appropriate problems for neural network learning, Perceptions, Multilayer networks and the back propagation algorithm, Remarks on the back propagation algorithm, An illustrative example face recognition Advanced topics in artificial neural networks

Dynamics of Chaos: Introduction to chaos, Lorenz system, Lorenz attractor, Dimension of chaotic attractor, applications in communications.

Fractals: Introduction to fractals, Types of fractal dimensions, Generation of fractals by mathematical approach, Julia and Mandelbrot sets.

Text/References


AM 622 Simulation of Linear and Nonlinear Systems


Generation of random numbers, Pseudo random numbers, Test for random number simulation of probability distribution.

Discrete event simulation: simulation of single server and multiple server queuing system.

Concept of systems, Classification of systems, General Properties of Linear and nonlinear systems.

Periodic orbits, Poincare Bendixson criterion, limit cycle, bifurcation, Lyapunov Stability, basic stability and instability theorems, uniform stability, asymptotic stability, exponential stability

Text/References

AM 623 Machine Learning

Introduction - Well-posed learning problems, Designing a learning system, Perspectives and issues in machine learning

Concept learning and the general to specific ordering – Introduction, A concept learning task, Concept learning as search, Find-S: finding a maximally specific hypothesis, Version spaces and the candidate elimination algorithm, Remarks on version spaces and candidate elimination, Inductive bias

Decision Tree learning – Introduction, Decision tree representation, Appropriate problems for decision tree learning, The basic decision tree learning algorithm, Hypothesis space search in decision tree learning, Inductive bias in decision tree learning, Issues in decision tree learning

Evaluation Hypotheses – Motivation, Estimation hypothesis accuracy, Basics of sampling theory, A general approach for deriving confidence intervals, Difference in error of two hypotheses, Comparing learning algorithms

Bayesian learning – Introduction, Bayes theorem, Bayes theorem and concept learning, Maximum likelihood and least squared error hypotheses, Maximum likelihood hypotheses for predicting probabilities, Minimum description length principle, Bayes optimal classifier, Gibbs algorithm, Naïve Bayes classifier, An example learning to classify text, Bayesian belief networks

Computational learning theory – Introduction, Probability learning an approximately correct hypothesis, Sample complexity for Finite Hypothesis Space, Sample Complexity for infinite Hypothesis Spaces, The mistake bound model of learning - Instance-Based Learning

Introduction, k -Nearest Neighbour Learning, Locally Weighted Regression, Radial Basis Functions, Case-Based Reasoning, Remarks on Lazy and Eager Learning
Genetic Algorithms – Motivation, Genetic Algorithms, An illustrative Example, Hypothesis
Space Search, Genetic Programming, Models of Evolution and Learning, Parallelizing Genetic Algorithms


Analytical Learning - Introduction, Learning with Perfect Domain Theories: Prolog-EBG Remarks on Explanation-Based Learning, Explanation-Based Learning of Search Control Knowledge

Combining Inductive and Analytical Learning – Motivation, Inductive-Analytical Approaches to Learning, Using Prior Knowledge to Initialize the Hypothesis, Using Prior Knowledge to Alter the Search Objective, Using Prior Knowledge to Augment Search Operators, Reinforcement Learning – Introduction, the Learning Task, Q Learning, Non-Deterministic, Rewards and Actions, Temporal Difference Learning, Generalizing from Examples, Relationship to Dynamic Programming.

Text / References

1. Machine Learning – Tom M. Mitchell, - MGH
5. Chris Bishop, Neural Networks for Pattern Recognition, Oxford University Press, 1995

AM 624 Tensor Analysis and Engineering Applications


Text / References:

**AM 625 Digital Images Processing**


**Morphological image processing:** Dilation, Erosion, Opening, Closing, Applications to; Boundary extraction, Region filling, Extraction of connected components.


**Object recognition:** Decision-theoretic methods.

**Text / References**

    Woods, Steven L. Eddins, Gatesmark Publishing.
6. Pattern Recognition, Applications to Large Data-Set Problems, 1984, Sing-Tze Bow, Marcel
    Dekker.

**AM 626 Computational Heat and Mass Transfer**

**Philosophy of Computational Fluid Dynamics:** Introduction to CFD, CFD- a research tool,
CFD- a design tool, Applications and Advantages of CFD, The basic governing fluid flow
equations in differential form, Models of Fluid flow, Concept of Substantial derivative, Navier-
Stoke's model and Euler's model equations.

**Convective Heat Transfer:**
Introduction to convection, review of conservation equations - Forced convection in laminar
flow - Exact and approximate solutions of Boundary layer energy equation for plane isothermal
plate in longitudinal flow - problems. Forced convection heat transfer in laminar tube flow -
forced convection in turbulent flow – Internal Flows-Correlations-Problems. Approximate
analysis of laminar free convective heat transfer on a vertical plate-external flows-correlations-
problems.

**Convective Mass Transfer**
Definitions of concentration and velocities relevant to mass transfer, Fick's law, species
conservation equation in different forms. Steady state diffusion in dilute solutions in stationary
media, transient diffusion in dilute solutions in stationary media, one dimensional non dilute
diffusion in gases with one component stationary. Convective mass transfer - governing
equations-forced diffusion from flat plate-Dimension less correlation’s for mass transfer.
Simultaneous heat and mass transfer - analogy between heat, mass and momentum transfer

**Finite Element Method Technique:** Formulation Techniques: Methodology, Engineering
problems and governing differential equations, finite elements, Variational methods-potential
energy method, Raleigh Ritz method, strong and weak forms, Galerkin and weighted residual
methods, Piecewise Defined Shape functions, Essential and natural boundary conditions. One-
dimensional finite element methods: Bar elements. Element matrices, assembling of global
stiffness matrix, Application of boundary conditions, Quadratic Element, Implementation of the
FEM - The Solution Procedure.

Text / References


AM 627  Introduction to Non-Newtonian Fluids

**Governing Equations:** Introduction, Measure of Mechanical Interactions, Euler’s Laws of Motion, Stress and Couple Stress Vectors, Stress and Couple Stress Tensors, Cauchy’s Laws of Motion, Analysis of Stress, Energy Balance Equations, Entropy Inequality.

**Couple Stress Fluids:** Introduction, Constitutive Equations, Equations of Motion, Boundary Conditions, Steady Flow between Parallel Plates, Steady Dimensional Flow between Two Co-axial Cylinders, Poiseuille Flow through Circular Pipes, Creeping Flow Past a Sphere, Some Time- Dependent Flows, Hydromagnetic Channel Flows.


**Micropolar Fluids:** Introduction, Skew-symmetric of the Gyration Tensor and Micro Isotropy, Micropolar Fluids, Thermodynamics of Micropolar Fluids, Equations of Motion, Boundary and Initial Conditions, Two Limiting Cases, Steady Flow between Parallel Plates, Steady Couette Flow between Two Co-axial Cylinders, Pipe Poiseuille Flow, Micropolar Fluids with Stretch.

**Text / References**


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**AM 628 Computational Number Theory and Cryptography**


**Number Theory:**

**Divisibility:** Representations of Integers, Computer Operations with Integers, Complexity of Integer Operations, Divisibility, Prime Numbers, The Fundamental Theorem of Arithmetic,
Sieve of Eratosthenes, The Distribution of Primes, Greatest Common Divisor, Euclidean Algorithm, Mersenne Numbers, Fermat Numbers, Perfect numbers

**Congruence:** Congruences, Congruence Applications, Linear Congruences, The Chinese Remainder Theorem, Theorems of Fermat and Euler- Fermat, Wilson’s Theorem, Pseudo Primes, Carmichael Numbers, The Euler Phi-Function, The Sum and Number of Divisors, Quadratic Residue, Quadratic Reciprocity.

**Factorization and Primality Testing:** Complexity of Number Theoretic Algorithms, Fermat’s Factorization, Kraitchik’s Improvement, Pollard Rho Algorithm, Legendre and Jacobi Symbols, Computing Legendre symbols, Primitive Roots, Pseudo Primality Testing, Miller-Rabin Algorithm, Quadratic Reciprocity Law

**Finite fields:** Groups, Fields, Finite Fields, Arithmetic in Finite Field, Finding Multiplicative Inverses in finite fields, Binary Fields and their application in Cryptosystems, Primitive roots.


**Elliptic Curve Cryptography:** Introduction to Elliptic Curves, Geometry of Elliptic curves over Reals, Weierstrass Normal form, Point at infinity, Elliptic Curves over Finite fields, Group structure, Discrete Log problem for Elliptic curves, Factorization using Elliptic Curve, Advantage of Elliptic Curve Cryptography over other Public Key Cryptosystems.

**Text / References**

AM 629  Calculus of Variations and Integral Equations

Linear integral equations, Some basic identities, Initial value problems reduced to Volterra integral equations, Methods of successive substitution and successive approximation to solve Volterra integral equations of second kind, Iterated kernels and Neumann series for Volterra equations. Resolvent kernel as a series in, Laplace transforms method for a difference kernel, Solution of a Volterra integral equation of the first kind.


Green’s function, Use of method of variation of parameters to construct the Green’s function for a non-homogeneous linear second order boundary value problem, Basic four properties of the Green’s function, Orthogonal series representation of Green’s function, Alternate procedure for construction of the Green’s function by using its basic four properties. Reduction of a boundary value problem to a Fredholm integral equation with kernel as Green’s function. Hilbert-Schmidt theory for symmetric kernels.

Motivating problems of calculus of variations, Shortest distance, Minimum surface of revolution, Branchistochrone problem, Isoperimetric problem, Geodesic. Fundamental lemma of calculus of variations, Euler’s equation for one dependant function and its generalization to ‘n’ dependant functions and to higher order derivatives, Conditional extremum under geometric constraints and under integral constraints.

Text / References


**AM 630  Domain Decomposition Methods**


**Text / References**


**AM 631  Multigrid Methods**

Basic concepts, local and global processing, discretization, 1D model problem and its direct and iterative solution, convergence analysis, 2D model problem, classical relaxation methods, error-smoothing by relaxation, grid-refinement algorithm, two-grid and multigrid algorithm, Fourier analysis of convergence, ellipticity and $h$-ellipticity, nonlinear and anisotropic problems, advanced techniques, algebraic approach, applications.

**Text / References:**

**AM 632 Ballistics**

**Explosives:** Explosive compounds and explosive mixtures-classification of explosives: Measurement of various explosive parameters


**External Ballistics:** Projectile Aerodynamics: General introduction-yaw-The aerodynamic forces and moments acting on a projectile-linearised aerodynamics-centre of pressure and stability-Aerodynamic coefficients-Drag laws-Angular motion of projectiles-Gyroscopic stability-Yawing behaviour-The linearised theory of yawing motion-projectiles with slight configurational asymmetries-projectiles not obeying classical linear theory.

**Projectile Transitional Motion:** Motion in vacuum-Motion of point mass-Trajectory modelling-constant corrections to the plane-particle trajectory, biases-variable corrections to the plane-particle trajectory, dispersion-the effect of wind.

**Terminal Ballistics:** Kinetic Energy projectiles: Penetration into resisting medium-Empirical formulae for the prediction of penetration-Analytical models of failure modes-Numerical methods-plate charges.

**Design and Defeat of Armour:** Introduction –Mechanical property requirements-Armour material Characteristics –Armour structure-stress-strain relationship-Waves in rods-Defeat of armour-Failure
**Wound Ballistics:** Threshold velocity for penetration of skin, flesh, bones- Nature of wounds on entry, exit- Explosive wounds- Evaluation of injuries caused due to shot gun, rifle, hand guns and country made firearms- Method of measurement of wound ballistic parameters- post mortem and ante-mortem firearm injuries.

**Text / References:**

3. Interior Ballistics, 1951, HMSO publication
4. Terminal Ballistics- A Text Book and atlas of gunshot wounds, Malcom J Dodd, CRC press, Taylor & Francis publications
5. Firearms in criminal investigation and trials, Dr. BR Sharma, 3rd Edition, Universal Law publishing Co. Pvt Ltd.

**AM 633        Bio-Mechanics**


Introduction - Continuum Approach - Blood Flow in Heart, Lung, Arteries and Veins: Introduction - The geometry of the circulation system - Field equations and Boundary conditions, Pulsatile Flow in Arteries - Progressive

The Rheological Properties of Blood Bio-fluid dynamics concept, Transport phenomena and the cardiovascular system.

Text / References:

2. Bio-fluid Dynamics Taylor and Francis: Clement Kluinstreuer
3. Frontier in Mathematical Biology: S.A.Levin
4. Biomathematics: Ricciardi
M. Tech. (Sensor Technology)

**Brief Description:** Sensors is one area of science and technology which has witnessed a paradigm shift from conventional bulky components to extremely miniaturized and smart devices. The technological advancements in the area of Electronics, Electrical engineering, along with the advancements in basic sciences in the areas of microfluidics, nanotechnology, biotechnology and photonics have been responsible for this concomitant growth in the development of current sensors. An interdisciplinary approach which will involve materials engineering, electronics and electrical engineering along with a flavor of chemical engineering and bio-engineering, is now required to understand such sensors. The objective is to make them faster, smaller, smarter and selective. This domain has, hence, seen large number of Industries, Institutes and small entrepreneur companies coming up in recent times. The programme intends to educate and train bright fresh students in the field of sensor technology to carry out challenging responsibilities in their future career, and meet the current challenges and foster the opportunities which the globe has to offer. This is an interdisciplinary course concerning broadly Electronics, Instrumentation, Sensors, Optics, Electromagnetism, Nanotechnology and Advanced Materials.

**Stakeholders:**

(i) Sponsored candidates from Army, Navy, Air Force, DRDO Laboratories, Public Sector Undertakings and other departments
Graduates in the relevant field of science/technology from recognized Universities across the country.

**Eligibility:**
The candidate should possess Master degree or equivalent in Physics, Applied Physics, Electronic Science, Photonics **OR** B. E./ B. Tech/ BSc.(Engg.) or equivalent in Electronics Engg./ Electrical Engg./ Electrical & Electronics Engg./ Electronics & (Tele)Communication Engg./ Electrical Communication Engg./ Electronics & Instrumentation Engg./ Instrumentation Engg./ Optics & Optoelectronics.

**Organization:** The M. Tech. programme is of four-semester duration. In each of the first two semesters there are six courses and practical each. There would be continuous evaluations through the semester and a final semester examination for every course. Half yearly evaluation of the project takes place at the end of the third semester. At the end of the final semester the student submits a thesis and makes a presentation about the project, which is evaluated by the Internal and External examiners. Course syllabus has been updated periodically to keep pace with the contemporary technological advancement.

### Semester I

<table>
<thead>
<tr>
<th>SI No</th>
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<th>Course Name</th>
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<tr>
<td>1</td>
<td>AP 601</td>
<td>Principles of Sensing: Material Science and Physics</td>
<td>L:3</td>
<td>4</td>
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<tr>
<td>2</td>
<td>AP 603</td>
<td>Sensor Data Acquisition and Signal Conditioning</td>
<td>L:3</td>
<td>4</td>
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<tr>
<td>3</td>
<td>AP 604</td>
<td>Fabrication Technology and Packaging of MEMS Systems</td>
<td>L:3</td>
<td>4</td>
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<tr>
<td>4</td>
<td>AP 614</td>
<td>Fibers Optic Sensors</td>
<td>L:3</td>
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<tr>
<td>5</td>
<td>AP 602</td>
<td>Sensor Technology Laboratory-I</td>
<td>L:4</td>
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<td>6</td>
<td>AM 602</td>
<td>Mathematics for Engineers</td>
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**TOTAL**

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<tr>
<td>2</td>
<td>AP 608</td>
<td>Machine learning techniques for</td>
<td>L:3</td>
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<table>
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<td>Sensor Technology Laboratory-II</td>
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<td>Elective I</td>
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<td>Elective – II</td>
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**Semester III:**

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**Semester IV:**

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* 1 Credit in Theory/Tutorial means 1 contact hour and 1 credit practice/Project Thesis means 2 contact hours in a week.

**Contact Hours/ week

**List of Electives**

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<th>Course Code</th>
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<td>AP 610</td>
<td>Programming embedded system for sensors</td>
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<td>3</td>
<td>AP 611</td>
<td>Remote sensing and sensors</td>
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<td>Control Systems</td>
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<tr>
<td>5</td>
<td>AP 615</td>
<td>Sensors for Defence</td>
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<tr>
<td>6</td>
<td>AP 612</td>
<td>Nanotechnology for Advanced Sensors</td>
</tr>
<tr>
<td>7</td>
<td>AP 613</td>
<td>Energy Conversion Systems</td>
</tr>
</tbody>
</table>
1. **Introduction**: Sensor fundamentals, Application considerations, Definition of Sensors; sensors, signals and systems, Sensor classification

2. **Physical Aspects in Sensing**: Input output relationship, interfering and modifying inputs, compensation techniques, static and dynamic characteristics, impedance, reliability

3. **Material Aspects in Sensing**: Structure, dynamics of solids and mechanics of solids:
   a. **Metals**: Properties of metals; structural, electrical, mechanical, thermal, Applications; thermal expansion devices, shape memory alloys, thermocouples, ohmic and schottky contacts, thermal conductivity, sensors based on these properties
   b. **Semiconductors**: Intrinsic and extrinsic semiconductors, direct-indirect band gap materials, metal semiconductor junctions, gas sensitive resistors, MOS sensors, peizoresistance, peizoresistive sensors
   c. **Dielectric Materials**: Polarization, internal fields, frequency response, piezoelectric, pyroelectric, ferroelectric materials
   d. **Magnetic and superconducting materials**: paramagnetic, ferromagnetic, antiferromagnetic, ferromagnetic materials, superconductors, applications of magnetic materials and sensors, SQUID

4. **Sensor Characterization**: Study of Static and Dynamic Characteristics, Sensor reliability, aging test, failure mechanisms and their evaluation and stability study.

5. **Measurement, Instrumentation and Calibration**: Introduction, classification of transducers, Errors in measurement, statistical analysis of random errors, calibration and standards, Noise


7. **Velocity and Acceleration sensors**: Electromagnetic velocity sensor, Doppler with sound or light or other EM wave, Accelerometer characteristics, capacitive, piezo-resistive, piezoelectric accelerometer, thermal accelerometer, rotor, monolithic and optical gyroscopes and mechanical gyroscopes.

8. **Strain, Force, Torque and Pressure sensors**: Strain and stress, strain gages, strain gage beam force sensor, piezoelectric force sensor, load cell, torque sensor, units of pressure-diaphragm, bellows, thin plates, piezo-resistive and capacitive pressure sensor, optoelectronic pressure sensors, vacuum sensors- pirani gauge, ionization gage, gas drag gauge.

9. **Magnetic Sensors**: Inductive and magnetic sensor, LVDT, RVDT, eddy current, transverse inductive, Hall effect, magnetoresistive, magnetostrictive sensors

10. **Position, Direction, Displacement and Level sensors**: Potentiometric and capacitive sensors. Fiber optic liquid level sensing, Fabry Perot sensor, ultrasonic sensor, capacitive liquid level sensor.

**Texts/References**
4. Transducers and Instrumentation, DVS Murty, 2nd Edition 2013
5. Sensor Materials by P T Moseley and A J Crocker

**AP602 Sensor Technology Laboratory-I 3-1-100**

1. Experiments using Piezoelectric sensor
2. Experiments using Strain gauge sensor
3. Experiments using Bourdon Gauge sensor
4. Experiments using Temperature Sensor consisting of thermocouple, thermistor and RTD
5. Experiments using Resistive, Inductive, capacitive measurement
6. Experiments using Automotive sensor (Oxygen sensor, coolant temperature sensor, level sensor, humidity sensor, sound sensor, tilt sensor, UV sensor, flame sensor, opto sensor, motion sensor, light intensity measurement sensor)
7. Study of solar power
8. Use of PLC Trainer & Application
9. Use of SCADA for supervisory control
11. Experiments using Flow measurement systems
12. Mini projects

**AP 603 Sensor Data Acquisition and Signal Conditioning 3-1-100**

1. **Fundamentals of Data Acquisition:** Essentials of computer interfacing –configuration and structure -interface systems-interface bus.
2. **Signal conditioning:** Types of signal conditioning, classes of signal conditioning, field wiring and signal measurement, noise and interference, minimising noise, shielded and twisted-pair cable
3. **Data Acquisition boards:** A/D Boards, Single ended vs differential signals, Resolution, dynamic range and accuracy of A/D boards, Sampling rate and the Nyquist theorem, Sampling techniques, D/A Boards.
4. **Serial data communication:** RS232 and RS485 interface standards.
5. **Stand-alone Loggers/controllers:** Methods of operation, stand-alone loggers/controller hardware, communications hardware interface, stand-alone loggers/controller firmware and software design, Data acquisition using PCMCIA cards.
7. **Ethernet & LAN systems:** Physical layer, Ethernet design rules.
8. **Universal Serial Bus:** Overall structure, Physical layer, datalink layer, user layer.
9. Virtual instrumentation: Virtual instrument and traditional instrument, Hardware and software for virtual instrumentation, Virtual instrumentation for test, control, and design, Graphical system design, Graphical and textual programming, Data acquisition with PCI, PCI express and PXI bus interfaces.

10. Lock in amplifier, box car averaging, time resolved data analysis, pulse width modulation, data structure.

Reference Books:

AP604 Fabrication Technology and Packaging of MEMS Systems

3. Etching and Lithographic techniques: Bulk etching and RIE, Top down approach to nanolithography-Immersion lithography- Optical lithography, UV photolithography- Phase lithography- Including Plasma X-ray sources- E-Beam Lithography- Focused Ion beam lithography, LIGA, Soft lithography for nanofilms and nanoscale patterning.
4. MEMS actuators: Electrostatic actuators, Thermal actuators, Piezoelectric Actuators, Magnetic Actuators
5. Structural MEMS: Static Bending of thin plates, mechanical vibration, thermomechanics, fracture mechanics, thin film mechanics, Mechanical Testing of MEMS and NEMS
6. Packaging: Foundation of MEMS packaging, Types of Packaging: metal, ceramic, thin film multilayer packaging, plastic packaging, Chip scale packaging, Ball grid array, Multichip packaging, COF/HDI technology, Packaging in high endurance applications
7. Case Studies: Thin films for microelectronics, optical coatings, photodetectors, smart sensors, Pressure, strain, acceleration and vibration sensors, and micro fluidics: chemical and bio medical sensors, Examples aeronautics (control surfaces) aerospace, automobiles engineering, tire pressure sensor, structural health monitoring, biomedical engineering and intelligent consumer product design.
8. Nanoimprint technology, Dip pen lithography, Polymer MEMS.

References:

10. Microelectronic processing, Stephan Campbey

AP 614  Fiber Optic Sensors

1. **Optical Fibers:** Light Propagation in Optical Fibers, Optical fiber Modes and Configurations, Mode Theory for Circular waveguides, SM and GI Fibers, Fiber Materials, PhC fibers, Fiber fabrication, Mechanical Property of Fiber and Fiber Optics Cables.
3. **Power Launching and Coupling:** Source to Fiber launching and Launching Schemes for Coupling Improvements. Fiber to Fiber joints, Laser coupling to SM fiber, Fiber splicing, Optical Fiber Connector.
4. **Fiber Amplifier:** Optical Amplification in rare-earth doped fibers, Types of Fiber Amplifiers, EDFA, Amplifier Noise, Optical SNR, System Application, Raman Amplifiers, Wideband Optical Amplifier.
7. Microspheres (WGM), evanescent modes in fiber optics, SPR mode
8. Fiber Optics and waveguides, concentrators, coatings for thermal absorption, electro-optic and acousto-optic modulators, interferometric fiber optic modulators.

**Text/References**

**AP 606 Sensors, Transducers & Actuators** 3-1-100

1. **Properties and components of transducers:** Electric charges, fields and potentials, capacitance, induction resistance, Measurement of current, voltage, resistance, impedance, phase angle, frequency measurement, time interval measurement, resistive, inductive, Proximity and capacitive transducers
2. **Mechanical transducers:** Mechanical transducers for Temperature measurement, pressure measurement, force measurement, torque measurement, density measurement, liquid level measurement, viscosity measurement, flow measurement
3. **Thermal properties and transducers:** pyroelectric effect, Seebeck and Peltier Effect, thermal expansion, heat capacity, heat transfer
4. **Optical properties, components, sources and detectors:** Radiometry, Photometry, windows, mirrors, lenses, Fresnel lenses Lasers based sensors: gas sensing— Basic Principle, Thermal detectors, Photo multipliers, photoconductive detectors, Photo diodes, Avalanche photodiodes, CCDs, Image Intensifiers, Solar Cells, photon counting techniques to count low photon flux,
5. **Chemical Properties for sensors:** Electrochemical properties: Debye-Huckel ion transport theory, basics of electrode potential, measurement of pH, potentiometric properties, amperometric properties, catalysis, Chemical spectrometry, Biosensors, Explosive class sensors, SERS, Mass spectroscopy, Ion mobility sensor, Combustible gas detection, photoionization detectors for detecting VOC.
6. **Actuation and actuators:** Active elements: Piezoelectric, magnetostrictive, photoelectric, thermolectric, actuator principles, actuators as system components, actuators in mechatronics and adaptronics, intelligent and self sensing actuators, design of actuators, Electromagnetic actuators (types of motors), PZT actuators, Smart actuators, multilayer actuator.

**References:**

**AP 607 Sensor Technology Laboratory-II** 3-1-100
(Fabrication, Testing and characterization of sensors)
1. Interfacing LCD and LED using Arduino/ Labview
2. Interfacing a Gas Sensor using Arduino/ Labview
3. Interfacing a Humidity Sensor using Arduino/ Labview
4. Interfacing a proximity detector using Arduino/ Labview
5. Stepper motor control using Arduino/ Labview
6. Thin film deposition
7. Soft Lithography
8. Optical Fiber Sensors
9. Interferometric Sensing
10. Study of Hall Effect
11. Study of Material Crystallinity using X-ray diffraction
12. Microscopic Study of materials

AP 608 Machine Learning Techniques for Sensor Data Analytics 3-1-100

1. Introduction: Role of Machine learning techniques in sensor data analytics, Learning from data, Machine learning examples, Simple model for Machine Learning, Types of learning,
2. Theory of generalization: Feasibility of learning, Hoeffding inequality, complexity of hypothesis set, growth function, VC dimension, Training versus testing
4. Feature extraction and dimensionality reduction: Curse of dimensionality, Principal Component analysis, Linear discriminant analysis
5. Unsupervised Learning: Clustering, K-means clustering, Agglomerative hierarchical clustering
6. Machine Learning issues: Overfitting, Validation, Occam’s razor, Sampling bias, Data Snooping

Reference:

v. Y. S. Abu-Mostafa, M. Magdon-Ismail, and Hsuan-Tien Lin, Learning from data, AMLbook.com
vi. Y. S. Abu-Mostafa, Learning from data, Caltech lectures (online).
vii. S. Sarkar, Introduction to Machine Learning, NPTEL course, IIT Kharagpur (online).
Background: Wireless Sensor networks (WSN) is an emerging technology and have great potential to be employed in critical situations like battlefields and commercial applications such as building, traffic surveillance, habitat monitoring and smart homes and many more scenarios. One of the major challenges wireless sensor networks face today is security. While the deployment of sensor nodes in an unattended environment makes the networks vulnerable to a variety of potential attacks, the inherent power and memory limitations of sensor nodes makes conventional security solutions unfeasible. The sensing technology combined with processing power and wireless communication makes it profitable for being exploited in great quantity in future. The wireless communication technology also acquires various types of security threats.

Objective: To meet End-User, Network-Administrator and Network-Designer perspectives

Subject Contents:

1. Introduction, WSN Resources & constraints, Relevance to Cyber-Physical Systems, Relevance to Network Centric Operations, Relevance to Data Stream Management Systems, Relevance to the increasing demand of high performance computations, SCADA, battle sensor

2. WSN Network Architecture, MAC Layer protocols, Naming and Addressing, Synchronization, Location & positioning, Topology control, Connected Dominating Sets, Routing Protocols

3. Operating Systems, Data-Centric & Content-based networking, Data-Centric querying, Data Fusion, Role of Clouds Services, Challenges

4. Vulnerabilities, threats, attacks & safeguards in WSN

Text Book:


References: Refer CE 691: References Research Papers from 1 to 5.

Tutorials:

u. Routing techniques: Overview of Proactive and reactive routing protocols, significance of a hop in adhoc networks

v. Flooding, Gossiping, Zonal Routing Protocols ZRP, Hybrid Routing, TTL significance with respect to routing protocols

w. Impact of hardware and software on Battery Performances/Utilisation

x. IEEE 802.15.4: A study, Features, Types of Devices FFD (PAN coordinators, Coordinators), RFDs Reduced Function Devices, Network Setup process & parameters in Consideration, Programming Strategies to suit the standards, MAC and PHY structure
y. Demo 1: Controlling DIOs. Demonstrate the usage of DIO using LEDs. Learning how to handle data sampling period.
z. Demo 2. Reading data from a single IoT device. Interpretation of data.
aa. Demo 3: Create a broadcast wireless network and capture the traffic generated by the participating nodes.
ce. Understanding MBR & LBR (MAC Based Routing and LBR Level-Based Routing)
dd. Understanding exiting API, Libraries & its association with pre-existing demonstration codes.

AP 609 Advanced Sensors 3-1-100

3. Sensors in Biomedical Applications: Physical Sensors in Biomedicine, Electrochemical Sensors, EEG, EMG & ECG, Detectors in Radiology, Sound in Medicine, Amperometric Biosensor, Potentiometric Biosensor, Optical Biosensor, Immunosensors, Hybrid Biosensor, In Vivo Biosensor and Commercial Biosensor
5. Heptics sensors, Sensors in missiles, safety and ARMY, electronic nose, any other contemporary topic
8. Smart Sensors: Shape memory alloys, Rheological materials, Polymers and composites
9. LIDAR, sensor for dynamic system digital image correlation

References:
6. Automotive Sensors, BOSCH, 2002
Sensors for Defence

3-1-100

(Micro) µ radar for personnel use and for unmanned miniaturized vehicles, SAR, GPR principles.

Night vision devices, Portable and /or wearable inertial and position, motion and acceleration sensors.

Miniaturised and highly sensitive vision camera system, CBW sensors (remote operation or hand-held).

Health monitoring sensors (embedded, continuous or intelligent), Condition monitoring of equipment and munitions.

Drug and nutraceutical (nutrition) delivery sensors and systems.

Sonar sensors

Ultrasonic sensors, measurements for anemometers, tank or channel level, and speed through air or water, Robot sonars, counter measures, active sonar systems, sonars for military applications, antisubmarine warfare, submarine navigation, intercept sonar.

Extra Low Frequency Electromagnetic (ELFE) sensors (sensors for 3-30 Hz, requirements of such sensors, submarine applications, underwater communications, other applications such as pipeline gauges, ham radio, night vision), Star Sensors

References

2. Inputs from DRDO scientists working in the relevant field.
**Programming embedded systems for sensors**

1-2-100

**Programmers model for computers:** computer architectures

**Programming:** C and Assembly, Programming Style, Declarations and Expressions, Arrays, Qualifiers and Reading Numbers, Decision and Control Statements, Programming Process, More Control Statements, Variable Scope and Functions, C Preprocessor, Advanced Types, Simple Pointers, Debugging and Optimization, In-line Assembly, Handling bits & bytes, Handling I/O, Hardware and Software Interrupts, Timers

2. **C Programming Tool chain in Linux:** C preprocessor, Stages of Compilation, Introduction to GCC, Debugging with GDB, The Make utility, GNU Configure and Build System, GNU Binary utilities, Profiling, using gprof, Memory Leak Detection with valgrind - Introduction to GNU C Library

3. **Handling challenges specific to embedded systems:** Object oriented programming with C, Header files for Project and Port, Examples. Meeting Real time constraints, Creating hardware delays, Need for timeout mechanism, Creating loop timeouts, Creating hardware timeouts. Creating embedded operating system, Basis of a simple embedded OS, Introduction to sEOS, Using Timer 0 and Timer 1, Portability issue


Embedded C lab
- Programming using Ports
- Delay generation using Timer
- Programming Interrupts
- Implementation of standard UART communication
- Creating Simple Embedded OS [sEOS]
- EOS based on Timers
- Time triggered architecture programming

Linux Lab
- Basic commands
- File Handling Using SHELL Scripting
- Print the Environmental variables in Linux using C
- Create process in Linux using C

**Remote sensing and sensors**

1-2-100

1. Basics of remote sensing

2. **RF Sensors:** Microwave Antenna-Introduction, types of Antenna, fundamental parameters of antennas, radiation mechanism, Fresnel and Fraunhoffer regions. Antenna for communication and Antenna for sensing, radiometer and radar

3. **Applications of Radar:** Automotive, remote sensing, agriculture, medicine, detection of buried objects, NDT, defense factors affecting the performance of RADAR, RADAR transmitters, Receivers
4. **Radiometers**: Radiative transfer theory, SMMR, Types of radiometers - and Bolometers, Applications in automotive, agriculture, medicine, weather forecasting

5. **Microwave power Sensors**: Diode Sensors: Diode detector principles, dynamic range average power sensors, signal waveform effects on the measurement uncertainty of diode sensors. Thermocouple Sensors: Principles of Thermocouple sensor, power meters for thermocouple sensors

6. **RFID Sensors**: Introduction, Components of RFID systems, hardware and software components, RFID standards, RFID applications.

7. **THz Sensor**: THz Technology- An Overview, THZ Rays sensing and imaging

References:


e. Terahertz Sensing Technology Volume 1: Electronic Devices and Advanced Systems Technology Edited by: Dwight L Woolard (US Army Research Laboratory, USA), William R Loerop (US Army Soldier Biological and Chemical Command, USA), Michael S Shur (Rensselaer Polytechnic Institute, USA)

**AP 605 Control Systems**

3-1-100

a. **Introduction**: Basic Concepts, Classification, Effect of feedback on Control System performance, Examples of control systems, Introduction to MATLAB/SIMULINK for control system design and simulation.

b. **Mathematical modelling of physical systems**: Examples of modelling different systems (e.g. electrical, mechanical, chemical, biological etc.), Linear and nonlinear systems, Transfer function representation, Concepts of pole & zero, Block diagram algebra.

c. **Stability**: Concept and definitions, stability analysis using Routh-Hurwitz’s criterion, Kharotonov’s stability criteria, Introduction to root locus method.

d. **Time response analysis**: Type and order of Control system, Standard tests signals, Time Response of first and second order systems, Steady state errors -Static error coefficients, Time Domain Specifications of Second Order System.

e. **Frequency response analysis**: Steady state response of a system for sinusoidal input; Relation between time & frequency response, Frequency response specifications. Bode plots and stability analysis with Bode plots, Nyquist stability criterion.

f. **Control system design**: Basic control actions, On-off controllers, PID Controller, Ziegler – Nichols Method for PID controller tuning, Lead and lag compensation.

g. **Introduction to state space analysis**: State space representation, state space model from transfer function, state equation-solution, transition matrix, stability analysis in state space, concepts of controllability and observability, introduction to state feedback control.

**Corresponding Lab / Tutorial Session:**
1. Design and simulation of PID controller for a given plant.
2. Design and simulation of lead/lag/lead-lag compensators.
3. Design and simulation of state feedback control.
4. Implementation of controller on hardware platform.

Reference Books:


AP 612 Nanotechnology for advanced sensing 3-1-100

1. Implications of nano size on physical and chemical properties: Density of States, 2D, 1D, 0D, Quantum size effect, large surface to volume ratio, surface functionalization, tenability of properties, Physical Chemistry of solid surfaces, crystal structures, surface energy, chemical potential, Fundamentals of nucleation and growth, Electrostatic Stabilization Surface charge density, Electric potential at the proximity of solid surface, Van der Waals attraction potential, Interactions between two particles: DLVO theory, Solvent and polymer, Interactions between polymer layers, Mixed steric and electric interactions


3. Characterization and properties of nanomaterials: Structural Characterization, X-ray diffraction (XRD), Small angle X-ray scattering (SAXS), Scanning electron microscopy (SEM), Transmission electron microscopy (TEM), Scanning probe microscopy (SPM), Surface plasmon resonance, Quantum size effects, Surface scattering, Change of electronic structure, Quantum transport, Effect of microstructure, Ferroelectrics and dielectrics, Superparamagnetism.


Corresponding Lab Session:
Lab demos in the form of synthesis, characterization of metal and oxide nanoparticles.

Text/References

286
2. Introduction to Nanotechnology, Charles Poole Jr and Frank J Owens, Wiley India, New Delhi (2006)

**AP 613 Energy Conversion systems 3-1-100**

1. **General Energy Sources:** Classification of Energy Sources, Principle fuels for energy conversion: Fossil fuels, Nuclear fuels. Conventional & Renewable Energy Energy Sources: prospecting, extraction and resource assessment and their peculiar characteristics. Direct use of primary energy sources, Conversion of primary into secondary energy sources such as Electricity, Hydrogen, Nuclear energy. Energy Conversion through fission and fusion, Nuclear power generation.


3. **Solar Energy converters:** Solar spectrum on the earth surface and estimation of energy received per unit area on the earth surface at different location in the country. Concept of Air Mass Zero Condition(A.M.O.) Basic principle of conversion of solar energy in to thermal energy. Working principle of room heaters and drying systems using solar energy. Photovoltaic effect in p-n junction, and solar cells. Hetero junction, interface, and thin film solar cells. Ideal conversion efficiency. Large area Solar panels for electric power generation, power load, and distribution system. Units of electric power. Power storage in batteries.


5. **Supercapacitors:** Basic principle, energy storage mechanism, benefits and limitations of supercapacitors, types of supercapacitors, hybrid capacitors, batteries, hydrogen storage devices

**References**

4. Direct Energy Conversion : W.R.Corliss
M. Tech in Lasers and Electro-optics

Brief Description: One of the greatest scientific discoveries of the twentieth century that has led to technological advancement touching all aspects of human life is the LASER. Applications of lasers range from medical applications, communications, and industrial applications to military applications. An understanding of laser technology is essential for an engineer working in many of the present day cutting edge technologies. The aim of this programme is to train the students in the field of lasers, fiber optics, electro-optics and photonics that would enable them to meet the challenges in this rapidly developing field.

Stakeholders:

(iii) Sponsored candidates from Army, Navy, Air Force, DRDO Laboratories, Public Sector Undertakings and other departments

(iv) Graduates in the relevant field of science/technology from recognized Universities across the country.

Eligibility:
The candidate should possess Master degree or equivalent in Physics, Applied Physics, Electronic Science, Photonics OR B. E./ B. Tech/ BSc.(Engg.) or equivalent in Electronics Engg./ Electrical Engg./ Electrical & Electronics Engg./ Electronics & (Tele) Communication Engg./ Electrical Communication Engg./ Electronics & Instrumentation Engg./ Instrumentation Engg./ Optics & Optoelectronics.

**Organization:** The M. Tech. programme is of four-semester duration. In each of the first two semesters there are five theory courses and one laboratory course. There will be three continuous evaluation examinations and a final semester examination for every course. Half yearly evaluation of the project takes place at the end of the third semester. At the end of the final semester, the student submits a dissertation and makes a presentation about the work carried out by him/her on the project, which is evaluated by the Internal and External examiners. Course syllabus is updated periodically to keep pace with the contemporary technological advancement.

### Semester I

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* 1 Credit in Theory/Tutorial means 1 contact hour and 1 credit practice/Project Thesis means 2 contact hours in a week.

**Contact Hours/week**

List of Electives

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</table>

AP 631 Applied Optics

1. **Wave optics**: Basic postulates of wave optics, Monochromatic waves, plane waves, spherical waves, paraxial waves, Interference of waves, Multiwave interference, Polychromatic waves, Group velocity and Pulse Dispersion.

2. **Gaussian and special beams**: Complex amplitude of Gaussian beam, Parameters of Gaussian beam, transmission of Gaussian beams through optical components, Hermite-Gaussian beam.

3. **Fourier Optics**: Impulse response and transfer function of free space, Fourier transform using a lens, Fraunhofer and Fresnel diffraction, Off-axis and On-axis Fourier transform holography.

4. **Electromagnetic fields**: Wave equation, Plane waves, Reflection and Refraction of plane waves, Fresnel Formulae, Wave propagation in stratified medium.

6. **Basic optical components and Devices**: Polarisers, Quarter, Half, and Full waveplates, Beam splitters: polarizing and non-polarizing, wavelength filters, dichroic mirrors, Lenses.

**Text**


**References**

2. E. Hecht, Optics, Pearson Education India, 2012

**AP632 Lasers & Optical Electronics**

1. **Light-matter interaction**: Interaction of radiation with atomic systems, Einstein’s coefficients, spontaneous emission, stimulated emission, Linewidth of the laser, line broadening
2. **Laser Amplifiers**: Laser Amplifier, Amplifier power source, Nonlinearity & gain saturation, Amplifier noise
3. **Resonator Optics**: Planar mirror & spherical mirror resonators; stability condition.
5. **Anisotropic media**: Review of propagation of Electromagnetic waves in Uniaxial and biaxial crystals, the dielectric constant tensor and the ‘index ellipsoid’.
6. **Electro-optics**: Basic principles: Pockel and Kerr effects, Electro-optic devices: modulators, switches, and scanners, E.O. effect in liquid crystals; LCDs and SLMs, Applications.
7. **Acousto-optics**: Strain waves in solids and liquids, the strain-optic tensor; theory of Raman-Nath and Bragg diffraction; small-angle and large-angle Bragg diffraction. Accousto-optic devices: Modulators, deflectors, scanners, interconnections, and acousto-optic tunable filters.
Text


References


AP633 Semiconductor Photonic Devices

6. Photodetectors: Types of photodetectors, Photoconductors, PMT, Junction photodiode, PIN photodiode and APD, Quantum Well IR Detectors, High Speed Measurements, Detectors for long wavelength operation, Wavelength selective detection, Coherent detection. CCDs and PICs.

Text:


Reference
1. **Formation and analysis of optical waveguides**: Introduction to optical waveguides. Differences between optical and microwave waveguides, Planar and channel waveguides. General characteristics of guided waves, Formation of optical waveguides on LiNbO3, GaAs, InP, Si substrates. Electromagnetic analysis of modes in optical waveguides; The asymmetric planar waveguide, TE and TM modes in planar waveguides, Rectangular and channel waveguides; modal solutions using the effective index and perturbation methods.

2. **Guided-wave interactions**: Coupled mode analysis of coupled waveguide structures., Examples of coupled mode analysis – the grating reflection filter, and the directional coupler.


4. **Silicon-on-Insulator (SOI) Photonics**: Introduction, Silicon-on-Insulator waveguides, Effective Index Method of Analysis, Large Single-mode Rib Waveguides, Refractive Index and Loss Coefficient in Optical Waveguides, Coupling to the Optical Circuit; Grating Couplers, Butt Coupling and End-fire Coupling. Optical Modulation Mechanisms in Silicon. Fabrication of Silicon Waveguide Devices.

5. **Photonic Devices**: Optical Phase Modulators and Variable Optical Attenuators, Mach–Zehnder Interferometer, Waveguide Bend, Waveguide-to-Waveguide Coupler, Arrayed Waveguide Grating (AWG), Waveguide Couplers for Small-dimension Waveguides, Advantage and Disadvantage of Silicon Photonics.

6. **Silicon Light-emitting Devices**: Erbium Doping, Low-dimensional Structures, Dislocation-engineered Emitters, Raman Excitation.

**Text/References:**


AP 636 Laser Systems and Applications

2. **Laser Metrology:** Laser for measurement of distance, length, velocity, acceleration; rotation sensing; RLG and FOG.
3. **Military Applications:** Low power laser applications including Laser Range finders-LRF(DPSSL, Eye Safe & High PRF) & Laser Target Designators; Laser based EO CM: Dazzlers, Laser Warning receivers, Infrared countermeasures, Laser DIRCM; Laser Guidance; Laser based navigation; Laser based imaging; Laser based remote sensing: Laser radar, laser radar seekers, laser bathmetry, obstacle avoidance, proximity sensors, Laser Fuze, detection of chemical, biological & explosive materials; identification of friend or foe(IFF); Multifunction laser systems.
4. **Laser Spectroscopy:** IR absorption Spectroscopy, Laser Raman spectroscopy, Laser induced breakdown spectroscopy(LIBS), laser induced fluorescence(LIF), Tunable diode laser spectroscopy (TDLS), Terahertz spectroscopy, Photoacoustic spectroscopy, Instrumentation in laser spectroscopy, Isotope Separation & Enrichment.
6. **Industrial Application of Laser:** Laser cutting, Laser welding, Laser drilling, Laser marking,, Photolithography, Laser based unmanned ground vehicles
7. **Commercial Applications:** Video Discs, Optical Data storage, Laser printer, Barcode readers etc..
8. **Holography:** Holographic interferometry and applications; Holography for non – destructive testing – Holographic components

**Text/References:**

AP 637  High Power Lasers

1. **Introduction to Directed Energy Applications**: Historical development & military utility; Types of DEWs (Laser based & Microwave based), Elements of a Laser DEW system, Technology Development: History and Status, Types of DEW Systems (Laser based, Microwave based etc), Potential applications of HPL & HPM based DEWs, Benefits of laser, laser technology for Novel systems, laser system requirements for Military applications; Technology Advances: Relevance to India; Opportunities and Priorities for India, national/international scenario of HPL technology.


4. **Beam Director Technology**: Design considerations for beam director, threat alerting system, target acquisition & tracking system, laser beam pointing, target sightline stabilization, system processor & boresight functions, HPL beam control, battle damage assessment.


7. **Safety aspects of laser & legislation**: Introduction: Effective laser safety, laser safety standards; hazard classification of lasers, maximum permissible exposure (MPE), hazard distances, zones, calculation of NOHD; Potential hazard to personnel: eye anatomy & hazards, hazards to skin, other potential hazards(non-beam hazards; common causes of laser incidents; safety operating guidelines/procedures; field testing & planning, range laser safety officer; Legislation: Protocol IV.

**Text/References:**

**Text/References:**


**Computational Photonics**

1. **Mode Solver Method**: Theory of fully vectorial mode solvers in 2D and 3D structures, low-index polymer waveguides, high-index silicon (SOI) and GaAs/AlGaAs waveguides, single-mode and multi-mode optical fibers, as well as photonic crystal fibers (PCFs), buried, etched (rib, ridge), and diffused geometries commonly used in opto-electronics slot waveguides, slanted-wall and graded structures, plasmonic and microwave waveguides, optically active and magneto-optic waveguides.

2. **Beam Propagation Method**: Theory and working of beam propagation method, Tutorials on MMI couplers, optical gratings, co-directional couplers or polarization converters.

3. **FTDT Method**: Theory and working of FTDT method, Tutorials on photonics band gap simulation: 2D and 3D of different crystal lattices.

4. **Nanodesign**: Mask designing for nanofabrication of different device geometry.

**Software Tool**: Suitable Commercial software tools would be used.

1. **AP 639** Computational Photonics

2. **AP 640** Nanophotonics

1. **Metamaterial**: Definition, Negative refractive Index materials, Metamaterials as perfect lens and cloaking objects. Geometries of metamaterials.

2. **Plasmonics**: Evanescent waves, Surface Plasmon dispersion equations, resonance, excitation of surface plasmons, surface Plasmon properties, SPR spectroscopy, Applications of Plasmonics.

3. **Photonic crystals**: Photonics Band-Gap: Introduction to Photonics crystal, Photonic Band Structures, One, two and three dimensional photonic crystals, Photonic crystal fibers, Applications of Photonic crystals.


5. **Fabrication techniques**: Various top-down, bottom-up fabrication techniques.

AP 641 Nonlinear Optics

1. **Nonlinear optics basics:** Simple Harmonic Oscillator model, Anharmonic oscillator model, Nonlinear polarization, Nonlinear wave equation, Nonlinear susceptibilities and mixing coefficients.

2. **Second order nonlinear effects:** Second harmonic generation, Phase matching condition, Various phase matching techniques, Characterization of second order nonlinear optical materials, Periodically poled materials and their applications in nonlinear optical devices. Sum and difference frequency generation, Optical parametric amplification (OPA) and oscillation (OPO), Analysis of OPA and OPO; practical device configurations and applications.

3. **Third order and Higher order effects:** Third harmonic generation, Four wave mixing and Self-phase-modulation Optical Kerr effect, Self-focusing, Optical Solitons; Optical phase conjugation and Optical bistability. Stimulated Raman Scattering and Stimulated Brillouin Scattering.

4. **Ultrafast Optics:** Introduction to ultrashort pulses, Ultrashort pulse generation through mode-locking, Nonlinear Schrödinger equation, Supercontinuum generation.

**Text/References**

AP 642 Guided Wave Optical Components and Devices

1. **Review of optical fiber properties:** multimode, single mode, birefringent, photonic crystal and holey fibers.
2. **Directional couplers**: Analysis, fabrication and characterization of different directional couplers, application in power dividers, wavelength division multiplexing, interleavers and loop mirrors.

3. **Fiber Bragg grating**: Analysis, fabrication and characterization: Application in add-drop multiplexing, gain flattening, dispersion compensation and wavelength locking.

4. **Fiber half-block devices**: Analysis and applications in polarizers, modulators, tunable power splitters, and wavelength filters.

5. **Fiber polarization components**: Polarization controllers and associated micro-optic components like isolators and circulators.

6. **Optical fiber sensors**: Intensity, phase and polarization based sensors, applications in various disciplines. Photonic crystal fibers for applications in sensing.

**Text/References:**


**AP 648 Fourier Optics & Holography**

1. Two dimensional signals and systems: Fourier analysis in two dimensions, spatial frequency, two dimensional sampling theory


3. Coherent & Incoherent imaging systems: Phase transformation and Fourier transforming properties of a thin lens, Image formation in a coherent imaging system, Frequency response of coherent and incoherent imaging systems, Phase contrast microscopy- Principals and Applications.


5. Applications of Holography: Microscopy, Holographic Interferometry, Holographic storage, other applications.

**References:**

298

**AP 649 Quantum optics**

1. Review of Quantum Mechanics basics
2. Quantization of electromagnetic fields, Number states, Coherent states and squeezed states of light and their properties, Beam splitters and interferometers, spontaneous parametric down conversion, concept of quantum entanglement, application of optical parametric processes to generate squeezed states of light and entangled states

**Textbooks/References:**

5. M. O. Scully and M. S. Zubairy, Quantum Optics (Cambridge 1997).
Pre-requisite: Laser safety tutorials/video demonstration of Laser safety followed by written test

1. Michelson Interferometer: Setting up Michelson interferometer using a highly monochromatic laser source, evaluation of laser wavelength by fringe counting.
2. Beam Width, Divergence and M² measurement of He-Ne/Diode Laser with and without collimation lens.
4. Detection of polarisation states using polarisation components like polarizers, waveplates etc.
5. Analysis of various light source spectra using OSA.
6. Determination of the refractive index profile of a multimode and single mode fiber by the transmitted near field scanning technique and measurement of NA.
7. Macro and Microbending loss in optical fibers and its application
8. Measurement of Photodiode I-V characteristics
10. Fiber optic link design
11. Measurement of attenuation and dispersion in optical fibers
12. Fiber to Fiber splicing and splicing loss measurement.
13. Setting up of Mach-Zender interferometer
15. Design of driver circuit for LED and Laser diode
16. Pulse width measurement of different laser using autocorellator.
17. Phase Sensitive detection technique using lock-in amplifier.
18. One Mini project (compulsory for all)

Note: Every student should perform a minimum of 12 experiments from the above list.

AP 638 Laser & Optical Communication Laboratory-II

1. Characterization of Fiber Bragg grating
2. Characterisation of Erbium Doped Fiber Amplifier
3. Power budget analysis using Optical Time Domain Reflectometer (OTDR)
4. Study of Time Division Multiplexing of digital signals
5. Study of a Wavelength Division Multiplexing(WDM) in optical fiber link
6. Study of Add/drop multiplexer
7. Study of Bit error rate and Eye pattern analysis
8. Setting up a Free space Laser Communication experiment link
9. Study of Electro-optic effect (Pockel and Kerr)
10. Measurement of third order nonlinear optical coefficient using Z-scan
11. Study of Faraday effect
12. Design of a fiber optic sensor
13. Line coding and decoding, voice coding
14. Measurement of insertion loss of an isolator, coupler and multiplexer
15. Beat length measurement in bi-refringent fibers.
Note: Every student should perform a minimum of 12 experiments from the above list.

M. Tech. in Optoelectronics and Communication Systems
(Optical Communication and Photonics)
**Brief Description:** The rapid growth of networks and the internet over the past decade has been enabled by advances in photonics technology. Optical communication networks provide the high capacity ubiquitous connectivity that forms the backbone of global internet. Today, optics has become the way by which most of the information is communicated around the globe and is the only technology that is capable of meeting the exponentially growing demand for communicating information. The programme intends to impart training to selected candidates in the field of Optical Communication and Photonics that would enable them to meet the challenges in this rapidly developing field.

**Stakeholders:**

(v) Sponsored candidates from Army, Navy, Air Force, DRDO Laboratories, Public Sector Undertakings and other departments

(vi) Graduates in the relevant field of science/engineering from recognized Universities/Institutes across the country.

**Eligibility:**
The candidate should possess Master degree or equivalent in Physics, Applied Physics, Electronic Science, Photonics OR B. E./B. Tech/ BSc.(Engg.) or equivalent in Electronics Engg./ Electrical Engg./ Electrical & Electronics Engg./ Electronics & (Tele)Communication Engg./ Electrical Communication Engg./ Electronics & Instrumentation Engg./ Instrumentation Engg./ Optics & Optoelectronics.

**Organization:** The M. Tech. programme is of four-semester duration. In each of the first two semesters there are five courses and practical. There will be three continuous evaluation examinations and a final semester examination for every course. Half-yearly evaluation of the project takes place at the end of the third semester. At the end of the final semester the student submits a thesis and makes a presentation about the project, which is evaluated by the Internal and External examiners. Course syllabus has been updated periodically to keep pace with the contemporary technological advancement.

**Semester I**

<table>
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* 1 Credit in Theory/Tutorial means 1 contact hour and 1 credit practice/Project Thesis means 2 contact hours in a week.

**Contact Hours/ week**

**List of Electives**

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<td>AP 641</td>
<td>Non-linear Optics</td>
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<tr>
<td>3</td>
<td>AP 642</td>
<td>Guided Wave Optical Components &amp; Devices</td>
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</table>
AP 643  Introduction to Fiber Optics

1. **Optical Fibers:** Light Propagation in Optical Fibers, Optical fiber Modes and Configurations, Mode Theory for Circular waveguides, SM and GI Fibers, Fiber Materials, PhC fibers, Fiber fabrication, Mechanical Property of Fiber and Fiber Optics Cables.


3. **Power Launching and Coupling:** Source to Fiber launching and Launching Schemes for Coupling Improvements. Fiber to Fiber joints, Laser coupling to SM fiber, Fiber splicing, Optical Fiber Connector.


5. **Fiber Amplifier:** Optical Amplification in rare-earth doped fibers, Types of Fiber Amplifiers, EDFA, Amplifier Noise, Optical SNR, System Application, Raman Amplifiers, Wideband Optical Amplifier.


8. **Overview of Optical Fiber Communication:** Light wave communications, Optical Spectrum Bands and Visible Units, Network Information rate and WDM concepts. Key Elements of fiber optics system, Standards for Optical fiber communications.

**Text Book:**


**References**
Broadband Communication Systems

1. **Introduction**: Broadband Network Architectures, Future of broadband communications
3. **xDSL**: IDSL, HDSL (SDSL, ADSL, RADSL, CDSL, and VDSL), xDSL, xDSL Coding Technologies, Provisioning of xDSL.
4. **Cellular Communication**: Analog Cellular Communications, The Cell site, The Mobile Telephone Switching Office (MTSO), Cell site Configurations, Tiered sites, Reuse of Frequencies, Allocation of Frequencies
5. **Global Services Mobile Communications (GSM)**, Wireless Data Communication (Mobile IP) and GPRS: Analog to Digital Movement, GSM Architecture, Mobile Equipment (MS), BTS, BSC, BSS, MSC, VLR, IP Routing, Applications That Demand Mobile IP, Variations in Data Communications (Wireless), Possible Drawbacks with Wireless, Wireless Data Technology Options, The GSM Phase II Overlay Network, Circuit-Switched or Packet-Switched Traffic, GPRS Radio Technologies, PDP Contexts, GSM and NA-TDMA Evolution, Applications for GPRS

**References:**

AP 645 Digital and Optical Communication Systems


2. **Digital Modulation techniques**: Introduction, Pulse amplitude modulation (binary and M-ary, QAM), Pulse position modulation (binary and M-ary), Carrier modulation (M-ary ASK, PSK, FSK, DPSK), Continuous phase modulation (QPSK and variants, MSK, GMSK), Trellis Code Modulation, Probability of Error & Bit Error Rate, Error Performance.


7. **Nonlinear effects in Optical Fibers**: Stimulated Raman scattering, Stimulated Brillouin scattering, Self-phase modulation, Cross Phase modulation, Four-wave mixing. Solitons communication systems.

8. **Tutorials**: Modelling of Fiber Optics Communication system
   a. Calculate the attenuation-limited fiber length based on the power budget equation. Simulate the resulting system and verify that it meets performance objectives.
   b. Calculate the dispersion-limited fiber length for a fiber optic transport system that employs standard single-mode fiber and a directly-modulated single-mode laser diode transmitter. Simulate the resulting system and verify that it meets performance objective.
c. Design and simulate a fiber optic system using dispersion-compensating fiber to reduce chromatic dispersion.
d. Simulate the broadening of a Gaussian pulse propagating through an optical fiber. Compare the results predicted by the linear system model of an optical fiber with the results of simulation.
e. Determine the sensitivity of a PIN photodiode based optical receiver by determining the minimum received power necessary to achieve a given Q factor. Compare the results of simulation with the results of an analytic approach.
f. Loss managements and Use of EDFA
g. Design and modeling of Multi amplifier system and Effect on OSNR

Text Books:

References
1. **Introduction FSOC/OWC**: Various modes of wired & wireless communication, Wireless access schemes, Historical perspective OWC, current scenario and challenges, Basic Link configuration of FSOC, various application areas of FSOC

2. **Laser sources & Receivers for free space communications**: Atmospheric low loss windows, optical sources and detectors for these windows, Characteristics of source and detectors.

3. **Channel Modeling - Indoor channel**: Various link configurations, propagation models for LOS, nLOS, Diffuse configurations, Artificial light interference effects in indoor channel.

4. **Channel Modeling - Outdoor channel**: Atmospheric channel loss, Absorption and scattering characteristics of atmosphere Fog & Visibility effects, Beam divergence, Optical & Window loss, Geometrical Loss, pointing loss, Various models of FSO in atmospheric channels, Power calculations,

5. **Atmospheric turbulence effects**: Atmospheric composition and structure, Significance and Measurement of $C_n^2$, Atmospheric Attenuation, Various atmospheric turbulence models, Basic beam propagation types, Effects of atmospheric turbulence on laser beam propagation, Realization of atmospheric effects on OWC test beds

6. **Modulation Techniques**: Importance of modulation in FSO, various modulation formats, selection criteria for modulation, basic modulation schemes OOK, PPM, PIM, DH-PIM, BPSK etc. error propagation in Gaussian channels in each modulation formats

7. **FSO link Performance under atmospheric turbulence**: performance of FSO link in various modulation formats, comparison across the modulation formats, turbulence induced penalty in FSO link

8. **Mitigation techniques**: introduction, aperture averaging, various diversity techniques, spatial diversity, time diversity coding techniques, adaptive optics and other techniques

9. **Laser beam Tracking, pointing & acquisition**: Acquisition and Tracking systems, System description, Acquisition methodology, tracking and pointing control system, RF cross link system design, link equation.

10. **Introduction to Satellite free Space Communication and under water communication, visible light communication**

**Tutorials**: Relevant tutorial will be conducted using optisystem and matlab

**Text/References**

3. Infrared Technology: Applications to Electro-Optics, Photonic Devices and Sensors, A.K.Jha

**AP647 Optical Networks**


3. **WDM Network elements:** Optical Line Terminals, Optical Line Amplifiers, Optical Add/Drop Multiplexers, Optical Crossconnects.

4. **Control and Management:** Network Management Functions, Optical Layer Services and Interfacing, Layers within the Optical Layer, Multivendor Interoperability, Performance and Fault Management, Configuration Management, Optical Safety.


7. **Photonic Packet Switching:** Optical Time Division Multiplexing, Synchronization, Header Processing, Buffering, Burst Switching, Testbeds.

8. **FTTx:** Introduction to FTTX, Fiber to the Home Architectures, FTTH in MDUs (Multiple Dwelling Units), FTTH PON Types, FTTH PON (Passive Optical Network), Triple Play Systems (BPON, GPON, EPON, RFOG) WDM and PON Other Uses For PONs, FTTX hardware and components (Cables, Splitters, Cabinets, Subscriber components).

9. **FTTx Installation, Testing and Management:** Outdoor cable installation, Duct, aerial, direct burial, Micro-duct solutions, Drop cable installation, Fiber terminations on with pigtail, Splicing and joint closing, Testing FTTH (Key factors affecting network, Testing during construction, Testing for commissioning).

**Practical Exposure (Optional)**

1. Practical View samples Set up FTTX link
2. Splicing and joint closing,
3. Installation of indoor hardware rack and wall mounting
4. Fiber arrangement and trucking
5. Connector installations
6. OTDR Testing, Troubleshooting
7. Multicore cable termination

**Text/References**

5. Gerd Keiser, Wiley-IEEE “FTTx Concepts and Applications”
1. **Open Source Technologies**: Fundamentals of open source, Linux introduction, Open RTOS, Open source virtualisation, Testing platforms, Open source networking, Programming for open source, Open source software principles, Open source projects. Open source code sharing, GIT


4. **Virtualization & cloud computing**: Virtualization concepts, Cloud Fundamentals, Cloud as IaaS, Public Cloud Environment, Managing Hybrid Cloud environment, Setting up your own cloud environment, Future directions, Cloud Domain and scope of work.

5. **Artificial Intelligence and Data analytics**: Introduction to Artificial intelligence, Sample AI applications, Data Analytics basics, Data Protection Implications, Compliance Tools


**Text Books/References:**
1. Dayanand Ambavade, Kogent Publishing, Linux Labs and Open Source Technologies
2. Imran Bashir, Packt Publishing, Mastering Blockchain: Deeper insights into decentralization, cryptography, Bitcoin, and popular Blockchain frameworks
5. Wolfgang Ertel, Springer, Introduction to Artificial Intelligence
## DEPARTMENT OF TECHNOLOGY MANAGEMENT

### M. Tech in Technology Management

#### Semester I

<table>
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<tr>
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<tr>
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<td>TM601</td>
<td>Introduction to Technology Management</td>
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<td>2</td>
<td>TM602</td>
<td>R&amp;D Management</td>
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### Intellectual Property

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Note: 04 weeks Practice school during summer vacation for scholarship students.

**Semester III**

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* 1 Credit in Theory/Tutorial means 1 contact hour and 1 credit practice/Project Thesis means 2 contact hours in a week.

**Contact Hours/week**

**LIST OF ELECTIVES**

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SEMESTER 1: INTRODUCTION TO TECHNOLOGY MANAGEMENT (TM601)

Unit I: Introduction to technology, History of managing tech in India, Managing in today’s high tech environment and mgmt. Tech – scope and focus, The Role of Technology in the Creation of Wealth, Critical Factors In Managing Technology, Management of Technology: The New Paradigms, Technology Life Cycles, Tech life cycle and product life cycles, Tech maturation and tech substitution, Integrating tech and strategic planning, Core competencies for tech development,

Unit II: The Process of Technological Innovation, Competitiveness, Business Strategy and Technology Strategy, Technology Planning, Acquisition and Exploitation of Technology, Managing risk in high technology, Need for innovation in business: measuring innovative performance, Characteristics of innovative work environment, Open innovation in tech management, Transfer of tech from lab to land.
Unit III: Technology Transfer, Manufacturing and Service Industries, Design of Organizations, Changing Game of Management, Case Studies (How the World Does It).

Text Books:

Reference Books:

SEMESTER I : R & D MANAGEMENT (TM 602)


Unit II: Human Resource Management in R&D, Attraction and Retention of Talent in R&D, Creativity in R&D Organizations, Interpersonal Relationships, Teams and Team building.

Unit III: Innovation Management, Portfolio Management, New Product Development.

Text Books:

Reference Books:

SEMESTER 1 : PROJECT MANAGEMENT (TM 603)

Unit I: Project Systems Management: a life cycle approach, stage-gate model, project characteristics; project life cycle phases: conception, definition, planning and organising, implementation and project clean up, Management of projects. Organization Strategy and Project Selection. Project feasibility analysis, The project manager: role and responsibilities, Tools and techniques for project management, Environmental impact analysis of a project.

Unit II: Managing Risks, Network techniques for project management-PERT and CPM Accounting for risk, uncertainty and fuzziness. Time cost tradeoffs and crashing procedures. Multi project planning and scheduling with limited resources.

Unit III: Projects financing, performance budgeting and control. Project materials management. Pricing, estimating, and Contract Administration and Management, Building and Bid evaluation

Text Books:

Reference Books:

SEMESTER 1: STRATEGIC MANAGEMENT FOR TECHNOLOGY (TM604)

Unit I: Strategic Management Process; Challenge of Globalization; Strategic Planning in India; Corporate Governance; Board of Directors; Role and functions of Top Management, Environmental scanning: Industry Analysis, Internal Scanning: Organizational Analysis


Unit III: Case Studies-Demonetization, Strategic initiatives of Govt. of India, FDI in defence, start-ups, “Make in India” for document of cutting edge technology coming from abroad-offset policies, Freedom to operate, strategic aspects of Technology Management.

Texts Books:

Reference Books:

SEMESTER 1: MANAGEMENT OF INNOVATION AND INTELLECTUAL PROPERTY (TM605)

Unit I: Organizational and technological innovation: role of organizational design and processes, strategic role of intellectual property protection in technological innovations case studies, role of open source, the R&D value chain, stage gates, differences in priority with the R&D value chain
Unit II: *New Product Development*: International, national, organizational, individual actors, organizations and vehicles to manage intellectual property, critical steps in managing R&D process management during stage gates for patent searches, technology landscaping, specification writing, timeline management, rights and responsibilities in competitive technology environments

Unit III: *Innovative inventions*: Commercial potential, management of processes to enhance innovative patents and technological know-how transfer, incubators, assessing patent value implications on managing the R&D value chain for corporate R&D, designing innovation and intellectual property divisions, and information technology support systems in managing innovation and intellectual property.

Texts/References:

**SEMESTER 1 : APPLIED STATISTICS FOR MANAGEMENT (TM606)**


**Unit II: Hypothesis testing**: Z-test, t-test, Basic Two-Level Factorial Experiments, Additional Tools for Design and Analysis of Two Level Factorials, Correlation and Regression analysis, Multiple and Partial Correlation, ANOVA, Chi-square tests, Factor Analysis, Time Series Analysis and Business Forecasting, Non-Parametric Methods, SPSS and their use for statistical modeling, applications and case studies in data analysis.

**Unit III: Optimization Experiments**: Response Surface Methodology, Responses Surface Model Fitting, Mixture Experiments, Variability and Quality: Characterizing Variability in Data, Shewhart Control Charts, Off-Line Quality Control and Robust Design, Excel, Minitab, R.

**Text Books**:

**Reference Books**:
SEMESTER 2 : MANAGEMENT OF MANUFACTURING AND INTEGRATION (TM 607)

Unit I: Introduction to Manufacturing, Concepts of Total Quality Management (TQM) and Six Sigma, Benchmarking and Business Process reengineering, The continuous process improvement cycle.

Unit II: Lean Manufacturing, Design for Manufacturing, Rapid Prototyping, 3D printing, IT for Manufacturing: Digital and Smart Factory, Virtual Product Creation, Interface between R&D and Manufacturing, Product Lifecycle Management, Concurrent and Simultaneous Engineering, cellular manufacturing system, design planning and implementation.


Text Books:

References Books:

SEMESTER 2 : KNOWLEDGE MANAGEMENT (TM 608)

Unit I: Data Information Knowledge wisdom, Knowledge cycle, Basics of Knowledge Management: Knowledge capture, storage, use and reuse learning organisations.

Unit II: Intellectual capital and its measurements, Performance management systems in Knowledge Management, Knowledge transfer in organisations, knowledge mapping, knowledge ownership, knowledge losses, knowledge management for new product development, Human aspects of knowledge management.

Unit III: IT support systems for Knowledge management, Ontology, case studies and applications of knowledge management, using data from patents, technology, measurement of
innovation and in corporate organizations, learning in the context of open innovation and open source.

Text Books:
1. Harvard Business Review on Knowledge Management by Peter Ferdinand Drucker, David Garvin, Dorothy Leonard, Susan Straus, John Seely Brown
2. Knowledge Management: Concepts and Best Practices by Kai Mertins (Editor), Peter Heisig (Editor), Jens Vorbeck (Editor)

References Books:
1. If Only We Knew What We Know: The Transfer of Internal Knowledge and Best Practice by Carla O’dell, C. Jackson Grayson

ELECTIVES FROM DEPARTMENT

SYSTEMS ENGINEERING (TM 609)

Unit I: Systems definitions and concepts. Conceptual system design; Introduction to engineering design and decision making

Unit II: Quality Function Deployment; Queuing theory; Design options; Monte Carlo modelling; Engineering microelectronics; Utility theory; Forecasting, Engineering systems modelling. Analysis of system: Reliability; Maintainability; Serviceability; Disposability and Affordability. Cost and benefit analysis.

Unit III: Methods of decision analysis; State transition matrix models; Modeling the research and development process; Information, System life-cycle modelling and optimization. Game Theory, Management of engineering systems designs and operation, Programme management with case studies.

Text Books:

References Books:

LEADERSHIP & ORGANISATIONAL BEHAVIOUR (TM610)
Unit I: Organisation: context, structure, processes, Theories of organisation, organisation and its environment, organisational analysis: Individual and Group, Organisational change and development.

Unit II: Functions of Human Resource Management, Recruitment, Selection, Performance Management, Reward and Compensation Management, Training and development, administration wage and salary, labour legislations and Industrial Relations.

Unit III: Basics of Human Behaviour, Leadership, Competing for the future through leadership management, career management and leadership pipeline, succession planning and change management.

Text Books:
1. Paul Hersey, Kenneth H Blanchard & Dewey Johnson, Management of Organisational Behavior PHI
3. Fred Luthans, Organizational Behavior, McGraw Hill

References Books:
1. Paul Hersey & Kenneth H Blanchard, Management of Organisational Behavior: utilizing Human behaviour, PHI
2. Stephen P Robbins, Organizational Behavior: Concepts, controversies and applications, PHI

SOFTWARE PROJECTS MANAGEMENT (TM611)

Unit I: Introduction to Software Project Management: Software projects versus other types of project, Activities Covered by software project management, Some ways of categorizing software projects, Stakeholders, Project success and failure; Project Evaluation and Programming Management: Project portfolio management, Evaluation of individual projects, Cost-benefits Evaluations techniques, Risk Evaluation, Programme management, managing the Allocation of Resources within programmes, Aids to programme management; An overview of Project Planning: Introduction Step wise project planning; Selection of an Appropriate Project Approach: Build or Buy?, Choosing Methodologies and Technologies, Software processes and process Models, Choices of process Models, Structure versus speed of Delivery, The waterfall Model, The Spiral Model, Software prototyping, Other Ways of Categorizing Prototypes, Incremental Delivery, Atern/ Dynamic systems development methods, Rapid application development, Agile methods, Extreme programming (XP), Scrum, Managing Iterative processes, Selecting the most appropriate process Model.

Unit II: Software Effort Estimation: The basis for software estimating, Software effort estimation techniques, Bottom up estimating, the top-down Approach and parametric models, Expert Judgement, estimating by analogy, Albrecht function point analysis, COSMIC full function points, COCOMO II: A parametric productivity Model, cost estimation; Activity Planning: Sequencing and Scheduling Activities, Network planning Models, Formulating a Network Model, Identifying the Critical path; Risk Management: Categories of risk, Risk identification, Risk assessment, Risk planning, Risk management, Evaluating risks to the schedule, Monte carlo simulation; Resource Allocation: The nature of Resources, Identifying Resource Requirements, Scheduling resources, Counting the cost, Being specific, Cost schedules;
Unit III: Monitoring And Control: Creating the framework, visualizing progress, cost monitoring, earned value analysis, prioritizing monitoring, Getting the project Back to target. Software Configuration management (SCM); Managing Contracts: Stages in contract placement, typical terms of a contract, Contract management, Acceptance; Working In Teams: Becoming a team, Decision making, Organization and team strictures, Dispersed and virtual teams, Communication plans; Software Quality: Defining software Quality, ISO 9126. Product and process metrics, Quality management systems, process capability models, techniques to Help Enhance software Quality, software reliability.

Text Books:

References Books:
1. Pankaj Jalote: Software Project Management in Practice, Pearson

QUALITY MANAGEMENT (TM 612)

Unit I: Introduction to TQM and Six Sigma: 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, Quality assurance, OC curve.

Unit II: Statistical Process Control; Advanced Analytical tools: Statistical Design of Experiments; Taguchi Approach; Cost of Quality; Reliability and failure analysis. FMEA, Six Sigma tools and techniques for DMAIC phases, Quality Function Deployment.

Unit 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 and Six Sigma case studies implementation.

Text Books:
Reference Books:

VALUE ENGINEERING (TM 613)

Unit I: Introduction to Value Engineering and Value Analysis, Methodology of V.E., Quantitative definition of value, Use value and prestige value, Estimation of product quality/performance, Classification of functions, functional cost and functional worth, Effect of value improvement on profitability.

Unit II: Introduction to V.E. job plan / Functional approach to value improvement, Various phases and techniques of the job plan, Life Cycle Costing for managing the total value of a product, Cash flow diagrams, Concepts in LCC, Present Value concept, Annuity cost concept, Net Present Value, Pay Back period, Internal rate of return on investment (IRR), Continuous discounting, Examples and illustrations.

Unit III: Creative thinking and creative judgment, False material, labor and overhead saving, System reliability, Reliability elements in series and in parallel, Decision Matrix, Evaluation of value alternatives, Estimation of weights and efficiencies, Sensitivity analysis, Utility transformation functions, Fast diagramming, Critical path of functions, DARSIRI method of value analysis.

Text Books:

References Books:
1. Del l. Younker, Value Engineering: Analysis And Methodology,
2. J. Paul Guyer, Value Engineering (Engineering Sound Bites) Kindle Edition

DESIGN MANAGEMENT (TM 614)

Unit I: Introduction; Designer’s view; Philosophical and psychological issues in design; Fostering creativity and innovation; cognition: Action selection, memory, decision making; Perception: Auditory & Visual, errors. Design and Competitiveness: Oligopoly, Monopoly

Unit II: Requirement elicitation and analysis: QFD, HOQ; Anthropometrics, Human factors & Ergonomics; Environmental design; Industrial design management; basics of work study: time study, motion study; Economic analysis: Break even analysis, profit, Taguchi function.
Unit III: Collaboration and conflict management; concept of value analysis and value engineering - design perspective; role of computer in design; rapid prototyping; designer as an entrepreneur, designer’s knowledge on Intellectual Property Rights

Text Books:
2. Kathryn Best, Design Management: Managing Design Strategy, Process and Implementation
3. Brigitte Borja de Mozota, Design Management: Using Design to Build Brand Value and Corporate Innovation

References Books:
1. Michel Farr, Design Management.
2. Rachel Cooper, Sabine Junginger and Thomas Lockwood, Design Management.

HUMAN RESOURCE MANAGEMENT FOR TECHNOLOGY INTENSIVE ORGANISATIONS (TM 615)

Unit II: Cross Culture: nature, Hofstede’s cultural dimensions, strategy; HR Audit: need, concept, strategy, structure, role of HRD audit, functions, methodology; Human capital and performance: elements, significance, measurement, reporting.
Unit III: Management of change: The nature of change · Eight steps to successful change · Change management and organizational structure · Change strategies · Change resistance · Effective communication · Effective leadership, Emotional Intelligence: An overview, emotions and brain, importance, theories, models,

Text Books:
1. Aswathappa, Human Resource Management: Text and Cases.

References Books:

INTRODUCTION TO VARIABLES OF NATION BUILDING (TM 616)
Unit I: Introduction and Basic Concepts of National Service Scheme (NSS): History, philosophy, aims & objectives of NSS, Emblem, flag, motto, song, badge etc., Organizational structure, roles and responsibilities of various NSS functionaries.

Unit II: Life competencies & Disaster Management: Definition and importance of life competencies, Communication, Inter Personal, Problem-solving and decision-making, Introduction to Disaster Management, classification of disasters, Role of youth in Disaster Management.

Unit III: Entrepreneurship Development: Definition & Meaning, Qualities of good entrepreneur, Steps/ways in opening an enterprise, Role of financial and support service Institutions.

Text Books:
1. Disaster Management, Harsh k Gupta
2. Management of natural disasters in developing countries, H N Srivastava
3. Entrepreneurship Development, S Anil Kumar

References Books:
2. National Service scheme Manual, Govt. of India.
3. Training Programme on National programme scheme, TISS.
4. Orientation courses for N.S.S. programme officers, TISS.
5. Case material as Training Aid for field workers, Gurmeet Hans

LOGISTICS AND SUPPLY CHAIN MANAGEMENT (TM617)

Unit I: Introduction to Logistics and supply chain management (LSCM): Concept and objectives of logistics management and supply chain management (SCM), Flow in supply chain, Decision phases in supply chain, Push-pull supply chains, Supply chain integration, Process view of a supply chain, Lead time management, Cold chains, Reverse logistics, Uncertainties in supply chain, supply chain drivers. Demand management in SCM; Sourcing and Procurement: Vendor development, Outsourcing benefit, Vendor evaluation and rating, supply contracts, competitive bidding and Negotiation, E-Procurement, Vendor managed inventory (VMI); Purchasing: Objectives, Relations with other departments, centralised and decentralised purchasing, Purchasing procedure in government organisations in India, Types of orders, Tender buying, purchasing department records, Computer-based systems/EDI, Stores management.

Unit II: Inventory Management in SCM: Introduction of inventory system, EOQ model, ABC-VED Analysis, Service-level management, Risk pooling and postponement strategies, Lean, Agile and Leagile supply chain, Designing lean supply chain; Distribution Management in Supply Chain: Different distribution strategies in supply chain, warehousing and cross- locking, Network planning and design, 3PL and 4PL

Unit III: Managing Information flow in supply chain: Bullwhip effect- cause and remedy. Role of Information technology in SCM; Performance management in a supply chain: Balance

Text Books:

Reference Books:

OPERATIONS MANAGEMENT (TM618)

Unit 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.

Unit 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.


Text Books:
2. Production and Operations Management; R. Paneerselvam, 3rd edition, PHI.

Reference Books:

ADVANCED PROJECT MANAGEMENT TECHNIQUES (TM619)

Unit I: Advanced concepts in Project Management: Agile PM, Capability Maturity Model (CMM), Earned Value Analysis (EVA) and Earned Duration Analysis (EDA)
Unit II: Software Project Management: Software testing and quality Management, Effort estimating and scheduling, Project Monitoring and control, Reviews, Risk Management, Tools for software project such as MS project.

Unit III: Applications and case studies in Project Management, Management of multiple projects.

Text Books:

References Books:
2. Pankaj Jalote:Software Project Management in Practice, Pearson

ACCOUNTING AND FINANCE FOR TECHNOLOGISTS (TM 620)

Unit I: Introduction to accounting, accountability, transparency, responsibility; Basic accounting concepts and financial statements, sources and use of finance, Basics of Project finance in Public domain, feasibility study, Asset Funding.

Unit II: Social cost benefit analysis; Return on Investment, Cost of Capital, Audit and control; Cost concepts and profit centers and responsibility accounting; costing and profitability analysis; Good costs vs. Bad costs.

Unit III: Basics of contracts, Cost escalation clause in contracts and consequences, Planning and budgeting; Basic concepts of working capital, Basics of financing of imports, exchange rate risk in capital expenditure decisions

Text Books:
5. Jain S P ,Narang K L , Cost and Management Accounting, Kalyani Publishers
7. Dr. V K Goyal, Finanacial Accounting, Excel Books

Reference Books:

**SCIENTIFIC / ENGINEERING PRACTICES AND SKILLS (TM 649)**


**Unit II:** Finance Management: approaches, working capital, investment & dividend, sources; Project Management: characteristics, types of projects, Project Life cycle; Strategic Management: environmental analysis, formulation, evaluation, implementation, control; Human Resource Management: Nature, components, functions, challenges

**Unit III:** Technology life cycle, Technology Implementing, Technology diffusion, Technology Forecasting, Technology Transfer, Intellectual Patent Right (IPR), Knowledge Management: Learning theory, learning organizations, tacit and explicit knowledge, knowledge sharing culture, Knowledge capture, Stress Management and Yoga, Stress Management Techniques.

**Text Books:**
1. Akhilesh K B, R&D Management, Springer
3. Dabholkar & Krishnan, 8 steps to Innovation, HarperCollins Publishers

**References Books:**
4. Montgomery, Design and Analysis of Experiments, Wiley India Pvt Ltd

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Department of
### M. Tech. in Electronics and Communication Engineering  
**Signal Processing and Communication**

#### Semester I

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* Four week industrial practice school during summer vacation for scholarship students (optional).

**Contact Hours/week**

### Semester III

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* 1 Credit in Theory/Tutorial means 1 contact hour and 1 credit practice/Project Thesis means 2 contact hours in a week.

**Contact Hours/week**

**M. Tech. in Electronics and Communication Engineering**  
(Radar and Communication)

### Semester I

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* Four week industrial practice school during summer vacation for scholarship students (optional).

**Contact Hours/week

**M. Tech. in Electronics and Communication Engineering**

(Defence Electronics Systems)

**Semester I**

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**Contact Hours/ week
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*Four week industrial practice school during summer vacation for scholarship students (optional).*

### Semester III

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### Semester IV

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**Contact Hours/week**

### M. Tech. in Electronics and Communication Engineering
*(Navigation Systems)*

#### Semester I

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<td>Radar System Design</td>
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**Contact Hours/ week**

### M. Tech. in Electronics and Communication Engineering
(Wireless Networks and Applications)

#### Semester I

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<td>EE603</td>
<td>Mobile and Wireless Communication</td>
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<td>CE663</td>
<td>Applied Cryptography</td>
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**Contact Hours/week

M. Tech. in Electronics and Communication Engineering
(VLSI and Embedded Systems)

Semester I (@DIAT, Pune)

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Semester II (@DIAT, Pune)

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**Contact Hours/week

Semester III and Semester IV [Project work and VLSI related Courses @ NIELIT CALICUT].

List of Electives

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<td>Inertial Sensors and Systems</td>
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<td>EE636</td>
<td>Navigation &amp; Avionic Systems</td>
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<td>ASIC Verification using System Verilog</td>
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<td>Analog and Mixed mode VLSI Design</td>
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<td>Computer Aided Design for VLSI Circuits</td>
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<td>EE640</td>
<td>FPGA Architecture and Applications</td>
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<td>VLSI Signal Processing</td>
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Course Name: MICROWAVE ENGINEERING  
Course Code: EE601

UNIT-I: INTRODUCTION TO EM WAVE AND TRANSMISSION LINES  
Introduction to microwaves, Maxwell’s equations, wave Equation, Plane wave reflection, Dielectric Interference, circuit model and field analysis, Quarter-wave transformer, lossy transmission lines, TEM, TE and TW wave solutions, types of waveguides, strip lines, relation between dB, dBm, dBw, dBμ.

UNIT-II: MICROWAVE NETWORK ANALYSIS:  
Impedance, voltage, current, Matrices, scattering, transmission (ABCD) matrix, signal flow graph, Discontinuities and Model analysis, Excitation of waveguides, Lumped elements, stub tuning, Binomial and Chebyshev multi-section, tapered lines, Bode-Fano criterion.

UNIT-III: MICROWAVE RESONATORS, DIVIDERS AND COUPLERS:  
Serial and parallel resonant circuit, line resonators, Cavity resonators, Excitation of resonators, cavity perturbations, properties of dividers and couplers, Wilkinson power dividers, directional couplers, Quadrature (90°) Hybrid, Coupled line directional couplers, large couplers, other couplers.

UNIT-IV: MICROWAVE FILTERS:  
Periodic structures filter design by Image Parameter Method, Insertion loss method, filter transformation, filter implementation, stepped-Impedance low-pass filters, coupled line filters, filters using coupled resonators.

UNIT-V: MICROWAVE DEVICE AND AMPLIFIES DESIGN:  
Diode circuits, BJT, FET, Microwave integrated circuits, Microwave tubes, RF oscillators, Microwave oscillators, Phase noise, frequency multiplier, mixers, Two-port power gain, single stage- broadband transistor amplifier design, power amplifiers.

UNIT-VI: MICROWAVE MEASUREMENTS:  
S-parameter measurements, Network analyzer, Spectral characteristics measurements, Spectrum analyzer, Phase noise measurement, Power measurement, Microwave subsystem and system characteristics.

TEXT BOOKS:  
1. David M. Pozar, Microwave Engineering, John Wiley, India.  
2. Robert E. Collin, Foundations of Microwave Engineering, John Wiley USA.

REFERENCE BOOKS:  
2. Lio SY, Microwave Devices and Circuits, Prentice Hall, India.  
4. Electromagnetic, John D. Kraus, Mcgraw-Hill.

LIST OF EXPERIMENTS

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<tr>
<th>Sr. No.</th>
<th>Experiments</th>
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<tr>
<td>1.</td>
<td>Characteristics of Klystron Tube and to determine its electronics tuning range</td>
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<td>2.</td>
<td>Practical and theoretical aspects of V-I characteristics of Gunn diode</td>
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<td>3.</td>
<td>Determine the frequency and wavelength in a rectangular wave guide working on TE10 mode and determine the standing wave ratio and Reflection coefficient</td>
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<td>Functions of multi-hole directional coupler by measuring the following parameter</td>
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<td>b) Coupling factor and directivity</td>
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Course Name: DIGITAL SIGNAL PROCESSING
Course Code: EE602


UNIT-II: NON-PARAMETRIC METHODS: Estimation of spectra from finite duration observation of signals, Non-parametric, Methods: Bartlett, Welch & Blackman-Tukey methods, Comparison of all Non-Parametric methods.


UNIT-IV: MULTI RATE SIGNAL PROCESSING: Introduction, Decimation by a factor D, Interpolation by a factor I, Sampling rate conversion by a rational factor I/D, Multistage Implementation of Sampling Rate Conversion, Filter design & Implementation for sampling rate conversion. Examples of up-sampling using an All Pass Filter.


TEXT BOOKS:
2. Discrete Time signal processing - Alan V Oppenheim & Ronald W Schaffer, PHI.

REFERENCE BOOKS:

LIST OF EXPERIMENTS:

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<tr>
<th>Sl. No</th>
<th>Experiment</th>
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<tr>
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<td>Introduction of Matlab/Simulink, Labview and its tool boxes</td>
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<td>Sampling and Reconstruction of signals</td>
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<td>3.</td>
<td>Deterministic &amp; Random Signal analysis using power spectral estimation techniques</td>
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<td>• Period gram power spectral estimation technique</td>
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<td>• PSD through correlogram technique</td>
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<td>• Spectrogram analysis</td>
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<td>Model based power spectral estimation techniques</td>
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<td>1. AR Model, MA Model, ARMA Model</td>
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### Covariance methods

5. **Speech analysis using LPC. Performance analysis with respect to the Prediction Filter Order & SNR**

6. **Digital filter design using Matlab & implementation in FPGA**
   - a) FIR & IIR Filters

7. **High Resolution pseudo-spectral estimation technique via**
   - a) MUSIC & ESPRIT

8. **Design of Quadrature Mirror Filters (QMF)**

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**Course Name:** MOBILE AND WIRELESS COMMUNICATION  
**Course Code:** EE603

**UNIT-I: WIRELESS COMMUNICATIONS AND DIVERSITY**: Fast Fading Wireless Channel Modeling, Rayleigh/Ricean Fading Channels, BER Performance in Fading Channels, Diversity modeling for Wireless Communications, BER Performance Improvement with diversity, Types of Diversity – Frequency, Time, Space

**UNIT-II: BROADBAND WIRELESS CHANNEL MODELING**: WSSUS Channel Modeling, RMS Delay Spread, Doppler Fading, Jakes Model, Autocorrelation, Jakes Spectrum, Impact of Doppler Fading

**UNIT-III: CELLULAR COMMUNICATIONS**: Introduction to Cellular Communications, Frequency reuse, Multiple Access Technologies, Cellular Processes – Call Setup, Handover etc., Teletraffic Theory

**UNIT-IV: CDMA**: Introduction to CDMA, Walsh codes, Variable tree OVSF, PN Sequences, Multipath diversity, RAKE Receiver, CDMA Receiver Synchronization

**UNIT-V: OFDM**: Introduction to OFDM, Multicarrier Modulation and Cyclic Prefix, Channel model and SNR performance, OFDM Issues – PAPR, Frequency and Timing Offset Issues

**UNIT-VI: MIMO**: Introduction to MIMO, MIMO Channel Capacity, SVD and Eigen modes of the MIMO Channel, MIMO Spatial Multiplexing – BLAST, MIMO Diversity – Alamouti, OSTBC, MRT, MIMO □ OFDM

**UNIT-VII: UWB (Ultra wide Band)**: UWB Definition and Features, UWB Wireless Channels, UWB Data Modulation, Uniform Pulse Train, Bit Error Rate Performance of UWB

**UNIT-VIII: 3G AND 4G WIRELESS STANDARDS**: GSM, GPRS, WCDMA, LTE, WiMAX

**TEXT BOOKS:**

1. Fundamentals of Wireless Communications – David Tse and Pramod Viswanath, Publisher □ Cambridge University Press.
4. MIMO Wireless Communications – Ezio Biglieri – Cambridge University Press. A joint venture by IISc and IIT

**REFERENCE BOOKS:**

1. **Introduction to Space-Time Wireless Communications** – Arogyaswami Paulraj – Cambridge University Press.

**LIST OF EXPERIMENTS:**

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<tr>
<td></td>
<td>a) MUSIC &amp; ESPRIT</td>
</tr>
<tr>
<td>8.</td>
<td>Design of Quadrature Mirror Filters (QMF)</td>
</tr>
</tbody>
</table>
| 1. | Error Vector Magnitude Measurement for GSM Signal  
**Objective**  
   i) To measure the error vector magnitude, occupied bandwidth, and channel power of a GSM modulated RF signal using an oscilloscope and the VSA software |
| 2. | Spectrum Analysis of CDMA Signal  
**Objectives**  
   i) To measure the channel power of a CDMA modulated RF signal using an oscilloscope and the VSA software  
   ii) To perform an in-band limit test or spectrum emission mask test on a CDMA modulated spectrum |
| 3. | Spectrum Analysis of GSM Signal  
**Objectives**  
   i) To measure the spurious and harmonics of the GSM and CDMA modulated RF signal using an oscilloscope and the VSA software  
   ii) To perform an out-of-band limit test that identifies the pass or fail level of the spurious and harmonics |
| 4. | Occupied Bandwidth Measurement for GSM and CDMA Signals  
**Objectives**  
   i) To measure the occupied bandwidth of a GSM and CDMA modulated RF signal using an oscilloscope and the VSA software  
   ii) To determine the parameter that changes the occupied bandwidth |
| 5. | Adjacent Channel Power Ratio Measurement for GSM and CDMA Signals  
**Objective**  
   i) To measure the adjacent channel power ratio of the GSM and CDMA modulated RF signal using oscilloscope and VSA software |
| 6. | Noise and Error Influence for GSM Signal  
**Objective**  
   i) To measure the error vector magnitude of a GSM modulated RF signal with influence of noise and error using oscilloscope and VSA software |

**Course Name:** RADAR SYSTEM DESIGN  
**Course Code:** EE604

**UNIT-I: INTRODUCTION TO RADAR** - Basic principle of radar, Frequencies of operation, Classification of radars, their functionality and applications, Types of radar – CW, FMCW, Pulse Doppler, – principles and applications.

**UNIT-II: RADAR PARAMETERS/DEFINITIONS** - Radar Range, Cross Range and Doppler/Velocity measurements and Resolutions, Peak power, Average power and Duty Cycle, Target, Noise Power, Noise Power density, False Alarm, Concept of Detection

**UNIT-III: RADAR EQUATIONS:** Derivation of the Basic Radar Equation, Point Target in Interference, Receiver Noise and Noise Bandwidth, Signal to Noise Ratio (SNR), Losses in Radar Equation, Signal Integration and Processing Gain, Radar Equation for Bistatic, Search and Tracking Radars, Equation for Beacon, Cover Up and Self Protection Jamming.

**UNIT-IV: RADAR CROSS SECTION (RCS) & THEORY OF DETECTION** - Probability of Detection $P_d$, Probability of False Alarm $P_{fa}$ and Relation between $P_d$, $P_{fa}$ and SNR--statistical phenomenon of Noise. Target characteristics-- RCS, RCS fluctuation, Swirling Models, SNR deviation for fluctuating targets,


UNIT-VII: SURVEILLANCE AND TRACKING RADAR – Concept of Tracking, Conical Scan Angle Tracking, Lobing Angle Tracking, Monopulse Tracking; Amplitude and Phase Comparison, Wideband Monopulse Tracking, Conventional 2D Surveillance radar : Battlefield Surveillance Radar, Coastal Surveillance radars.

RADAR DESIGNS: RADAR ELEMENTS’ DESIGN


TEXT BOOKS:

REFERENCE BOOKS:

LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Generation of different Radar waveforms, Measurement of Doppler frequency shift, RCS measurement, Range measurement using Radar trainer kit.</td>
</tr>
<tr>
<td>2</td>
<td>Calculation of probability of detection for fluctuating targets, Modeling a pulse Doppler radar system, MIMO radar simulation using SystemVue tools.</td>
</tr>
<tr>
<td>3</td>
<td>Simulating moving targets, FMCW simulation using SystemVue.</td>
</tr>
<tr>
<td>4</td>
<td>Target cluster forming and range finding, Dead-zone marking and target detection using BFSR.</td>
</tr>
<tr>
<td>5</td>
<td>Target relative range/speed estimation, Realization of TWS using BFSR</td>
</tr>
<tr>
<td>6</td>
<td>Demonstration of the principle of IFF, Realization of Target position prediction using its data.</td>
</tr>
</tbody>
</table>

Course Name: NAVIGATION SYSTEM CONCEPTS
Course Code: EE605


UNIT – IV PRINCIPLES OF RADIO POSITIONING: Radio Positioning Configurations and Methods, Positioning Signals, User Equipment, Propagation, Error Sources, and Positioning Accuracy


UNIT – VI ADVANCED SATELLITE NAVIGATION: Differential GNSS, Carrier-Phase Positioning and Attitude, Poor Signal-to-Noise Environments, Multipath Mitigation, Signal Monitoring, Semi-Codeless Tracking


UNIT – IX SHORT-RANGE POSITIONING: Pseudolites, Ultra wideband, Short-Range Communications Systems, Underwater Acoustic Positioning, Other Positioning Technologies


TEXT BOOKS:

REFERENCE BOOKS:
### LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Experiment</th>
<th>Objectives</th>
</tr>
</thead>
</table>
| 1      | Single satellite-waveform | - Simulate single satellite with C/A code for GPS, IRNSS, GLONASS, Galileo, Beidou, SBAS (should include GAGAN) and QZSS  
- Specify the frequency channel, dynamic pattern: Static, constant velocity, constant acceleration |
| 2      | Multi-satellite waveform | - Simulate multi-satellite signals  
- Constellation from GPS, GLONASS, QZSS, Galileo, Beidou |
| 3      | GPS, GLONASS, Galileo, Beidou, SBAS and QZSS real-time signal generation | - Simulate up to 15 line-of-sight satellites for each constellation: GPS L1 C/A, GLONASS L1 C/A, or Beidou B1, Galileo, SBAZ, QZSS  
- Provide real-time control for individual satellites, including satellite on/off, absolute or relative satellite power, adding multipath, and applying a pseudo-range error. |
| 4      | Scenario generation and editing | - Create custom scenarios with your choice of location, date, time, and duration for either static and moving receivers |
| 5      | Satellite based augmentation system (SBAS) | - SBAS message editor to configure the SBAS message for PRN Mask, Fast Correction, Fast Correction Degradation Data Factor, Network Time, GP Mask, Long Term Correction and Ionosphere Correction |
| 6      | Real-time CW interference | - Should support adding multiple CW interference signal to real-time GNSS signals within GPS, GLONASS or Beidou bands. |
| 7      | Real-time display | - Display the location of each satellite in sky-view to get real-time update of the satellite as its azimuth/elevation changes in time.  
- Bar view of real-time satellite power for all visible satellites.  
- Real-time receiver trajectory view to display the history trajectory of the playing scenario with detailed information on UTC, longitude, latitude, altitude, heading and velocity. |

**Course Name:** STATISTICAL SIGNAL PROCESSING  
**Course Code:** EE606

**UNIT I: INTRODUCTION**  

**UNIT II: LINEAR PREDICTION AND OPTIMUM LINEAR FILTERS.**  

**UNIT III: LEAST-SQUARES METHODS FOR SYSTEM MODELING AND FILTER DESIGN.**  

**UNIT IV: ADAPTIVE FILTERS.**  
Applications of Adaptive Filters, Adaptive Direct-Form FIR Filters, Adaptive Lattice-Ladder Filters, Summary and References, Problems.
UNIT V: RECURSIVE LEAST-SQUARES ALGORITHMS FOR ARRAY SIGNAL PROCESSING.

UNIT VI: POWER SPECTRUM ESTIMATION.

TEXT BOOKS:

REFERENCE BOOKS:

LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Simulation of Adaptive BFSK, BPSK, ASK modulators and demodulators.</td>
</tr>
<tr>
<td>2.</td>
<td>Simulation of delay estimation</td>
</tr>
<tr>
<td>3.</td>
<td>Simulation of Adaptive Beam forming, concept of IQ channels and Adaptive filter</td>
</tr>
<tr>
<td>4.</td>
<td>Simulation of MUSIC algorithm</td>
</tr>
</tbody>
</table>

Course Name: DETECTION AND ESTIMATION THEORY
Course Code: EE607

UNIT-I: REVIEW OF VECTOR SPACES: Vectors and matrices: notation and properties, orthogonality and linear independence, bases, distance properties, matrix operations, eigen values and eigenvectors.

UNIT-II: PROPERTIES OF SYMMETRIC MATRICES: Diagonalization of symmetric matrices, symmetric positive definite and semi definite matrices, principal component analysis (PCA), singular value decomposition.

UNIT-III: STOCHASTIC PROCESSES: Time average and moments, ergodicity, power spectral density, covariance matrices, response of LTI system to random process, cyclostationary process, and spectral factorization.

UNIT-IV: DETECTION THEORY: Detection in white Gaussian noise, correlator and matched filter interpretation, Bayes’ criterion of signal detection, MAP, LMS, entropy detectors, detection in colored Gaussian noise, Karhunen-Loeve expansions and whitening filters.


TEXT/REFERENCE BOOKS:
LIST OF EXPERIMENTS:

<table>
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<tr>
<th>Sl. No</th>
<th>Experiment</th>
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<tbody>
<tr>
<td>1</td>
<td>Introduction of Matlab/Simulink, Lab view and its tool boxes to simulate Signal models in the presence of various ambient Noise models (correlated/uncorrelated , White/Colored with Gaussian mixture models)</td>
</tr>
<tr>
<td>2</td>
<td>Target Signal &amp; Ambient Noise Simulation (Scalar &amp; Vector Sensor Array Data Vector Simulation): Generation of Multiple spatially separated targets in presence of Strong interferences and Additive Correlated/Uncorrelated, White/Colored Ambient Noise</td>
</tr>
<tr>
<td>3</td>
<td>Development of Detection Techniques for following cases</td>
</tr>
<tr>
<td></td>
<td>1. Constant amplitude Signal in AWGN</td>
</tr>
<tr>
<td></td>
<td>2. Time varying Known Signals in AWGN</td>
</tr>
<tr>
<td></td>
<td>3. Unknown Signals in AWGN</td>
</tr>
<tr>
<td>4</td>
<td>Development and performance comparison of the following Estimation techniques using a given signal &amp; noise model (sensor data model) - MLE, MMSE, Bayes Estimator, MAP Estimator, Expectation Maximization (EM) algorithm</td>
</tr>
<tr>
<td>5</td>
<td>Case Study: Detection of targets using NP Criterion &amp; target parameter (Range, bearing, Doppler, etc) estimation algorithms Performance comparison of Conventional Energy Detectors and Coherent Matched Filter Techniques</td>
</tr>
</tbody>
</table>

Course Name: ADVANCED WIRELESS COMMUNICATION  
Course Code: EE608

UNIT-I: INTRODUCTION  

UNIT- II: THE WIRELESS CHANNEL  
Overview of wireless systems — Concept of fading: Large scale fading, small scale fading, Physical modeling for wireless channels, different statistical channel models.  
Channel parameters: Time and Frequency coherence, delay spread, power profile, Capacity of wireless Channel-Capacity of Flat Fading Channel, Channel State Information, Capacity with Receiver diversity — Capacity comparisons – Capacity of Frequency Selective Fading channels, Jakes model for wireless channel correlation.

UNIT-III: CODE DIVISION FOR MULTIPLE ACCESS (CDMA):  
Introduction to Spread Spectrum, DSSS, FHSS, CDMA, Block diagram, fundamental of CDMA codes, Multi-user CDMA, advantages of CDMA, the Near-Far problem, performance of CDMA (uplink and down-link) with Multiple Users, Asynchronous CDMA.

UNIT-IV: MULTICARRIER MODULATION:  
Data Transmission using Multiple Carriers, Overlapping Sub channels, Mitigation of Sub Carrier Fading, Orthogonal Frequency Division Multiplexing (OFDM), Cyclic Prefix, Matrix Representation of OFDM, Vector Coding, PAR, Frequency and Timing Offset, Multi-user Channels, Multiple Access, Downlink Channel Capacity, Uplink Channel Capacity, Capacity in AWGN, SC-FDMA.

UNIT-V: MULTIPLE-INPUT-MULTIPLE-OUTPUT WIRELESS COMMUNICATIONS  
Introduction to MIMO wireless communication, MIMO system model, MIMO channel estimation.  
MIMO receivers: Zero Forcing, MMSE, Sphere decoding, Successive Interference Cancellation (SIC) (Non-linear receiver). Singular value decomposition (SVD) of MIMO channel and MIMO capacity.  
MIMO Techniques: Space-time block codes (STBC), Spatial Multiplexing (SMX), Vertical Bell Labs Layered Space time (VBLAST), Spatial Modulation (SM), Generalized Spatial Modulation (GSM), Generalized Space Shift Keying (GSSK), MIMO-OFDM, Massive MIMO.
UNIT VI: OVERVIEW OF EXISTING AND FUTURE WIRELESS SYSTEMS:
802: Overview & Architecture, 802.1: Bridging & Management, 802.2: Logical Link Control, 802.3: Ethernet, 802.11: Wireless LANs, 802.15: Wireless PANs, 802.16: Broadband Wireless MANs, 802.17: Resilient Packet Rings, 802.19:
Concept of compressive sensing, TV White Space Coexistence Methods, 802.20: Mobile Broadband Wireless Access, 802.21: Media Independent Handover Services, 802.22: Wireless Regional Area Networks, Zigbee

TEXT BOOKS:

REFERENCE BOOKS:

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<td>Error Vector Magnitude Measurement for GSM Signal</td>
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<td></td>
<td>ii) To measure the error vector magnitude, occupied bandwidth, and channel power of a GSM modulated RF signal using an oscilloscope and the VSA software</td>
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<td>2.</td>
<td>Spectrum Analysis of CDMA Signal</td>
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<td>Objectives</td>
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<td></td>
<td>iii) To measure the channel power of a CDMA modulated RF signal using an oscilloscope and the VSA software</td>
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<td>iv) To perform an in-band limit test or spectrum emission mask test on a CDMA modulated spectrum</td>
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<td>Spectrum Analysis of GSM Signal</td>
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<td></td>
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<td>iii) To measure the spurious and harmonics of the GSM and CDMA modulated RF signal using an oscilloscope and the VSA software</td>
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<td>iv) To perform an out-of-band limit test that identifies the pass or fail level of the spurious and harmonics</td>
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<td>4.</td>
<td>Occupied Bandwidth Measurement for GSM and CDMA Signals</td>
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<td></td>
<td>iii) To measure the occupied bandwidth of a GSM and CDMA modulated RF signal using an oscilloscope and the VSA software</td>
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<td>iv) To determine the parameter that changes the occupied bandwidth</td>
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<tr>
<td>5.</td>
<td>Adjacent Channel Power Ratio Measurement for GSM and CDMA Signals</td>
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<tr>
<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>ii) To measure the adjacent channel power ratio of the GSM and CDMA modulated RF signal using oscilloscope and VSA software</td>
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<td>6.</td>
<td>Noise and Error Influence for GSM Signal</td>
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<tr>
<td></td>
<td>Objective</td>
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<tr>
<td></td>
<td>ii) To measure the error vector magnitude of a GSM modulated RF signal with influence of noise and error using oscilloscope and VSA software</td>
</tr>
</tbody>
</table>

Course Name: ANTENNA SYSTEMS

UNIT II: BASIC OF RADIATION MECHANISM - Concept of Electric and Magnetic Current Distribution of Antennas, Vector and Scalar Potentials (Electrical and Magnetic), Derivation of Radiation Patterns for Ideal, Small, and Half Wavelength Dipole Antennas, WIRE ANTENNAS: Monopole, Dipole, Loop, Yagi Uda Antenna, Design of dipole and monopole antenna.


UNIT V: PLANAR/PATCH ANTENNAS - Microstrip Antennas (MSAs): Principle of radiation of Rectangular Microstrip Antenna, Feeding Techniques of MSAs, E & H field, RLC model, basic design equation, impedance and beam width characteristics, Circular and Triangular MSAs, Compact Microstrip Antennas, Broadband techniques. Printed Dipole and Monopoles – principles and broad banding techniques. Design a Rectangular, Circular and Triangular Patch Antennas.


UNIT VIII: ANTENNA MEASUREMENTS – Input impedance, Return Loss, VSWR, Bandwidth, Polarization, Radiation Patterns, Beam-width, Gain, Antenna Noise Power

TEXT BOOKS:
2. Vijay Madisetti, Wireless, Networking, Radar, Sensor Array Processing, and Nonlinear signal processing, CRC press....

REFERENCE BOOKS:
1. Mike Golio, JanetRF and Microwave Passive and Active Technologies, CRC press.
2. Frank Gustau, RF and Microwave Engineering, Wiley.

LIST OF EXPERIMENTS

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Measure the functions of the front panel board keys’s of Vector Network Analyzer (VNAZVA40) for the frequency range from 10MHz to 40 GHz for measurement of various antenna parameters.</td>
</tr>
<tr>
<td>2.</td>
<td>Measurement of various parameters of antenna on VNA (i.e. Return loss, VSWR, gain, bandwidth, radiation pattern, E-palne and H-plane etc.)</td>
</tr>
</tbody>
</table>
3. Radiation pattern measurement using DAMS controller and their connectivity to the antenna positioner inside the anechoic chamber and to the VNA.

4. Measure and understood the antenna software which support to VNA, Antenna positioned and DAMS controller for “automated antenna measurement system”.

5. Delay measurement between two micro strip antennas using two port VNA ZVA40

Course Name: RADAR SIGNAL PROCESSING  
Course Code: EE610


UNIT-II: RADAR SIGNAL PROCESSING CHAIN: Introduction, Radar receiver chain, derivation of Doppler frequency shift, N-pulse DLC, Moving Target Indictor (MTI), Optimum MTIs, Improvement Factor, Coherent Pulse integration – FFT, FIR filters, Concept of Constant False Alarm Rate(CFAR), CFARs for various scenarios, Clutter map CFAR, site adaptive Radar signal processing, Radar displays.


UNIT-VI: TRACKING ALGORITHMS: Kalman Filters, Manouver Detection, Adaptive Kalman Filter, Interactive Multiple Model (IMM), Kalman Filter Track Initiation, False Track handling, Track Quality Tracking in Clutter, Data Association, Probabilistic Data Association, Multi-Target Tracking, Multiple Hypothesis Tracking on moving Platform, Tracking with Phased Array Radars, Performance Measures, Multi-Radar Tracking Schemes.

UNIT-V: DATA PROCESSING FOR PHASED ARRAY RADAR: Introduction, analog and digital beam forming, verification and Tracking, multi target tracking, high precision tracking, adaptive array processing, Introduction to photonics Radar.


TEXT BOOKS:
1. Mark A. Richards, Fundamentals of radar signal processing, Tata MG Hill.
2. Eyung W. Kang, Radar systems: analysis, design and simulation, Artech house.
5. Ian G. Cumming and Frank H. Wong, Digital processing of synthetic aperture radar, Artech House.

REFERENCE BOOKS:
1. D. Curtis Schleher, MTI and Pulsed Doppler radar with MATLAB, Artech house.
LIST OF EXPERIMENTS:

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<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Radar clutter modeling and statistical analysis of various clutter distributions, Realization of N-pulses DLC MTI using FPGA, Analysis of detection performance improvement due to coherent/non-coherent pulse integration using MATLAB.</td>
</tr>
<tr>
<td>2</td>
<td>Realization of various CFAR using FPGA, Generation and spectral analysis of different pulse compression waveforms using MATLAB.</td>
</tr>
<tr>
<td>3</td>
<td>Realization of Matched filtering operation and detection concept, analyzing the ambiguity diagram for different Radar waveforms, Modeling and simulation of micro-Doppler effect and processing.</td>
</tr>
<tr>
<td>4</td>
<td>Realization of adaptive Mono-pulse, Kalman and other tracking algorithms.</td>
</tr>
<tr>
<td>5</td>
<td>Simulating the phased array assisted tracking technique, Realization of digital and non-adaptive beam forming, Adaptive array processing using LMS algorithm.</td>
</tr>
<tr>
<td>6</td>
<td>Modeling an adaptive digital beam former using, SAR simulation and Moving platform (airborne, space-borne and ship-borne) modeling using System Vue.</td>
</tr>
</tbody>
</table>

**Course Name: ARRAY SIGNAL PROCESSING**

**Course Code: EE611**

**UNIT – I: SPATIAL SIGNALS**
Array processing fundamentals, Signals in space and time, Spatial frequency, Direction vs. frequency, wave fields, far field and near field signals, spatially white signals, Array signal & Noise models, Isotropic Noise characteristics.

**UNIT – II: SENSOR ARRAYS**

**UNIT – III: SPATIAL FILTERS**
Aliasing in spatial frequency domain, Spatial Domain Filtering, Time Delay Beam forming, Spatial DFT/FFT, Frequency domain Beam forming, Beam power pattern responses for ULA, Optimum beam formers

**UNIT – IV: ADAPTIVE BEAM FORMING & DIRECTION OF ARRIVAL ESTIMATION**

**UNIT-V: ACOUSTIC VECTOR SENSOR ARRAY PROCESSING**

**TEXT BOOKS:**

**REFERENCE BOOKS:**
LIST OF EXPERIMENTS

<table>
<thead>
<tr>
<th>Sl. No</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction of Matlab/Simulink, Lab view and its tool boxes to simulate spatially coherent signals in the presence of spatially and temporally correlated/uncorrelated noise (Simulation of Received Array Data Vector)</td>
</tr>
<tr>
<td>2</td>
<td>Target Signal &amp; Ambient Noise Simulation (Scalar &amp; Vector Sensor Array Data Vector Simulation): Generation of Multiple spatial targets in presence of Strong interferences and Additive Correlated/Uncorrelated, White/Colored Ambient Noise</td>
</tr>
</tbody>
</table>
| 3      | Development of following Direction Of Arrival (DoA) estimation techniques  
1. Conventional Beam former Via Delay & Sum technique (Wideband Spatial Filter)  
2. Conventional Beam former Via Phase Shift based technique (Narrowband Spatial Filter) |
| 4      | Development and performance comparison of the following High Resolution Adaptive Beam former techniques using Scalar sensor array & Acoustic Vector Sensor Array: MVDR, MPDR, MUSIC, ESPRIT, Subspace Intersection Method (SIM), Generalized Side lobe Cancellation (GSC) Beam former |
| 5      | Performance comparison of Conventional (Lab3) and High resolution Adaptive beam formers (Lab4) in the presence of strong interferences and Spatially Correlated Noise |
| 6      | Real time demonstration – Direction of Arrival estimation of an acoustic source using 8 element microphone array hardware. |

Course Name: HIGH POWER MICROWAVE SYSTEMS AND DEW  
Course Code: EE612

UNIT-I: INTRODUCTION AND DESIGN OF HPMW SYSTEMS: Introduction, HPM operating regimes, future directions in HPM, system approach, components linking, system issues and advanced systems.

UNIT-II: MW FUNDAMENTALS: Introduction, Basic concepts in EMs, Periodic slow-wave structures, cavities, intense relativistic electron beam, rotating magnetically insulated electron layers, microwave generating interactions, amplifiers and oscillators, high and low current operating regimes, multispectral sources.

UNIT-III: HPM TECHNOLOGIES: Introduction, pulse power, electron beam generation/propagation, pulse compression, diagnostics, computations technology, HPM facilities, beam less systems, UWB switching technologies, UWB systems and non-linear transmission line.

UNIT-IV: HPM SOURCES AND STRUCTURES: Introduction, design principle, operational features, R&D issues: Relativistic magnetron, MILOs, BWOs, MWCGs and O-type Cerenkov devices, Klystrons and Reltrons, Vircators, Gyrotrons, Electron Cyclotron masers and free-electron lasers.

UNIT-V: HPM APPLICATIONS: HPM weapons, EM terrorism, counter DEW, High-power radar, power beaming, space propulsion, plasma heating and particle accelerators.

TEXT BOOKS:  

REFERENCE BOOKS:  
1. Victor L. Granatstein, Igor AlexeffHigh-power Microwave Sources, Artech House.  
2. Robert J. Barker, EdlSchamiloglu, High-Power Microwave Sources and Technologies, Wiley.  


UNIT-IV: ELECTRONIC COUNTER-COUNTERMEASURES: Search Radar Counter-Countermeasures, Tracking Radar Counter-Countermeasures, Infrared Counter-Countermeasures, Communications Counter-Countermeasures.


TEXT BOOKS:
1. EW101: A First Course in Electronic Warfare, David Adany, Artech House
2. EW102: A Second Course in Electronic Warfare, David Adany, Artech House
4. Introduction to Electronic Warfare 1984, Schleher De, Artech House

REFERENCE BOOKS:
3. Fundamentals of Electronic Warfare, Artech House by Sergei A. Vakin

LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Simulation of ESM Techniques using Spectrum Analysers</td>
</tr>
<tr>
<td>2.</td>
<td>Simulation of ECM techniques using Signal Generators and Spectrum Analysers</td>
</tr>
<tr>
<td>3.</td>
<td>Simulation of Direction Finding technique using Watson-Watt Technique</td>
</tr>
<tr>
<td>4.</td>
<td>Location Estimation technique using GPS Receivers</td>
</tr>
<tr>
<td>5.</td>
<td>Simulation of Wideband and Narrow band Receivers</td>
</tr>
</tbody>
</table>

Course Name: ELECTRONIC WARFARE
Course Code: EE613

Course Name: EMI/EMC,EMP, NEMP DESIGN
Course Code: EE614
UNIT-I: THEORY AND PRINCIPLES OF EMI/EMC: Sources of EMI, Conducted and Radiated EMI, Transient EMI, EMI/EMC definitions and units. Conducted, Radiated and Transient Coupling, Common Impedance Ground Coupling, Radiated, Common Mode and Ground Loop Coupling Radiated Differential Mode Coupling, Near Field Cable to Cable Coupling, Power Mains and Power Supply Coupling.


UNIT-IV: EMI CONTROL TECHNIQUES: Shielding, Filtering, Grounding, Bounding, Isolation Transformer, Transient Suppressors, Cable Routing, Signal Control, Component Selection and Mounting.


UNIT-VII: EMC MANAGEMENT CONCEPTS [E(MC)²]: Electromagnetic Environmental Effects (E3) Management, Spectrum Supportability (SS), E3 and SS policies- plans- and programs at the executive and working levels/program/project management, Spectrum Management, Program management services to DoD and military departments, Military Department Operational Spectrum Management, EM Modeling and Simulation (M&S) services, steps for the proper development of an EMC control plan (source- http://www.emcmanagement.com/)

TEXT BOOKS:


REFERENCE BOOKS:

2. Handbook for EMC- testing and measurement, Morgan D.
3. EMI & Compatibility Vol 1 to 6 Electrical Noise & EMI SPEC, White, DON white

LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Experiments</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>FieldFox and Spectrum Analyser</td>
</tr>
</tbody>
</table>

350
### Digital Pulse Spectra and Rise Time Measurement

**Objective**
- To investigate the relationship between the rise/fall time of a digital signal and its frequency spectrum

### Controlling Crosstalk: Frequency-Domain Perspective

**Objectives**
- To measure crosstalk in the frequency domain
- To investigate the factors affecting the crosstalk level

### Controlling Crosstalk: Time-Domain Perspective

**Objectives**
- To measure crosstalk in the time domain
- To investigate the factors affecting the crosstalk level

### Controlling Common Impedance Coupling

**Objectives**
- To illustrate the effect of power supply noise on sensitive circuits
- To illustrate the usage of decoupling capacitors and printed circuit board (PCB) layout in reducing power supply noise

### Controlling Radiated Emission from Cable and PCB

**Objectives**
- To observe the frequency spectrum of the near-field electromagnetic (EM) radiation from cables and printed circuit board (PCB) traces using a near-field probe and spectrum analyzer
- To learn some simple methods to reduce unwanted radiation using ferrite beads, grounding, and differential signaling

### Transfer Impedance Measurement

**Objectives**
- To measure the transfer impedance of a coaxial cable as a function of frequency
- To understand the importance of transfer impedance as a gauge of the shielding capability of a cable

### EMI Measurement

1. Measure the EMI using EMI test receiver, LISN, EMI software’s etc
2. Measurement of frequency ranges of various EMI/EMC antennas and there various test range comparison to MIL-STD-461F
3. Different probes of EMI/EMC used to measure the EMI (for H-field, E-field), which is present in the various electronic circuits and their frequency of operations.
4. To measure and verify the EMI present in the RADAR circuits/KITS

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**Course Name:** GNSS RECEIVER DESIGN AND APPLICATIONS  
**Course Code:** EE615

**UNIT-I:** UNDERSTANDING APPLICATIONS AS A FUNCTION OF GNSS RECEIVER DESIGN: Detailed explanation of a Receiver Input Output Diagram and explanation of possible applications at various sub-system levels.

**UNIT-II:** GNSS RECEIVER DESIGN AND MODIFICATIONS FOR HIGH SENSITIVITY APPLICATIONS: Detailed elaboration of receiver design for high sensitivity applications and its nuances. Case study of an application Module.

**UNIT-III:** GNSS RECEIVER DESIGN AND MODIFICATIONS FOR HIGH SIGNAL DYNAMIC APPLICATIONS: Detailed elaboration of receiver design for high signal applications and its nuances. Case study of an application.

**UNIT-IV:** GNSS RECEIVER DESIGN AND MODIFICATIONS FOR HIGH INTEGRITY APPLICATIONS: Detailed elaboration of receiver design for aerospace applications and its nuances. Introduction to SBAS. Case study of an application, Module.
UNIT-V: GNSS RECEIVER DESIGN AND MODIFICATIONS FOR INTEGRATION WITH OTHER SENSORS: Need for integration with other sensors and its merits case study of one integration concept Module.

UNIT-VI: INTRODUCTION OF GNSS IN ADVANCED SYSTEM LEVEL APPLICATIONS: Introduction and explanation of how GNSS is used in determination of attitude of a vehicle, precision farming, anti-collision techniques say in train and discussion on some new potential topics.

TEXT/REFERENCE BOOKS:

LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Simulation of Receiver Design and modifications for high sensitivity applications</td>
</tr>
<tr>
<td>2.</td>
<td>GNSS Receiver Design and modifications for integration with other sensors</td>
</tr>
<tr>
<td>3.</td>
<td>GNSS Receiver Design and modifications for high signal dynamic applications</td>
</tr>
<tr>
<td>4.</td>
<td>GNSS Receiver Design and modifications for high integrity applications Suggested</td>
</tr>
</tbody>
</table>

Course Name: MULTI SENSOR INTEGRATED NAVIGATION
Course Code: EE616


TEXT BOOKS:
1. Fundamentals of Statistical Signal Processing: Estimation Theory by Steven M. Kay
4. Estimation with Applications to tracking and navigation by Yaakov Bar-Shalom, X. Rong Li, Thiagalingam Kirubarajan.
5. Mathematical techniques in multi-sensor data fusion, David L. Hall, Artech House, Boston.
8. Aided Navigation GPS with High rate sensors, Jay A Farrell

**LIST OF EXPERIMENTS:**

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Using MATLAB program to check the (A) Controllability and (B) Observability of a system given by its state space model.</td>
</tr>
<tr>
<td>2.</td>
<td>Obtain a state-space representation of the system with given transfer function using MATLAB. 3. Obtain a transfer function of the system with given state-space representation using MATLAB. 4. Using MATLAB determines the state feedback-gain matrix K of a state space model given closed loop poles.</td>
</tr>
<tr>
<td>3.</td>
<td>Using MATLAB determine the observer gain matrix Ke of a state space model given closed loop poles.</td>
</tr>
</tbody>
</table>

**Course Name:** INERTIAL NAVIGATION SYSTEMS  
**Course Code:** EE617

**UNIT-I: FRAMES OF REFERENCES AND INERTIAL NAVIGATION FUNDAMENTALS**

**CONCEPT OF FRAMES OF REFERENCES:** inertial frames, non-inertial frames, geographic frame, geocentric frame, body frame; **Principles of inertial navigation:** types of inertial navigation, stabilized platform and strap down systems, comparison; **Earth models:** ellipsoid geometry, ellipsoid gravity, earth gravity field, gravitational potential, gravity and gravitation, plum-bob gravity; **Concepts of coordinate transformations:** direction cosine matrix(DCM), Euler angles, quaternion; relation between DCM, Euler angles & quaternion

**UNIT-II: CONCEPTS OF STRAPDOWN INERTIAL NAVIGATION**

**INERTIAL MEASUREMENTS:** concept of specific force, basic principles of accelerometer: pendulous and vibrating beam, basic principle of gyroscope: mechanical and optical; **Navigation equations formulation:** forces in inertial & non-inertial frames, navigation equations in inertial & non-inertial frames, choice of reference frame, strap down system mechanization for different frames: inertial frames, earth fixed frames, geographic frames

**UNIT-III: STRAPDOWN INERTIAL NAVIGATION COMPUTATIONS**

**SENSOR GEOMETRY:** measurement model, concepts of DOP, failure detectability, optimal sensor geometry for different number of sensors; sensor modeling & compensation algorithms (scale factor, bias, misalignment etc.), practical constraints; **Failure detection and isolation:** concepts of parity vectors, generalized likelihood test; **Attitude propagation algorithm:** using Euler angle, DCM and quaternion; quaternion in terms of rotation vector, first and second order orientation vector algorithms for quaternion propagation, acceleration transformations, velocity & position update algorithms, numerical integration methods, comparison

**UNIT-IV: INERTIAL NAVIGATION SYSTEM ALIGNMENT**

Initialization of inertial navigation system; **Principle of alignment:** alignment on a fixed platform: azimuth and level alignment, alignment on a moving platform: in-flight alignment and shipboard alignment: one shot transfer alignment, measurement matching, methods of measurement matching; gyro-compassing; self corrective alignment scheme

**UNIT-V: NAVIGATION SYSTEM SIMULATION AND ERROR ANALYSIS**

**ERROR ANALYSIS:** development of perturbation models, attitude response under angular vibration, velocity response under combined angular and linear vibration, size effect errors, modeling of sensor assembly response to system level vibration; specialized error analysis for strap down mechanization, **INS Simulation:** simulation of sensors, measurement electronics and navigation algorithm; **Navigation algorithm validation:** comparison testing, closed loop simulations using NGC software together, hardware in-loop simulations; static navigation test, Monte Carlo & covariance analysis; **General strap down algorithm validation:** spin-cone, spin-accel, spin-rock-size, gen-nav
UNIT VI: ADVANCED NAVIGATION CONCEPTS
Fundamentals of screw theory; fundamentals of Clifford algebra; dual quaternion and its applications in navigation

TEXT BOOKS:
1. David A Vallado; Fundamentals of astrodynamics and applications,
2. Kenneth R Britting; Inertial navigation system analysis
3. David H Titterton & John L Weston; Strap down inertial navigation technology.
4. Robert M Rogers; Applied mathematics in integrated navigation systems
5. Paul G Savage; Strapdown analytics
7. Oleg Salychev; Applied Inertial Navigation: Problems & Solutions

LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Use MATLAB to calculate the reliability of a TMR system if each component is having reliability R and only single module exist.</td>
</tr>
<tr>
<td>2.</td>
<td>Use MATLAB to calculate the measurement matrix of navigation sensors arranged in a skew symmetry given half cone angle.</td>
</tr>
<tr>
<td>3.</td>
<td>Use MATLAB to calculate the sensitivity of sensor errors.</td>
</tr>
<tr>
<td>4.</td>
<td>Use MATLAB to calculate the GDOP for sensor performance.</td>
</tr>
<tr>
<td>5.</td>
<td>Use MATLAB to calculate the PDOP for sensor performance.</td>
</tr>
</tbody>
</table>

Course Name: INDOOR NAVIGATION
Course Code: EE618

UNIT-I: INTRODUCTION:
Location-Based Services (LBS), Indoor LBS and Ubiquitous Computing, Classical Research Areas Related to Indoor LBS, Classical Applications of LBS, Information Services, Navigation Service, Safety-of-Life Applications, Retail and Commerce, Management, Social Networking and Joint Activities, Gaming, A Short History of Navigation,

UNIT-II: BASIC POSITIONING TECHNIQUES:

UNIT-III: BUILDING MODELING:

UNIT-IV: POSITION REFINEMENT:
Least Squares Estimation with Correlation, Recursive Least Squares Estimation, Discrete Kalman Filtering, The Extended Kalman Filter, Particle Filtering, Grid-Based Methods, Sampling Importance Resampling.

UNIT-V: TRAJECTORY COMPUTING:
The Process of Trajectory Computing, Trajectories, Trajectory Comparison, Hausdorff Distance, Fréchet Distance, Jaccard Distance, Closet Pair Distance, Euclidean Distance Sum, Dynamic Time Warping, Longest Common Subsequence (LCSS), Edit Distance on Real Sequences, Edit Distance with Real Penalties, Outlook, Trajectory Computing for Indoor LBS, Trajectory Computing for Positioning, Movement Patterns, Spatial Movement Patterns, Group-Based Motion Patterns

UNIT-VI: EVENT DETECTION FOR INDOOR LBS:
Event-Driven Applications, Event Sources for Indoor Navigation, Primary Events from Environmental Knowledge, Primary Events from Infrastructure, Primary Events from User Interface, Primary Events from Positioning, Primary Events from Activity Recognition, Secondary Events Relevant to the Navigational Task.

UNIT-VII: SIMULTANEOUS LOCALIZATION AND MAPPING IN BUILDINGS:
Data Sources for SLAM, Data from Inertial Navigation Systems, Data from Laser Scanners, Data from Landmarks, Data from Camera Systems, Important Algorithms for SLAM Systems, Visual Feature Point Extraction, Optical

UNIT-VIII: OPEN PROBLEM SPACES (CASE STUDIES):

TEXT BOOKS:
1. Indoor Location-Based Services Prerequisites and Foundations, Werner, Martin, Publisher: Springer; 2014 Edition ISBN-10: 3319106988

REFERENCE BOOKS:

LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Single satellite- waveform by using WLAN or Signal generator or GPRS</td>
</tr>
<tr>
<td>2.</td>
<td>Multi-satellite waveform by using WLAN or Signal generator or GPRS</td>
</tr>
<tr>
<td>3.</td>
<td>Indoor Mapping using WLAN</td>
</tr>
<tr>
<td>4.</td>
<td>Scenario generation and editing- by using WLAN or Signal generator or GPRS</td>
</tr>
<tr>
<td>5.</td>
<td>Satellite based augmentation system (SBAS)- by using WLAN or Signal generator</td>
</tr>
<tr>
<td>6.</td>
<td>Real-time CW interference- by using WLAN or Signal generator</td>
</tr>
<tr>
<td>7.</td>
<td>Real-time display- by using WLAN or Signal generator</td>
</tr>
</tbody>
</table>

Course Name: SOFTWARE DEFINED RADIO
Course Code: EE619


UNIT III: SIGNAL PROCESSING DEVICES AND ARCHITECTURES: General Purpose Processors, Digital Signal Processors, Field Programmable Gate Arrays, Specialized Processing Units, Tilera Tile Processor, Application-Specific Integrated Circuits, Hybrid Solutions, Choosing a DSP Solution. GPP-Based SDR, Non real time Radios, High-Throughput GPP-Based SDR, FPGA-Based SDR, Separate Configurations, Multi-Waveform
UNIT IV: COGNITIVE RADIO: TECHNIQUES AND SIGNAL PROCESSING History and background, Communication policy and Spectrum Management, Cognitive radio cycle, Cognitive radio architecture, SDR architecture for cognitive radio, Spectrum sensing Single node sensing: energy detection, cyclostationary and wavelet based sensing- problem formulation and performance analysis based on probability of detection vs SNR. Cooperative sensing: different fusion rules, wideband spectrum sensing- problem formulation and performance analysis based on probability of detection vs SNR.


TEXT BOOKS:

LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Simulation of SDR Flow in SystemVue</td>
</tr>
<tr>
<td>2.</td>
<td>Simulation of SDR Flow in FPGA.</td>
</tr>
<tr>
<td>3.</td>
<td>Simulation of SDR/CR using GNU radio Simulation Software</td>
</tr>
<tr>
<td>4.</td>
<td>Study of Wideband and Narrow Band frequency allocations and applications /Signals using USRP</td>
</tr>
<tr>
<td>5.</td>
<td>Simulation of SDR Flow in SystemVue</td>
</tr>
</tbody>
</table>

Course Name: SoC AND EMBEDDED SYSTEM
Course Code: EE620

UNIT-I: INTRODUCTION: Definition and Classification, Overview of Processors and hardware units in an embedded system, Software embedded into the system, Exemplary Embedded Systems, Embedded Systems on a Chip (SoC) and the use of VLSI designed circuits.


UNIT-IV: ADVANCED EMBEDDED COMPUTING: Programmable System on Chip, Cypress PSoC Technology. Advance DSP Processors. FPGA Technology towards Embedded system aspects- Pico blaze and micro

**TEXT BOOKS:**
3. An Embedded software primer David E Simon,Pearson Education Twelfth India reprint,2005

**REFERENCE BOOKS:**
5. DSP Architecture, Programming and Application- B Venkataramani, M Bhaskar.

**LIST OF EXPERIMENTS:**

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Simulation of ALP using 8086 Emulator</td>
</tr>
<tr>
<td>2</td>
<td>FPGA programming using VHDL.</td>
</tr>
<tr>
<td>3</td>
<td>Radar signal generation using FPGA.</td>
</tr>
<tr>
<td>4</td>
<td>Creating a custom IP core using the IP Integrator in Vivado IDE</td>
</tr>
<tr>
<td>5</td>
<td>Recording and play back of audio signal using Zedboard DMA</td>
</tr>
<tr>
<td>6</td>
<td>Peripheral Module Interface using soft core processor Microblaze</td>
</tr>
<tr>
<td>7</td>
<td>PWM Applications using PSoC</td>
</tr>
<tr>
<td>8</td>
<td>Introduction to CUDA programming and Tesla Processors</td>
</tr>
</tbody>
</table>

**Course Name:** DIGITAL INTEGRATED CIRCUIT DESIGN  
**Course Code:** EE621

**UNIT –I: MOS Design:** Pseudo NMOS Logic – Inverter, Inverter threshold voltage, Output high voltage, Output Low voltage, Gain at gate threshold voltage, Transient response, Rise time, Fall time, Pseudo NMOS logic gates, Transistor equivalency, CMOS Inverter logic.

**UNIT –II: Combinational MOS Logic Circuits:** MOS logic circuits with NMOS loads, Primitive CMOS logic gates – NOR & NAND gate, Complex Logic circuits design – Realizing Boolean expressions using NMOS gates and CMOS gates , AOI and OIA gates, CMOS full adder, CMOS transmission gates, Designing with Transmission gates.

**UNIT –III: Sequential MOS Logic Circuits:** Behavior of bistable elements, SR Latch, Clocked latch and flip flop circuits, CMOS D latch and edge triggered flip flop.

**UNIT –IV: Dynamic Logic Circuits:** Basic principle, Voltage Bootstrapping, Synchronous dynamic pass transistor circuits, Dynamic CMOS transmission gate logic, High performance Dynamic CMOS circuits.

**UNIT –V: Semiconductor Memories:** Types, RAM array organization, DRAM – Types, Operation, Leakage currents in DRAM cell and refresh operation, SRAM operation Leakage currents in SRAM cells, Flash Memory- NOR flash and NAND flash.

**TEXT BOOKS:**

**REFERENCE BOOKS:**

**LIST OF EXPERIMENTS:**

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Use of SPICE for MOSFET modeling and simulation of Digital combinational Circuits.</td>
</tr>
<tr>
<td>2</td>
<td>Schematic gate level Simulation of Digital combinational circuits</td>
</tr>
<tr>
<td>3</td>
<td>LVS simulation of Digital circuits.</td>
</tr>
<tr>
<td>4</td>
<td>Schematic gate level Simulation of Digital sequential circuits</td>
</tr>
<tr>
<td>5</td>
<td>Simulation of memory circuits using PSPICE.</td>
</tr>
</tbody>
</table>

**Course Name: RF IC DESIGN**  
**Course Code: EE622**


**UNIT III FREQUENCY SYNTHESIZERS:** Phase Locked Loops - Voltage Controlled Oscillators - Phase Detector – Analog Phase Detectors – Digital Phase Detectors - Frequency Dividers - LC Oscillators - Ring Oscillators - Phase Noise - A Complete Synthesizer Design Example (DECT Application).

**UNIT IV UB SYSTEMS:** Data converters in communications, adaptive Filters, equalizers and transceivers

**UNIT V IMPLEMENTATIONS:** VLSI architecture for Multitier Wireless System - Hardware Design Issues for a Next generation CDMA System.

**TEXT BOOKS:**

**REFERENCE BOOKS:**

**LIST OF EXPERIMENTS:**

<table>
<thead>
<tr>
<th>Sl. No</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Characterization of Mixer using FieldFox</td>
</tr>
<tr>
<td>2</td>
<td>Characterization of LNA and Power Amplifier using FieldFox</td>
</tr>
<tr>
<td>3</td>
<td>Characterization of Frequency Synthesizers.</td>
</tr>
<tr>
<td>4</td>
<td>Simulation of LNA and Power Amplifier using ADS Software.</td>
</tr>
<tr>
<td>5</td>
<td>Simulation of Mixer using ADS Software.</td>
</tr>
</tbody>
</table>
UNIT-I Basic Semiconductor Physics
Crystal lattice, energy band model, density of states, distribution statistics – Maxwell-Boltzmann and Fermi-Dirac, doping, carrier transport mechanisms, - drift, diffusion, thermionic emission, and tunneling; excess carriers, carrier lifetime, recombination mechanisms – SHR, Auger, radiative, and surface.

UNIT-II: Junctions
p-n junctions – fabrication, basic operation – forward and reverse bias, DC model, charge control model, I-V characteristic, steady-state and transient conditions, capacitance model, reverse-bias breakdown, SPICE model; metal- semiconductor junctions – fabrication, Schottky barriers, rectifying and ohmic contacts, I-V characteristics.

UNIT III: MOS Capacitors and MOSFETs
The MOS capacitor – fabrication, surface charge – accumulation, depletion, inversion, threshold voltage, C-V characteristics – low and high frequency; the MOSFET – fabrication, operation, gradual channel approximation, simple charge control model (SCCM), Pao-Sah and Schichman – Hodges models, I-V characteristic, second-order effects – Velocity saturation, short-channel effects, charge sharing model, hot-carrier effects, gate tunneling; subthreshold operation – drain induced barrier lowering (DIBL) effect, unified charge control model (UCCM), SPICE level 1, 2, and 3, and Berkeley short-channel IGFET model (BSIM).

UNIT IV : MOSFETs and HEMTs
MESFETs – fabrication, basic operation, Shockley and velocity saturation models, I-V characteristics, high-frequency response, backgating effect, SPICE model; HEMTs – fabrication, modulation (delta) doping, analysis of III-V heterojunctions, charge control, I-V characteristics, SPICE model.

UNIT V : BJTs and HBTs; BJTs – fabrication, basic operation, minority carrier distributions and terminal currents, I-V characteristic, switching, second-order effects – base narrowing, avalanche multiplication, high-injection, emitter crowding, Kirk effect, etc.; breakdown, high-frequency response, Gummel-Poon model, SPICE model; HBTs: - fabrication, basic operation, technological aspects, I-V characteristics, SPICE model.

REFERENCE BOOKS:

LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Use of SPICE for semiconductor modeling. Large signal and small signal modeling of PN Junctions</td>
</tr>
<tr>
<td>2</td>
<td>Schottky diode implementation in SPICE2</td>
</tr>
<tr>
<td>3</td>
<td>MOS Capacitor modeling in SPICE SPICE level 1, 2, and 3, and Berkeley short-channel IGFET modeling</td>
</tr>
<tr>
<td>4</td>
<td>I-V characteristics, Large Signal and small signal modeling of MOSFET</td>
</tr>
<tr>
<td>5</td>
<td>I-V characteristics, SPICE Modeling of BJTs and HBTs</td>
</tr>
</tbody>
</table>

Course Name: DIGITAL SYSTEM DESIGN USING FPGAs
Course Code: EE624

UNIT I INTRODUCTION TO DIGITAL DESIGN: Combinational Circuit Design, Synchronous Sequential Circuit Design - Mealy and Moore model, State machine design, Analysis of Synchronous sequential circuit, State equivalence, State Assignment and Reduction, Analysis of Asynchronous Sequential Circuit, flow table reduction,
races, state assignment, Design of Asynchronous Sequential Circuit, Designing with PLDs – Overview of PLDs – ROMs, EPROMs – PLA – PAL - Gate Arrays – CPLDs and FPGAs, Designing with ROMs - Programmable Logic Arrays - Programmable Array logic.


UNIT IV FPGA - FPGAs - Logic blocks, Routing architecture, Design flow technology - mapping for FPGAs, Xilinx FPGA Architecture, Xilinx XC4000 - ALTERA’s FLEX 8000, Design flow for FPGA Design, Case studies: Virtex II Pro.


TEXT BOOKS:

REFERENCE BOOKS:
5. Digital Circuits and Logic Design – Samuel C. Lee , PHI

LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Name of Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.</td>
<td>The Basic FPGA Design Flow</td>
</tr>
<tr>
<td></td>
<td>1. To understand use of Xilinx ISE</td>
</tr>
<tr>
<td></td>
<td>2. To understand Xilinx Synthesis Technology or XST.</td>
</tr>
<tr>
<td>02.</td>
<td>Familiarization of FPGA Boards</td>
</tr>
<tr>
<td></td>
<td>1. Xilinx FPGA Boards (Virtex 6, Kintex7)</td>
</tr>
<tr>
<td></td>
<td>2. Implementation of Full adder, ALU, Memory and FIFO on FPGA</td>
</tr>
<tr>
<td>03.</td>
<td>Fault Detection Logic Implementation on FPGA</td>
</tr>
<tr>
<td></td>
<td>1. Stuck at Fault</td>
</tr>
<tr>
<td></td>
<td>2. Memory BIST</td>
</tr>
<tr>
<td>04.</td>
<td>Implementation of RISC CPU on FPGA and debugging using Embedded Logic Analyzers.</td>
</tr>
</tbody>
</table>
UNIT I Introduction:
Digital Signal processing and DSP systems, Comparison between general purpose and DSP processors. Examples of
digital signal processors, Motivation of the specialized processors. Fixed point vs Floating point, native data word
width. Importance of the course, why FPGAs lend to high-performance DSP design

UNIT II VHDL Simulation and Synthesis: VHDL Code Structure, Data types, Operators, Concurrent & Sequential
code, Library Packages, Functions Procedures, Test bench. Combinational circuits, Binary Adders, Binary
Multipliers, Multiply Accumulator (MAC),CORDIC Algorithm. Sequential circuits, Mealy and Moore machine,
Frequency synthesizer, PLL, DDS (Direct digital Synthesizer).

UNIT III Implementation of Digital Filter.
Digital filters: Review of FIR and IIR filters, Optimal FIR filters Spectral or frequency transformation of IIR filters,
cascaded and lattice structures of FIR and IIR filters, Comparison of FIR and IIR filters.

UNIT IV Multi Rate Filters
Multi rate signal processing – Decimation by a integer factor, Interpolation by a integer factor, Sampling rate
conversion by a rational factor, Design of practical sampling rate converters, Software implementation of sampling
rate converters, Applications of Multi rate signal processing.

UNIT V Case Studies
VHDL Design with Basic displays, CIC Filter Implementation, Designing a MAC FIR -Serial Communication
circuits, Digital Correlation by FFT. QPSK Transmitter Model, Receiver Model

TEXT BOOKS:
1. Digital Signal Processing with Field Programmable Gate Arrays (Signals and Communication Technology). Uwe

LIST OF EXPERIMENTS:

<table>
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<th>SL No</th>
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<tbody>
<tr>
<td>01.</td>
<td>The Basic Design Flow of DSP Implementation in FPGA.</td>
</tr>
<tr>
<td></td>
<td>1. To understand use of Xilinx System Generator.</td>
</tr>
<tr>
<td></td>
<td>2. To understand Xilinx Synthesis Technology or XST.</td>
</tr>
<tr>
<td>02.</td>
<td>Implementation of Dual Port RAMS, Addressable Shift Register, FIFO And ROM in FPGA.</td>
</tr>
<tr>
<td></td>
<td>1. Familiarization with Memory Blocks implementation in FPGA.</td>
</tr>
<tr>
<td></td>
<td>2. To Understand FPGA Hardware.</td>
</tr>
<tr>
<td></td>
<td>3. Familiarization of XUP board (Vertex-5).</td>
</tr>
<tr>
<td>03.</td>
<td>Implementation of M Code Adder in FPGA</td>
</tr>
<tr>
<td></td>
<td>1. This exercise provides an introduction to the integration of M Code into a System Generator System.</td>
</tr>
<tr>
<td></td>
<td>2. To understand functionality of a basic 2-input adder is interpreted from the M-code.</td>
</tr>
<tr>
<td>04.</td>
<td>Generation of Simulink System Period</td>
</tr>
<tr>
<td></td>
<td>1. To understand Simulink system periods, and confirm the meaning of this parameter from the simulation results.</td>
</tr>
</tbody>
</table>

Course Name: COMPRESSED SENSING AND SPARSE SIGNAL PROCESSING
Course Code: EE626


UNIT-II: Sparse Representations: Motivations and basic formulations, Uniqueness of sparse representation.
UNIT- III: Measurement Matrices: Null Space Property, Restricted Isometry Property (RIP), Johnson Lindenstrauss Lemma, Random Matrices and RIP.


UNIT-V: Applications: Classification. There can be a mini project for the course

TEXT BOOKS:

LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sr. No.</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Simulation of algorithms in Matlab/Lab view.</td>
</tr>
<tr>
<td></td>
<td>a. Basic Pursuit</td>
</tr>
<tr>
<td></td>
<td>b. Matching Pursuit,</td>
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<tr>
<td></td>
<td>c. Orthogonal Matching Pursuit,</td>
</tr>
<tr>
<td></td>
<td>d. Subspace Pursuit,</td>
</tr>
<tr>
<td></td>
<td>e. Compressive Sampling Matching Pursuit.</td>
</tr>
</tbody>
</table>

Course Name: SIGNAL THEORY, LINER ALGEBRA & TRANSFORM TECHNIQUES
Course Code: EE627


UNIT III: Linear Algebra General (real) vector spaces, Subspaces, Linear independence, Dimension, Norms, Orthogonal bases and Gram-Schmidt orthogonalization, Linear transformation, Kernel and range. Inverse transformations, Matrices of linear transformations, Change of basis, Similarity, Eigen values and Eigen vectors, Diagonalization, Orthogonal diagonalization of symmetric matrices, Singular value decomposition and its applications.

TEXT BOOKS:
1. Linear Algebra and its Applications, 1980, Gilber-strang, Academic press 2nd Edn,

REFERENCE BOOKS:
LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Simulation of the following techniques:</td>
</tr>
<tr>
<td></td>
<td>a) Transform Techniques</td>
</tr>
<tr>
<td></td>
<td>b) Z Transform</td>
</tr>
<tr>
<td></td>
<td>c) Fourier Transform</td>
</tr>
<tr>
<td></td>
<td>d) Wavelet Transform</td>
</tr>
<tr>
<td>2.</td>
<td>Gram-Schmidt orthogonalization for multiple wave forms</td>
</tr>
<tr>
<td>3.</td>
<td>Real time implementation Eigen values and singular values for speech signals</td>
</tr>
</tbody>
</table>

---

**Course Name:** ADVANCED ELECTRONICS SYSTEMS  
**Course Code:** EE628

UNIT -I: Introduction

UNIT -II: Sensors and advanced topics
Sensors as system components - Temperature sensors - Force and pressure sensors - Magnetic field sensors - Optical sensors - Microwave sensors - Miscellaneous sensors –MEMS-Fabrication steps.

UNIT -III: Analog IC Design
Analog Conditioning circuits: Advanced Current Sources & sinks; Voltage Reference circuit, Operational amplifiers - Architectures- Instrumentation Amplifiers, feedback-Filter Design-ADC-DAC. Concepts of Virtual Instrumentation: Lab View (can be supported by laboratory).

UNIT -IV: Digital IC Design
MOS inverter- Static and switching characteristics, Combinational MOS logic circuits -static logic Synchronous system and Sequential circuits design.

UNIT -V: RF Microelectronics
Low Noise Amplifier (LNA), Mixer, Oscillator, VCO and PLL, Power amplifier-Transceiver Architecture.

REFERENCE BOOKS:
5. Handbook of Modern Sensors by Fraden

LIST OF EXPERIMENTS

<table>
<thead>
<tr>
<th>No.</th>
<th>Name of the Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>Write VHDL programs for the a)Full Adder b)Multiplexer c)BCD-Gray code converter d)Shift Registers e) Barrel Shifters.</td>
</tr>
</tbody>
</table>

Aim:
01. To understand various modeling such as a) data flow modeling b) behavioral modeling C) structural modeling of VHDL.
02. Writing the test bench to create various stimulus for the DUT.

02. Implement the Booth Multiplier using structural modeling in FPGA.
Aim:
1. To understand the structural modeling of VHDL.
2. To understand the wordlength effects.
3. To understand the use of Xilinx ISE 16.1.
4. Hands on experience in SPARTAN 3E FPGA kits.

03. Implement a Traffic Light controller using Mealy Machine in FPGA.
Aim:
1. To understand the Mealy State machine.
2. To understand the use of Xilinx ISE 16.1.
3. Hands on experience in SPARTAN 3E FPGA kits.

04. Implement a Sequence Detector using Moore machine in FPGA.
Aim:
1. To understand the Moore State machine.
2. To understand the use of Xilinx ISE 16.1.
3. Hands on experience in SPARTAN 3E FPGA kits.

05. Design a 8 bit Processor contain both combinational and sequential circuits to perform various arithmetic and logical operations.
Aim:
1. To understand the mixed modeling styles of VHDL.
2. To understand the use of Xilinx ISE 16.1.
3. Hands on experience in SPARTAN 3E FPGA kits.

**Course Name:** SONAR SIGNAL PROCESSING  
**Course Code:** EE 629

**UNIT-I: HISTORICAL BACKGROUND AND BASICS OF SOUND:** History of sonar evolution, basics of sound measurement, measurement parameters, sound velocity profile and its variation, medium parameters.

**UNIT-II: UNDERWATER CHANNEL MODELS**

**UNIT-III: AMBIENT NOISE IN THE OCEAN AND SONAR EQUATION:** Sources of sound in the ocean, propagation impact, characteristics of the sources and there, impact on sonar performance. Sonar parameters, sonar equation for active and passive sonar.

**UNIT-IV: RADIATED NOISE FROM MARINE VESSELS:** Components of radiated noise, transmission of the components, propulsion types and their characteristics, ship design and stealth aspects.

**UNIT-V: REFLECTION AND SCATTERING BY SONAR TARGETS:** Active sonar target characteristics, design and stealth aspects, Sensor performance and self noise characteristics, ROC, statistical analysis for detection, State-of-the-art.

**UNIT-VI: SHALLOW WATER ACOUSTICS:** Deep Vs Shallow waters, Propagation in Tropical Littoral Waters, Band limited Channel Characteristics, Fluctuations of a Shallow Water Underwater Channel.

**UNIT-VII: PASSIVE SONAR CLASSIFIER:** Feature Extraction, Feature Transformation, Acoustic Signature Characteristics, Classification Algorithms, Practical Classifiers, Cepstral Features.

**TEXT BOOKS:**
LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sr. No</th>
<th>Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction of Matlab/Simulink, Lab view and its tool boxes for simulating a single spatially coherent underwater acoustic signals in the presence of spatially and temporally correlated/uncorrelated noise (Simulation of hydrophone array data vector)</td>
</tr>
<tr>
<td>2</td>
<td>Target Signal &amp; Ambient Noise Simulation (Scalar &amp; Vector Sensor Array Data Vector Simulation): Generation of Multiple surface and subsurface targets in presence of Strong interferences and Additive Correlated/Uncorrelated, White/Colored, Gaussian/Non-Gaussian Ambient Noise Process.</td>
</tr>
</tbody>
</table>
| 3      | Development of Conventional Direction Of Arrival (DoA) estimation techniques for Passive & Active Sonar  
  1. Conventional Beam former Via Delay & Sum technique (Wideband Spatial Filter)  
  2. Conventional Beam former Via Phase Shift based technique (Narrowband Spatial Filter) |
| 4      | Development and performance comparison of the following High Resolution Adaptive Beam former techniques using Scalar sensor array & Acoustic Vector Sensor Array in Passive & Active Sonar:- MVDR, MPDR, MUSIC, ESPRIT, Subspace Intersection Method (SIM), Generalized Side lobe Cancellation (GSC) Beam former |
| 5      | Performance comparison High resolution Passive & Active Sonar Signal Processing algorithms in the presence of strong interferences and Spatially Correlated Noise |
| 6      | Design & Development of STAP techniques to remove self noise radiated from own ship. Compare the Passive Sonar performance with & without STAP. |

Course Name: SONAR SYSTEM ENGINEERING  
Course Code: EE630

UNIT I: SOUND  
Wave motion, Sound pressure, Reference intensity, Source level, Radiated power, Limitations to sonar power, Cavitation, Interaction, Octave Bands, dB Scale, Far Field and Near Field Measurements, Projector sensitivity, Hydrophone sensitivity, Spectrum level, Sound in air and in sea water.

UNIT II: SONAR EQUATION  
The Active and Passive Sonar Equation. Sonar Parameters, Sound Velocity Profile (SVP), Sonar Performance, Limitations of the Sonar Equation, Detection Threshold and Receiver Operating Curve (ROC).

UNIT III: ARRAYS  
Beam Forming, Beam Steering, Beam Patterns, Uniform Linear Arrays (ULA), Cylindrical Arrays, Shading, Delay-and-Sum Beam forming, Conformal Arrays, Three dimensional Arrays, Cross Arrays, Spherical Arrays, Receiver and transmitter Arrays, Directivity Index, Sonar Domes, transducer design and characteristics.

UNIT IV: PROPAGATION OF SOUND IN THE SEA  

UNIT V: NOISE IN SONAR SYSTEMS  
Sonar System Noise, Self Noise, Ambient Noise in the Ocean, Flow Noise, Radiated Noise, Noise Factor of a Sonar, Figure of Merit, Practical Noise Levels.
UNIT VI: PASSIVE SONAR

UNIT VII: ACTIVE SONAR

TEXT BOOKS:
2. Sonar for Practising Engineers Third Edition by A. D. Waite ; WILEY 2002

Course name: SATELLITE COMMUNICATION
Course Code : EE631

UNIT I: OVERVIEW OF SATELLITE SYSTEMS, ORBITS AND LAUNCHING METHODS

UNIT II: GEOSTATIONARY ORBIT & SPACE SEGMENT

UNIT III: EARTH SEGMENT & SPACE LINK

UNIT IV: SATELLITE ACCESS
Single Access, Preassigned FDMA, Demand-Assigned FDMA, SPADE System. Bandwidth-limited a Power-limited TWT amplifier operation, FDMA downlink analysis. DMA, Companion of uplink Power requirements for FDMA & TDMA. On-board signal processing for TDMA / FDMA operation, Satellite switched TDMA, CDMA.

UNIT V: DIRECT BROADCAST SATELLITE SERVICES
Introduction, Orbital Spacings, Power Rating and Number of Transponders, Frequencies and Polarization, Transponder Capacity, Bit Rates for Digital Television, MPEG Compression Standards, Forward Error Correction, Home Receiver Outdoor Unit (ODU), Home Receiver Indoor Unit (IDU), Downlink Analysis, Uplink, Problems, Satellite Mobile Services, VSATs, Radarsat, Global Positioning Satellite System, Orbcomm.

Text Books:
Reference Books:

LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>To set up a satellite communication link and study of change in uplink and downlink frequency</td>
</tr>
<tr>
<td>2.</td>
<td>Transmission of Audio and Video signals and Data Communication over satellite link</td>
</tr>
<tr>
<td>3.</td>
<td>Different GPS data like longitude, latitude and different types of dilute of precision using GPS receiver</td>
</tr>
<tr>
<td>4.</td>
<td>Selection of various PN codes like Gold, Barker and MLS in CDMA Technology</td>
</tr>
<tr>
<td>5.</td>
<td>Generation (spreading) and demodulation (dispreading) of DSSS modulated signal</td>
</tr>
<tr>
<td>6.</td>
<td>Minimum shift keying modulation and demodulation</td>
</tr>
<tr>
<td>7.</td>
<td>Determination of Maximum bit rate of a digital fiber optic link</td>
</tr>
<tr>
<td>8.</td>
<td>Demonstrating different modulation techniques with suitable demodulation</td>
</tr>
<tr>
<td>9.</td>
<td>Demonstrating different optical fiber losses</td>
</tr>
<tr>
<td>10.</td>
<td>Simulation of FSOC data link</td>
</tr>
<tr>
<td>11.</td>
<td>Atmospheric losses in FSOC</td>
</tr>
<tr>
<td>12.</td>
<td>Modeling and simulation of atmospheric attenuation and turbulence strength</td>
</tr>
<tr>
<td>13.</td>
<td>Demonstrating the beam steering system</td>
</tr>
</tbody>
</table>

Course Name: ADVANCED COMMUNICATION SYSTEMS
Course Code: EE632


Position Coordinates in Latitude and Longitude, need of satellite based navigation systems, evolution of satellite based navigation systems. Trilateration, GNSS system architecture: Space segment, Ground segment, User segment, Reference coordinate systems, SBAS, Maps, Datum’s & Coordinate Systems.

UNIT-VI: CASE STUDIES/ EXAMPLES  GSM, WLAN, WPAN, LTE, WiMAX, Underwater Communication, GPS.

TEXT/REFERENCE BOOKS:
6. Mobile Communications, 2/e, Jochen Schiller, Pearson Education
8. Data Communications and Networking, By Behrouz A. Forouzan

LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Simulation of Analog and Digital Communication Techniques</td>
</tr>
<tr>
<td>2.</td>
<td>Simulation of ODFM Techniques</td>
</tr>
<tr>
<td>3.</td>
<td>Simulation of Satellite Communication Techniques using Kits/Simulator</td>
</tr>
<tr>
<td>4.</td>
<td>Simulation of GNSS Techniques with Single or Multiple satellites</td>
</tr>
<tr>
<td>5.</td>
<td>Simulation of Wireless Networks using NS-2</td>
</tr>
</tbody>
</table>

Course Name: UNDERWATER COMMUNICATIONS
Course Code: EE633


OFDM Modem Development: Components of an Acoustic Modem-OFDM Acoustic Modem in Air -OFDM Lab Modem-NPOL OFDM Modem

UNIT-3: PAPR CONTROL -PAPR Comparison-PAPR Reduction-Clipping-Selective Mapping-Peak Reduction Subcarriers,
Receiver Overview and Pre-processing,
Detection, Synchronization and Doppler Scale Estimation

REFERENCE BOOKS:
LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Design and Simulation of conventional Underwater Communication techniques using Lab VIEW/Matlab</td>
</tr>
<tr>
<td>2.</td>
<td>Design, Simulate OFDM system using Lab VIEW/Matlab/ FPGA and Test the system over ‘Air Acoustic Channel’ using Speaker and mike</td>
</tr>
<tr>
<td>3.</td>
<td>Design, Simulate, MIMO-OFDM system using Lab VIEW- FPGA and Test the system over ‘RF Channel’ using LabVIEW NI USRP Platform</td>
</tr>
<tr>
<td>4.</td>
<td>Test the MIMO-OFDM system over ‘Underwater Acoustic Channel’ using acoustic transducer in a glass tank at the lab</td>
</tr>
<tr>
<td>5.</td>
<td>Test the MIMO-OFDM system over ‘Underwater Acoustic Channel’ using acoustic transducer in the Khadakwasla Lake</td>
</tr>
</tbody>
</table>

**Course Name:** MONOLITHIC MICROWAVE INTEGRATED CIRCUIT  
**Course Code:** EE634

**UNIT I: INTRODUCTION TO MICROWAVE INTEGRATED CIRCUITS AND APPLICATIONS:**  

**METHODS OF ANALYSIS IN MIC:** Analysis of MIC by conformal transformation, Numerical method, Hybrid mode analysis, Losses in micro strip, Introduction to slot line and coplanar waveguide.

**UNIT II: COUPLERS AND LUMPED ELEMENTS: PASSIVE DEVICES:** Introduction to coupled micro strip, Even and odd mode analysis, coplanar circuits, Design and fabrication of micro strip components: Branch line couplers, Filters, switches, attenuators, Directional couplers, lumped elements for 169 MICs: Inductors, capacitors, resistors, multilayer techniques, Ferromagnetic substrates and inserts, Micro strip circulators, Phase shifters, Micro machined passive components, Comparison with distributed circuits.

**UNIT III: MICROWAVE ACTIVE DEVICES:** Microwave transistors, parametric diodes and amplifiers, PIN diodes, Transferred electron devices, Avalanche diodes, IMPATT, BARITT devices. RF CMOS devices, Microwave BJTs, GaAs FETs, MSFETs, low noise and power GaAs FETs and their applications.

**UNIT IV: HIGH & LOW POWER CIRCUITS:** Introduction, Impedance transformers, Filters, High power circuits, Low power circuits, MICs in Radar and satellite  
**AMPLIFIERS:** Stability & gain analysis, matching techniques, reactively matched amplifier design, LNA

**UNIT V: OSCILLATORS:** Design principles, active device CAD techniques for large signal oscillators design, Phase noise, MMIC_VCO, mixers.

**UNIT VI: FABRICATION METHODS:** Fabrication process of MMIC, Hybrid MICs, Dielectric substances, Thick film and thin film technology and materials, Testing methods, Encapsulation and mounting of devices.

**TEXT BOOKS:**
LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Impedance matching and S-Parameter analysis of: Coupled Transmission Line, Matching Transformers</td>
</tr>
</tbody>
</table>
| 2.      | S-parameter analysis of:  
a) Power dividers  
b) Branch line couplers  
c) Rat race |
| 3.      | Filter design: Lumped to Micro strip Line transformation  
a) Low pass filter  
b) High Pass Filter  
c) Band Pass Filters  
d) Band Stop Filter |
| 4.      | Amplifier Design and Stability Analysis (Simulation using ADS/Matlab)  
a) Region of operation analysis  
b) Gain analysis  
c) Stability analysis using Smith Chart  
d) V-I characteristic and S-Parameter analysis |
| 5.      | Basic Oscillator Design and analysis using ADS/Matlab |
| 6.      | Design a complete single micro strip antenna for single frequency to verify the results |
| 7.      | Design different types of micro strip antennas and to verify the different results of these antenna |

Course Name: **INERTIAL SENSORS AND SYSTEMS**  
Course Code: EE635

**UNIT I:** Basic principles of Navigation and Inertial Navigation, Gimbaled platform and Strap down Navigation systems, Overview of Inertial Sensors.

**UNIT II:** Gyroscope working principle. Single degree of freedom rate gyro and rate integrating gyro.  
Dynamically Tuned Gyroscope: Principle of operation, Design features, Single gimbal and dual gimbal flexures, Rebalance loop configuration, DTG errors and error model.  
Ring Laser Gyro: Principle of operation and different types, Sagnac Effect, Design features, Lock in and Dither, RLG errors and error model.  
Fiber Optic Gyro: Principle of operation, Difference with RLG, Design features, open loop and closed loop operation, Error sources in FOG, difference between Fiber optic laser gyro and ring laser gyro.  
Hemispherical Resonator Gyro: Principle of operation, Design features, HRG errors and error model.  
Other types of gyros: Nuclear Magnetic Resonance Gyro, Electro statically Suspended Gyro, Atom Interferometric Gyro etc.

**UNIT III:** Configuration, working principle and design of pendulous servo accelerometers. Servo accelerometer errors and error model.  
Other types of accelerometers: Vibrating Beam Accelerometer, Fiber optic Accelerometers, Atom Interferometric Accelerometer etc.

**UNIT IV:** MEMS Inertial Sensors: Introduction to MEMS Inertial Sensors, Overview of MEMS Fabrication Techniques.  
MEMS Accelerometers: Pendulous and non-pendulous accelerometers, Resonant beam accelerometer.  
MEMS Gyros: Coriolis Vibrating gyro principle, Tuning fork gyro, Comb structure and Ring structure mechanizations.

**UNIT V:** Inertial Navigation Systems: Gimbaled platform technology and Strap down system technology, their mechanization. Redundant Inertial Navigation Systems: Basic concepts of sensor redundancy, redundant sensor configurations, Sensor Failure detection and Isolation. Strap down INS realization: Basic concepts of system configuration, vibration isolation and temperature control/compensation.

**UNIT VI:** Testing of Inertial Sensors and Systems: Basic concepts and test philosophy.
Gyroscope Testing: Multi position test and Rate test, Frequency response test, Thermal test, Magnetic sensitivity
  test, Vibration test and Shock test.
Accelerometer Testing: Multi position test, Centrifuge test, Frequency response test, Thermal test, Magnetic
  sensitivity test, Vibration test and Shock test.
Gyro and Accelerometer error modeling and compensation.
INS Testing: Rate test and Multi position test, Attitude test, Static navigation test, Hardware in Loop tests,
  Environmental tests like EMI, Thermal, Vibration and Shock.

REFERENCE BOOKS:

LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sr No</th>
<th>Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Obtain an interference pattern using Michelson interferometer.(Basics for SAGNAC effect)</td>
</tr>
<tr>
<td>2.</td>
<td>Simulate DTG using MATLAB to calculate the rate</td>
</tr>
<tr>
<td>3.</td>
<td>Use MATLAB to plot the frequency response (BODE Plot) of DTG given by its closed loop transfer function</td>
</tr>
<tr>
<td>4.</td>
<td>Use MATLAB to calculate acceleration channel error model</td>
</tr>
<tr>
<td>5.</td>
<td>Use MATLAB to calculate rate channel error model</td>
</tr>
</tbody>
</table>

Course Name: NAVIGATION & AVIONICS SYSTEMS
Course Code: EE636

UNIT-I: INTRODUCTION
Various navigation method, Dead Reckoning position (DR), estimated position (EP) & Observed Position,
Gyrosopes, Mechanical, electromechanical, Ring Laser gyro, Fiber-optic gyro, Accelerometers

UNIT-II: INERTIAL NAVIGATION SYSTEM
INS components: transfer function and errors-The earth in inertial space, the coriolis effect-Mechanization. Platform
and Strap down, INS system block diagram, Different coordinate systems, Schuler loop, compensation errors,
Gimbal lock, Alignment

UNIT-III: AVIONICS
Need for Avionics in civil and military aircraft and space systems, Integrated Avionics and Weapon system, typical
avionics sub systems, Design and Technologies, VHF avionics
Communication system, data link, Telemetry

UNIT-IV: RADIO NAVIGATION
Different types of radio navigation, ADF, VOR/DME, Doppler, LORAN, DECCA and Omega, TACAN

UNIT-V: SATELLITE APPROACH AND LANDING AID
ILS, MLS, GLS - Ground controlled approach system surveillance systems-radio altimeter

UNIT-VI: SATELLITE NAVIGATION AND HYBRID NAVIGATION
Introduction to GPS system description, basic principles, position and velocity determination, signal structure,
DGPS, Introduction to Kalman filtering, Estimation and mixed mode navigation, Integration of GPS and INS,
utilization of navigation systems in aircraft

UNIT-VII: RADAR NAVIGATION
Navigation and traffic control using ground based radar and airborne radar, Tactical Air Navigation (TACAN),
TACAN Equipment, Fischer Plotting, Radar Navigation Aid: radar reflectors, radar beacons, Principle of
superposition Navigation, Chart matching equipment, accuracy obtained by chart matching, PPI Simulations.
TEXT BOOKS:

LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Experiments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Satellite Position fixing</td>
</tr>
<tr>
<td>2.</td>
<td>User position fixing using 3, 4 and 5 satellites</td>
</tr>
<tr>
<td>3.</td>
<td>DOPs Calculation</td>
</tr>
<tr>
<td>4.</td>
<td>Elevation and Azimuth angle Calculation</td>
</tr>
<tr>
<td>5.</td>
<td>Simulate of the following modulation schemes using MATLAB</td>
</tr>
<tr>
<td></td>
<td>b. Amplitude Shift keying, Frequency Shift Keying, Phase Shift keying.</td>
</tr>
<tr>
<td>6.</td>
<td>Study of Sampling and Reconstruction of signals</td>
</tr>
<tr>
<td>7.</td>
<td>Study of signal sampling and Reconstruction Techniques</td>
</tr>
</tbody>
</table>

Course Name: ASIC VERIFICATION USING SYSTEM VERILOG
Course Code: EE637


UNIT-II: Introduction to object oriented programming, Classes and Objects, Inheritance, Composition, Inheritance v/s composition, Virtual methods. Parameterized classes, Virtual interface, Using OOP for verification, System Verilog Verification Constructs

UNIT III: SYSTEM VERILOG ASSERTIONS: Introduction to assertion, Overview of properties and assertion, Basics of properties and sequences, Advanced properties and sequences, Assertions in design and formal verification, some guidelines in assertion writing.

SV and C interfacing: Direct Programming Interface (DPI)

UNIT V: CASE STUDIES: System Verilog based Verification of UART,8 bit ALU, RISC CPU.

TEXT BOOKS:

REFERENCE BOOKS:
1. “Writing Test benches using System Verilog” Bergeron, Janick 2006,
## LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Experiment</th>
</tr>
</thead>
</table>
| 1     | 1. Write an example to demonstrate the user defined data type enum, struct, struct packed, union, typedef and string.  
2. Write an example to demonstrate the static array, multi-dimensional static array, dynamic array, associative array and queue type array.  
3. Write an example to demonstrate a simple interface. |
| 2     | 1. Write an example to demonstrate class constructor, inheritance, encapsulation, and polymorphism.  
2. Write an example to demonstrate randomization, rand casec, rand sequence, rand sequence abort.  
3. Write an example to demonstrate DPI (Direct Programming Interface), both sv to c and c to sv.  
4. Write an example to demonstrate semaphore, mailbox, virtual interface |
| 3     | 1. Create SV based test environment for 1-bit adder.  
2. Create class based test environment for 1-bit adder |
| 4     | 1. Create a class based test environment for RAM memory given.  
2. Create a class based test environment for FIFO memory given. |
| 5     | 1. Create coverage and assertions for decade counter.  
2. Create coverage and assertions for ones counter. |
| 6     | Create coverage and assertions for RAM memory previously created counter. |
| 7     | Create coverage and assertions for FIFO memory previously created counter. |

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**Course Name:** ANALOG AND MIXED MODE VLSI DESIGN  
**Course Code:** EE638  
*Maximum Marks – 100; Credits - 3*

### UNIT-I: INTRODUCTION AND BASIC MOS DEVICES:
Challenges in analog design-Mixed signal layout issues-MOS FET structures and **characteristics**-large signal model—small signal model-single stage Amplifier-Source follower-Common gate stage -Cascode Stage

### UNIT-II: SUBMICRON CIRCUIT DESIGN:
Submicron CMOS process flow, Capacitors and resistors, Current mirrors, Digital Circuit Design, Delay Elements – Adders-OP Amp parameters and Design.

### UNIT III: DATA CONVERTERS:
Characteristics of Sample and Hold -Digital to Analog Converters-architecture-Differential Non linearity-Integral Non linearity-Voltage Scaling-Cyclic DAC-Pipeline DAC-Analog to Digital Converters-architecture –Flash ADC-Pipeline ADC-Differential Non linearity-Integral Non linearity

### UNIT IV :SNR IN DATA CONVERTERS :
Overview of SNR of Data Converters-Clock Jitters-Improving Using Averaging –Decimating Filters for ADC-Band pass and High Pass Sinc Filters-Interpolating Filters for DAC

### UNIT V: SWITCHED CAPACITOR CIRCUITS:
Resistors, First order low pass Circuit, Switched capacitor Amplifier, Switched Capacitor Integrator

### TEXT BOOKS:
REFERENCE BOOKS:

LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AN INVERTER : Schematic Entry and Symbol Creation Building the Inverter Test Design , Simulation with Spectre, Parametric Analysis ,Creating Layout View of Inverter ,Physical Verification ,Creating the Configuration View, Generating Stream Data.</td>
</tr>
<tr>
<td>2</td>
<td>NAND DESIGN : Schematic Entry and Symbol Creation Building the NAND Test Design , Simulation with Spectre, Parametric Analysis ,Creating Layout View of NAND Gate, Physical Verification ,Creating the Configuration View, Generating Stream Data.</td>
</tr>
<tr>
<td>3</td>
<td>SRAM DESIGN: Schematic Entry and Symbol Creation Building the SRAM Test Design, Simulation with Spectre, Creating Layout View of SRAM, Physical Verification.</td>
</tr>
<tr>
<td>4</td>
<td>COMMON SOURCE AMPLIFIER: Schematic Entry and Symbol Creation Building the COMMON SOURCE AMPLIFIER Test Design, Analog Simulation with Spectre.</td>
</tr>
<tr>
<td>5</td>
<td>DIFFERENTIAL AMPLIFIER DESIGN: Schematic Entry and Symbol Creation Building the DIFFERENTIAL AMPLIFIER DESIGN Test Design, Analog Simulation with Spectre.</td>
</tr>
<tr>
<td>6</td>
<td>BASIC OP AMP DESIGN: Schematic Entry and Symbol Creation Building the OP AMP Test Design, Analog Simulation with Spectre.</td>
</tr>
<tr>
<td>7</td>
<td>ADC Design: Schematic Entry and Symbol Creation Building the ADC Test Design , Simulation with Spectre.</td>
</tr>
</tbody>
</table>

Course Name: COMPUTER AIDED DESIGN OF VLSI CIRCUITS
Course Code: EE639

Maximum Marks – 100; Credits - 4

UNIT-I Various CAD Tools for front end and Back end design, Schematic editors, Layout editors, Place and Route tools. Introduction to VLSI Methodologies - VLSI Physical Design Automation - Design and Fabrication of VLSI Devices - Fabrication process.

UNIT-II: Introduction to Design Tools: Introduction & Familiarity with Design Tools from various vendors e.g. Synopsis, CADENCE, Mentor Tools etc.
Verilog Basics - Modeling Levels - Data Types - Modules and Ports - Instances - Basic Language Concepts - Dataflow modeling - Behavioral modeling
Modeling and Simulation of systems/subsystems using Verilog HDL.
Typical case studies.

UNIT III: Layout Algorithms Circuit partitioning, placement, and routing algorithms; Design rule verification; Circuit Compaction; Circuit extraction and post-layout simulation
UNIT IV: CAD Tools for Automatic Test Program Generation; Combinational testing D-Algorithm and PODEM algorithm; Scan-based testing of sequential circuits; Testability measures for circuits.


TEXT BOOKS:
5. Verilog HDL by Samir Palnitkar

REFERENCE BOOKS:
1. VERILOG HDL SYNTHESIS: A PRACTICAL PRIMER by J Bhaskar

LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Modelling and simulation of the following using Verilog Language and VLSI CAD Tools</td>
</tr>
<tr>
<td>2</td>
<td>Modeling and Simulation of ALU using Verilog</td>
</tr>
<tr>
<td>3</td>
<td>Modeling and simulation of Memory and FIFO in Verilog</td>
</tr>
<tr>
<td>4</td>
<td>Simulation of NMOS and CMOS circuits using SPICE.</td>
</tr>
<tr>
<td>5</td>
<td>RTL to GDSII Generation</td>
</tr>
<tr>
<td>6</td>
<td>Modeling of MOSFET using C</td>
</tr>
<tr>
<td>7</td>
<td>ATPG Generation using CAD Tools.</td>
</tr>
</tbody>
</table>

Course Name: FPGA ARCHITECTURE AND APPLICATIONS
Course Code: EE640

UNIT-I: PROGRAMMABLE LOGIC DEVICES:

UNIT-II: FPGAs:
Field Programmable Gate Arrays- Logic blocks, routing architecture, design flow, technology mapping for FPGAs, Case studies Xilinx XC4000 & ALTERA's FLEX 8000/10000 FPGAs. Introduction to advanced FPGAs: Xilinx Virtex and ALTERA Stratix

UNIT III: FINITE STATE MACHINES (FSM):
Top Down Design, State Transition Table, State assignments for FPGAs, Realization of state machine charts using PAL, Alternative realization for state machine charts using microprogramming, linked state machine, encoded state machine. FSM Architectures: Architectures Centered around non registered PLDs, Design of state machines centered around shift registers, One Hot state machine, Petrinets for state machines- Basic concepts and properties, Finite State Machine Case study.
UNIT IV: SYSTEM LEVEL DESIGN:
Controller, data path designing, Functional partition, Digital front end digital design tools for FPGAs. System level design using mentor graphics/Xilinx EDA tool (FPGA Advantage/Xilinx ISE), Design flow using FPGAs.

UNIT V:
Case studies: Design considerations using FPGAs of parallel adder cell, parallel adder sequential circuits, counters, multiplexers, parallel controllers. Debugging using Embedded Logic Analyzers.

TEXT BOOKS:

REFERENCE BOOKS:

LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Experiment</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4 bit Counter: Design and porting of 4 bit counter on FPGA Platform(Xilinx/ALTERA)</td>
</tr>
<tr>
<td>2</td>
<td>Real Time Clock: Design and Implementation of Real Time Clock (RTC) on FPGA Platform.</td>
</tr>
<tr>
<td>3</td>
<td>ALU Design: Porting of an 8 bit ALU on FPGA Platform</td>
</tr>
<tr>
<td>4</td>
<td>FSM: Design and porting of Melay and More FSM (Sequence Detector) on FPGA</td>
</tr>
<tr>
<td>5</td>
<td>Clock Management Circuits: Implementation of Clock management circuits on FPGA.</td>
</tr>
<tr>
<td>6</td>
<td>IP Core Implementation: BRAMs, FFT IP, CORDIC etc.</td>
</tr>
<tr>
<td>7</td>
<td>Emulation: Typical RISC CPU Emulation on FPGA.</td>
</tr>
</tbody>
</table>

Course Name: VLSI SIGNAL PROCESSING
Course Code: EE641


UNIT III: Pipeline interleaving in digital filters- Pipelining and parallel processing for IIR filters-Low power IIR filter design using pipelining and parallel processing- Pipelined adaptive digital filters.

UNIT IV : Design of Communication Architectures For SoCs:

State variable description of digital filters- Round off noise computation using state variable description- Scaling using slow-down, retiming and pipelining.

UNIT V : Digital arithmetic, Fixed point and floating point. Fixed point implementation of FIR filter, IEEE 754 Floating point standards, Floating point arithmetic operations. Design of floating point adder and multiplier.

TEXT BOOKS:
REFERENCE BOOKS:

LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Experiment</th>
</tr>
</thead>
</table>
| 1      | RTL Modeling and testing of Digital filters  
        1) FIR  
        2)IIR |
| 2      | RTL Modelling and testing of 8 point FFT algorithm.  
        1) Serial architecture implementation  
        2) Parallel architecture implementation |
| 3      | Pipelined FIR Filter design and implementation using HDL |
| 4      | Design and implementation of Fixed point IIR Filter |
| 5      | Floating point adder and multiplier design |

Course Name: SOC DESIGN AND VERIFICATION
Course Code: EE642


UNIT III: SOC VERIFICATION: Verification technology options, Verification methodology, Verification languages, Verification approaches, and Verification plans. System level verification, Block level verification, Hardware/software co verification and Static net list verification.

UNIT IV: DESIGN OF COMMUNICATION ARCHITECTURES FOR SOCS:
On chip communication architectures, System level analysis for designing communication, Design space exploration, Adaptive communication architectures, Communication architecture tuners, Communication architectures for energy/battery efficient systems.

Introduction to bus functional models and bus functional model based verification.

UNIT V: Verification architecture, Verification components, Introduction to VMM, OVM and UVM.

TEXT BOOKS:

REFERENCE BOOKS:
2. “System- on -a- Chip Design and Test”, Rochit Rajsuman, ISBN.

LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Experiment</th>
</tr>
</thead>
</table>
| 1     | 1. Verilog Simulation and RTL Verification  
a) Memory  
b) Clock Divider and Address Counter  
c) n-Bit Binary Counter and RTL Verification |
| 2     | Basic Verification environment for FIFO/UART |
| 3     | Verification Planning for FIFO/UART  
a) Development of the test cases as per the verification plan  
b) Generation and Analysis of Code coverage Reports |
| 4     | Writing assertions for FIFO |
| 5     | Typical Soc Design and Emulation on FPGA Platform |

Course Name - Digital Interface Design

Course Code- EE 643

Unit I: Introduction: Definition and Classification, Overview of Robots and hardware units in Robotics, Introduction to Zed Board Embedded Systems on a Chip (SoC) and the use of FPGA in Robotics Application. State Machines and applications.


Unit III: Data converters interfacing: Introduction to ADC and DAC. Various Types and specification. SPI interfacing in FPGA.


Text/References:

LIST OF EXPERIMENTS:

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Experiment</th>
</tr>
</thead>
</table>
| 1     | 1. FPGA Interfacing Experiments  
a) LCD  
b) ADC |
| 2     | Motor Control and interface using PSoC |
| 3     | Case Study- underwater Glider and line follower Robot. |
Department of Applied Chemistry
DEPARTMENT OF APPLIED CHEMISTRY

ABOUT THE DEPARTMENT:
The Department of Applied Chemistry started in 1985 with the aim to impart education and training to DRDO work force in the area of high energy materials and propellants. Over the years Department has moved on to cater to the need of DRDO and civilian students in order to bring the DRDO achievements closer to our society. The Department’s aim is to contribute to our understanding of the chemical world through excellence in observational, theoretical and experimental science and to extend quantitative and other appropriate methodologies to address problems in the fields of applied chemical science. In Applied Chemistry, we are endowed with faculties who are dedicated teachers and distinguished researchers that carry out cutting-edge research in all modern areas of Applied Chemistry, as well as in inter-disciplinary areas like nanoscience and technology, high energy materials, polymer science and technology etc.

The first PhD of DIAT (DU) was from the Department of Applied Chemistry and currently it is amongst the Departments guiding very high number of PhD scholars and research publications in DIAT. In addition to PhD, there are numbers of M. Tech. & M.Sc students carrying their PG education. We provide a vibrant and creative learning environment for our students and researchers. We also participate extensively in R&D for various DRDO labs and industries.

In recent times, the Department has made significant contributions towards revenue generation through grant-in-projects and customized courses.

Description about the programmes:
To impart in-depth and intensive training in theory, testing and practice of chemical science especially in Chemical Science & Technology & High Energy Materials (HEM), Polymers and Composites to the young scientists of DRDO, other agencies of Ministry of Defence and fresh engineers / postgraduates.

The programme covers various disciplines like chemical science & engineering, High Energy materials, polymers and composites, chemistry of nano materials and their applications. The course is suitable for DRDO scientists, service officers and civilians.

Eligibility:
M.Sc. in any branch of Chemistry, BE / B.Tech in Chemical Engg or BE/ B.Tech Polymer, Textiles, Biotechnology or equivalent degree
Qualification: 55% marks or 5.5 CGPA in the qualifying examination as indicated against the disciplines concerned and valid GATE Score / UGC-CSIR NET Certificate. The qualification should have been obtained from a recognized (by UGC) University / Deemed University / Institution in India. The candidates who are in the final semester of their degree are eligible to apply; Mark sheet up to the last semester should be enclosed. Provisional certificate in such cases along with Mark sheet of the final semester are required to be submitted before commencement of program.

M. Tech. in Materials Science and Chemical Technology

(CHEMICAL SCIENCE AND TECHNOLOGY)

M. Tech. in Materials Science and Chemical Technology

(CHEMICAL SCIENCE AND TECHNOLOGY)

Semester I

<table>
<thead>
<tr>
<th>Sl. No.</th>
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<tr>
<td>1</td>
<td>AC-601</td>
<td>Chemistry for Chemical Technology</td>
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<tr>
<td>2</td>
<td>AC-602</td>
<td>Polymer Science &amp; Technology</td>
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<tr>
<td>3</td>
<td>AC-603</td>
<td>Thermodynamics and Combustion Process</td>
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<tr>
<td>4</td>
<td>AC-604</td>
<td>Chemical Process Design</td>
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<tr>
<td>5</td>
<td>AC-605</td>
<td>Advanced Analytical Techniques</td>
<td>3</td>
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<tr>
<td>6</td>
<td>AM-601</td>
<td>Advanced Mathematics</td>
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Semester II

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<tr>
<td>1</td>
<td>AC-606</td>
<td>Advanced Chemical Reaction Engineering</td>
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<td>2</td>
<td>AC-607</td>
<td>Nano-chemical technology</td>
<td>3</td>
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<td>3</td>
<td></td>
<td>Elective – I [From Dept. of Applied Chemistry]</td>
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<td>Elective – II [From Dept. of Applied Chemistry]</td>
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<td>Elective – III</td>
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- 04 weeks of industrial practice school during summer vacation for scholarship students (optional)

### Semester III

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<td>L</td>
<td>T/P</td>
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<td>M.Tech. Dissertation Phase I</td>
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### Semester IV

<table>
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<th>Contact Hours /week</th>
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<tr>
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<td>AC-652</td>
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### List of Electives/ Self Study

<table>
<thead>
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<th>Sl. No.</th>
<th>Course Code</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>AC-608</td>
<td>Safety, Health and Hazard management</td>
</tr>
<tr>
<td>2</td>
<td>AC-609</td>
<td>NBC Warfare (Concepts &amp; remediation)</td>
</tr>
<tr>
<td>3</td>
<td>AC-615</td>
<td>Technology of Propellants</td>
</tr>
<tr>
<td>4</td>
<td>AC-616</td>
<td>Technology of paints, pigments and varnishes</td>
</tr>
<tr>
<td>5</td>
<td>AC-619</td>
<td>Computational techniques of HEMs</td>
</tr>
<tr>
<td>6</td>
<td>AC-620</td>
<td>Inorganic and solid state chemistry</td>
</tr>
<tr>
<td>7</td>
<td>AC-621</td>
<td>Nuclear and Radiation chemistry, Photochemistry</td>
</tr>
<tr>
<td>8</td>
<td>AC-622</td>
<td>Advanced momentum, heat and mass transfer</td>
</tr>
<tr>
<td>9</td>
<td>AC-623</td>
<td>Surfactant Technology</td>
</tr>
</tbody>
</table>

Courses offered in Applied Chemistry or other Departments
CHEMISTRY FOR CHEMICAL TECHNOLOGY

Chemistry of air sensitive compounds & chalcogens: Electron deficient compounds, 18 e rules, S, Se, Te and their organic/inorganic compound e.g. alkyl/metal chalcogenides.
Chemistry of energetic compounds: Synthetic methods of advanced energetic compounds & their properties.
Biochemical Processes: Fermentation processes, biodiesel.
Fine Specialty Chemicals: Hydrazines, nitrogen rich compounds
Medicinal Chemistry: Introduction, Drug Chemistry, Bio-molecules, Antimicrobial properties
Technology of Dyes: Introduction, Types of Dyes, Application, Toxicity and Treatment
Chemistry of Natural Products & Industrial Applications: Types of Natural products, Extraction, Analysis, Industrial applications.

TUTORIALS/ PRACTICALS/ SEMINARS:
- Detection of toxic elements in waste effluents by use of ion chromatography and absorption spectroscopy
- Synthesis of Energetic chemicals (basic lead azide, tetryl)

TEXT/REFERENCES:-

AC-602: POLYMER SCIENCE & TECHNOLOGY

Introduction to polymer chemistry: Definition, classification and characteristic, Condensation and addition polymers
Advanced Polymers: Conducting Polymers, Photoactive Polymers, Thermoplastic and Thermosetting polymers.
Polymer blends: Polymer networks, processing and application of blends,
Functional polymers: Composite formulation, electronics application, textiles, foul release, impact, adhesion, sealing, energy storage, energy devices, microwave / EMI shielding etc.
Polymers for defence applications: Kevlar, HTPB, EPDM etc.
Bio, Biodegradable and Biomedical polymers: Natural and synthetic biodegradable polymers, catalytic biodegradation, chitosan and polylactic acid based copolymers
Polymers for commercial applications: Acrylics, nylon, nano-composites.
Rubber, Elastomer & Properties of Polymers (Thermal, Electrical etc.)

TUTORIALS/ PRACTICALS/ SEMINARS:
- Synthesis of polymers and their analysis e.g. viscosity
- Polymers film casting and its analysis by IR and UV-Visible spectroscopy

**TEXT/REFERENCES:**


**AC-603: THERMODYNAMICS & COMBUSTION PROCESS**

**General equations of equilibrium:** Vapor - liquid equilibrium in miscible Binary and multicomponent systems, methods for equilibria in complex multireaction systems, Homogeneous Closed Systems, Homogeneous Open Systems, Equilibrium in a Heterogeneous Closed System,


**Azeotropy:** Vapor-liquid equilibria in systems with partially miscible liquid phase. Liquid - liquid equilibria.

**Combustion:** An introduction, thermodynamics of combustion chemistry, combustion chemistry modeling combustion instability, flame, Combustion of solid rocket propellants, liquid propellants

**Chain reaction or specific reactions:** Hydrogen-oxygen, carbon monoxide oxidation, hydrocarbon oxidation

**TUTORIALS/ PRACTICALS/ SEMINARS:**

- Thermal properties of materials e.g. Polymers, organic compounds and nanocomposites (Thermo Gravimetric Analysis)
- Simulation studies of thermal properties of propellants and explosives

**TEXT/REFERENCES:**

2. *Basic Chemical Thermodynamics*, E Brian Smith, World Scientific Publishing Company, 2004
AC- 604: CHEMICAL PROCESS DESIGN

Screening of processes and analysis: The nature of process synthesis and analysis, Product life cycle, Cost diagrams and quick screening of process alternatives

Membrane based separation systems: Equilibrium & non equilibrium processes (MF, UF, RO, PV, Liquid Membranes and gas separation processes).

Developing a conceptual design: Finding the best flow-sheet, Input information and batch vs. continuous, Input output structure of the flow sheet.

Other Topics: Heat Exchanger networks; Process development for energy harvesting, Recycle structure of the flow-sheet Computational methods in process design, Case study

TUTORIALS/ PRACTICALS/ SEMINARS:

- Process designing for large scale synthesis of organic compounds/nanoparticles.
- Separation of mixtures using distillation techniques.

TEXT/REFERENCES:-


AC-605: ADVANCED ANALYTICAL TECHNIQUES

Instrumental Analysis: Qualitative analysis, genesis of instrumental analysis, hyphenated techniques

Polymeric Techniques: Rheology Techniques, Molecular weight determination

Thermal Techniques: ThermoGravimetry (TG), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC)

Chromatographic Techniques: Gas Chromatography (GC), High Performance Liquid Chromatography (HPLC), Thin Layer Chromatography (TLC), Ion chromatography.

Spectroscopy: Ultra Violet-Visible Spectroscopy UV-VIS, Infra-Red spectroscopy (IR), Nuclear Magnetic Resonance (NMR), Mass spectroscopy, Atomic Absorption Spectroscopy (AAS)

XRD and SEM techniques

Analytical techniques for defence: Types and Implimentations.

TUTORIALS/ PRACTICALS/ SEMINARS:

- Handling and demonstration of FTIR, UV-visible spectrophotometer, Mass spectrometer, NMR spectrometer, HPLC and GC.
Analysis of organic compounds by IR and UV-Visible spectroscopy

TEXT / REFERENCES:-


AC-606: ADVANCED CHEMICAL REACTION ENGINEERING

Non-Catalytic Fluid-particle reactions: Mechanism and examples
Catalyst for reactions: Homogeneous and Heterogeneous catalyst, Design of gas – solid catalytic reactors
Kinetics of reactions: Kinetics of Solid Catalyzed Reactions.
Classification of multiphase reactors: Qualitative description, examples of industrial importance.
Performance of multiphase reactors: Bubble columns, packed bubble columns, sectionalized bubble columns, plate columns, internal loop and external loop air-lift reactors, jet loop fixed beds, static mixers, Solid-Liquid and Gas – Solid fluidised Beds and solid-gas transport reactors, Stirred tank reactors.
Microreactors

Other Topics: Mass transfer with Chemical Reaction in Fluid – Fluid systems. Model contactors, pilot plants, and collection of scale-up data, Hydrodynamics, process design.

TUTORIALS/ PRACTICALS/ SEMINARS

TEXT/REFERENCES:

AC-607: NANO-CHEMICAL TECHNOLOGY

Introduction: Definition and concept - dimensionality and size dependent phenomena.

Nano and Mesopores materials: Chemistry of size dependent variation in nanomaterials, reactivity etc.

Nano-fluids: Basic chemistry of nano-fluids, preparation of nano-fluids, analysis of nano-fluids, applications of nano-fluids.

Nanostructures: Chemistry of Quantum dots, nanowires and nanotubes, 2D films.


Nano-catalysts: Surface chemistry of nanoparticles, examples, photo-catalysis

Polymer nano-composites and hybrid materials: Preparation, Characterization, Applications

Nanotechnology for chemical industry: Application in pharmaceuticals, Paint, Coatings, rubber and polymers.

Nanomaterials for Energy applications: Thermo electricity, Solar, Photonics.

Other Topics: Application of nanochemistry/ nanomaterials in civil and defence sector, Characterization of nanoparticles by various analytical techniques

TUTORIALS/ PRACTICALS/ SEMINARS:

➢ Synthesis of metal nanoparticles & analysis by particle size distribution and UV-Visible spectroscopy
➢ Synthesis of quantum dots and analysis by UV-Visible spectroscopy and Photoluminescence spectroscopy

TEXT/REFERENCES:-

4. Nanotechnology – Edited by Gregory Timp
6. Nanocomposite Materials, Prof. Goyal

AC- 608: SAFETY, HEALTH & HAZARD MANAGEMENT

Chemical Safety: Standards and regulations of chemical safety in Industries or Laboratories, Storage of hazardous chemicals, Compatibility and classification codes, Chemical risk analysis and management, Fire triangle and Handling of Toxic, Industrial Gases
Hazard Management: HAZOP and HAZAN techniques, Hazard in manufacture, Hazard prevention measures, Disposal of hazardous materials

Warfare: Classifications of explosives based on hazards, Nuclear, biological and chemical warfare safety

Health: Assessment of human factors, Health & Environment safety, Nano materials safety (Toxicology study)

TUTORIALS/ PRACTICALS/ SEMINARS:

- Handling & demonstration of air-sensitive, pyrophoric and toxic chemicals
- Monitoring of effluents through Gas Chromatography/Ion Chromatography

TEXT/ REFERENCES:

1. Safety and accident prevention in chemical operations John Wiley and sons, New York, 1982
2. Technical guidance for hazard analysis USEPA, FEMA, USDOT, 1987

AC- 609: NBC WARFARE (CONCEPTS & REMEDIATION)

Nuclear science: Structure of nucleus, Mass defect, Binding energy, Nuclear reaction, Fission & Fusion nuclear reactions, Controlled & uncontrolled release of nuclear energy, Concepts of critical mass & critical volume, Principle of operation of fission reactor

Nuclear weapons: Principle, Effects: Blast, thermal and radiation, Nuclear bombs (Fission & Fusion Type) Yield of weapon, Protection against nuclear weapons

Chemical & Biological weapons: Different chemical warfare agents, Their tactical roles / effects, Delivery systems, Biological warfare agents & their effects, Protection against biological, chemical warfare agents

TUTORIALS/ PRACTICALS/ SEMINARS

TEXT/REFERENCES:

2. Chemical warfare agents, 1992, S.M.Somai
3. Biological weapons, 1999, Joshua Lederberg

AC-610: RECENT ADVANCES IN CHEMISTRY

Introduction: Background and eminent discoveries in Chemical Technology
Frontiers in Electrochemistry: Equilibrium properties of electrolytes, electrode potential, electro analytical techniques.

Green Chemistry: Principals of green chemistry, sustainability, selected examples of green synthesis.


Chemistry of smart materials: Smart materials, their properties, distribution by type chemistry of macromolecules, phase change materials

TUTORIALS/ PRACTICALS/ SEMINARS

TEXT/REFERENCES:
4. Essentials of Pharmaceutical Chemistry, D. Cairns

AC-611: TECHNOLOGY OF ENERGETIC COMPOUNDS: (EXPLOSIVES, PROPELLANTS & PYROTECHNIQUES)

Energetic Compounds: Introduction, Classification, Nature of Energetic compounds

Burning, Deflagration & Detonation

Explosives: Initiation theories of explosives, Thermo chemistry of explosives and various performance parameters of explosives

Rocket propellants: Definition and classification, Propellant ingredients & their properties/role, Performance parameters of rocket propellants,

Other Propellants: Liquid Propellants, High Energy (or nitramine) propellant, LOVA Propellant, Surface coated, double base, extruded impregnated (EI) gun propellant

Pyrotechniques: Definition, classification, Ingredient, Various compositions of Pyrotechniques, Applications like color, smoke, sound, heat, etc. Recent Trends

Other Topics: Insulation, Linear & inhibition system, Classification and service requirements, Combustible Cartridge Case (CCC) & Bi-modular change systems (BMCS).

TUTORIALS/ PRACTICALS/ SEMINARS:
- Synthesis of secondary explosives
- Identification of secondary explosive by IR, UV etc.
- Thermal Analysis of explosives
AC- 612: CATALYTIC PROCESSES

**Introduction:** Catalyst and Catalysis, Adsorption, Diffusion, Heterogeneous catalysis, Homogeneous catalysis, Organocatalysis, Bio catalysis, photocatalysis, Electrocatalysis

**Kinetics of reactions:** Kinetics and reaction on surfaces

**Catalysis of transition metals:** Mo, Co, Ni, Cr, Pt, Pd, etc. Supported metal catalysts.

**Application:** Catalyst for defence applications, Catalysis in petrochemical Industry, Functionality concepts for control of reaction selectivity and microkinetic models, Industrial processes based on solid catalysts.

**TUTORIALS/ PRACTICALS/ SEMINARS:**
- Catalytic Polymerization of styrene or methyl methacrylate
- Catalytic Organic reactions
- Catalytic Inorganic reactions
- Identification of catalysts by various Analytical techniques

**TEXT/REFERENCES:**


AC- 614: ENVIRONMENTAL SCIENCE & TECHNOLOGY

**Atmospheric Chemistry:** Composition, Structure, and Transport in the Atmosphere, Photochemistry, ozone, aerosols.

**Water pollution and treatment:** Background, water chemistry & microbiology, water quality and pollution, water treatments.

**Solid waste management:** Solid Waste Management Pyramid – Key Technologies for SWM, relevant environmental regulations for waste disposal, site investigations.

**Advance oxidation processes:** Established AOP technologies e.g. H_2O_2/O_3, O_3/UV, emerging technologies.

**Other Topics:** Remediation of soil, Bioremediation and Biodegradation.

**TUTORIALS/ PRACTICALS/ SEMINARS:**
➢ Toxic dye degradation
➢ Testing of drinking water quality
➢ Determination of heavy metals in waste water

TEXT/REFERENCES:


AC-615: TECHNOLOGY OF PROPELLANTS


TUTORIALS/ PRACTICALS/ SEMINARS

TEXT/REFERENCES:


AC- 616: TECHNOLOGY OF PAINTS, PIGMENTS AND VARNISHES

Topics: Resin chemistry, The components and properties of paints, including resins, pigments, solvents and additives, Types of pigments, varnishes; preparation & their applications, The chemical composition, physical properties, function, wear characteristics and properties of PPV, Color standards, metamerism and color matching, Powder coating, Spray and electro-deposition techniques, Curing, testing methods for finished materials and quality control techniques, Dye technology, Degradation of Paint surfaces

TUTORIALS/ PRACTICALS/ SEMINARS

TEXT/REFERENCES:
2. Modern Technology of Synthetic Resins & Their Applications, NIIR, Asia Pacific Business Press.

**AC-617: EXPLOSIVES AND PYROTECHNIQUES**

**Explosives:** Introduction, Classification, Nature of Explosives, Burning, Deflagration & Detonation, Initiation theories of explosives, Techniques of Initiation of Explosives, Thermo chemistry of explosives and various performance parameters of explosives, HE filling techniques, Hydrodynamic theory of detonation, HE applications in different warheads, Fuel- Air explosives, thermo baric weapon, PCB-TB. Recent trends

**Pyrotechniques:** Definition, classification, Ingredient, Various compositions, Performance parameters of pyro stores, Pyrotechnique combustion theory, Manufacture of pyro stores, Applications like color, smoke, sound, heat, etc. Recent Trends

**TUTORIALS/ PRACTICALS/ SEMINARS**

**TEXT/REFERENCES:**

1. Introduction to Technology of explosives, 1996, Paul Cooper, McGraw Hill, NY.

**AC-618: ROCKET AND GUN PROPELLANTS**

**Rocket Propellants:** Definition and classification of Rocket propellants, Performance parameters of rocket propellants, Propellant ingredients & their properties/role, Liquid Propellants, gel propellants, Solid Rocket propellants: Processing techniques, Insulation, Linear & inhibition system

**Gun Propellants:** Classification and service requirements, High Energy (or nitramine) propellant, LOVA Propellant, Surface coated, double base, extruded impregnated (EI) gun propellant, Combustible Cartridge Case (CCC) & Bi-modular change systems (BMCS).

**TEXT/REFERENCES:**

- Solid Rocket Propulsion Technology, Alain Devanas, Pergamon Press, 1992
- Rocket Propulsion Elements, G.P. Sutton, John Wiley & SONS.
TUTORIALS/ PRACTICALS/ SEMINARS

AC-619: COMPUTATIONAL TECHNIQUES FOR PERFORMANCE EVALUATION OF HIGH ENERGY MATERIALS

Topics: Conventional computational Techniques (Methods) for performance evaluation of explosives and propellants and their limitations, Performance evaluation of Explosives & Propellants by different computer software / programmes.

TUTORIALS/ PRACTICALS/ SEMINARS

TEXT/REFERENCES:
1. BKW software for evaluation of performance and parameters of Explosives
2. NASA-CEC-711 programme
3. Explosive engineering “Paul Cooper”, 1996

AC-620: INORGANIC CHEMISTRY AND SOLID STATE CHEMISTRY

Topics: Nature of solids, Chemical bonding in solid, Types of crystal structure, Chemistry and physical properties of Boron/Boron Hydrides, Aluminum, Ammonium Perchlorate and their role as energetic material, Crystalline Imperfections: Points line and volume imperfections, Properties of solids, Theories of Mechanical Imperfections, Role of dislocations in plastic deformations, Phase Rule: Factors affecting crystal growth, Various inorganic compounds used in energetic formulations

TUTORIALS/ PRACTICALS/ SEMINARS

TEXT/REFERENCES:

AC-621: NUCLEAR AND RADIATION CHEMISTRY, PHOTOCHEMISTRY

393
Photochemistry: Interaction between electromagnetic radiation and matter, photo physical processes in electronically excited molecules. Photochemistry of nitro compounds, Laser photochemistry

Nuclear and Radiation Chemistry: Introduction to radiochemistry, radioactive disintegration, radiations induced decay, effects of radiations on explosives and propellants.

TUTORIALS/PRACTICALS/SEMINAR:

TEXT/REFERENCES:
1. Fundamental of photochemistry, Rohatgi and Mukherji Wiley Eastern Ltd, New Delhi, 1978

AC-622: ADVANCED MOMENTUM, HEAT AND MASS TRANSFER
- Fundamentals of mass transfer: Molecular diffusion in fluids, mass transfer coefficients, and interface mass transfer, steady state theories of mass transfer, Whitman's two-film theory, and its variations.
- Derivation of equation of momentum, energy, mass transfer in curvilinear coordinate system, constitutive equation (Newtonian & Non Newtonian fluids), Flow in some simple cases - Flow between two concentric cylinders, flow between two concentric rotating cylinders, hydrodynamics of bearings lubrication, steady flow around a sphere (theory of very slow motion).
- Singular perturbation theory, derivation of bounder layer equations (using singular perturbation theory), similar and non similar solutions for some forced, mixed and natural convection problems (using bounder layer theory).
- Flow stability, theory of ordinary diffusion in liquids, diffusion with homogenous chemical reaction, diffusion into falling liquids films (forced convection mass transfer).

TUTORIALS/ PRACTICALS/ SEMINARS

TEXT/REFERENCE BOOKS:

AC- 623: SURFACTANT TECHNOLOGY
- Introduction to surfactants
- Classification and application of colloids
- Interfacial phenomena and solution properties
- Various surfactant technologies
- Wetting, spreading and capillary flow, surfactant adsorption
- Nanoemulsions, microemulsions and liposomes, niosomes
- Applications of surfactants in nanomaterials
TUTORIALS/ PRACTICALS/ SEMINARS

TEXT/REFERENCES:


M. Tech. in MATERIALS SCIENCE & CHEMICAL TECHNOLOGY
(ENERGETIC MATERIALS AND POLYMERS)

Semester I

<table>
<thead>
<tr>
<th>Sl. No.</th>
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<td>Polymer Science &amp; Technology</td>
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<td>Thermodynamics and Combustion Process</td>
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<td>Chemical Process Design</td>
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<td>Advanced Analytical Techniques</td>
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<td>AM-601</td>
<td>Advanced Mathematics</td>
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Semester II

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- 04 weeks of industrial practice school during summer vacation for scholarship students (optional)

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Semester III

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<th>Sl. No.</th>
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Semester IV

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**List of Electives/ Self Study**

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<td>1</td>
<td>AC-608</td>
<td>Safety, Health and Hazard management</td>
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<tr>
<td>2</td>
<td>AC-609</td>
<td>NBC Warfare (Concepts &amp; remediation)</td>
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<tr>
<td>3</td>
<td>AC-615</td>
<td>Technology of Propellants</td>
</tr>
<tr>
<td>4</td>
<td>AC-616</td>
<td>Technology of paints, pigments and varnishes</td>
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<tr>
<td>5</td>
<td>AC-619</td>
<td>Computational techniques of HEMs</td>
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<tr>
<td>6</td>
<td>AC-620</td>
<td>Inorganic and solid state chemistry</td>
</tr>
<tr>
<td>7</td>
<td>AC-621</td>
<td>Nuclear and Radiation chemistry, Photochemistry</td>
</tr>
<tr>
<td>8</td>
<td>AC-622</td>
<td>Advanced momentum, heat and mass transfer</td>
</tr>
<tr>
<td>9</td>
<td>AC-623</td>
<td>Surfactant Technology</td>
</tr>
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</table>

Courses offered in Applied Chemistry or other Departments

**AC-601 : CHEMISTRY FOR CHEMICAL TECHNOLOGY**

**Chemistry of air sensitive compounds & chalcogens:** Electron deficient compounds, 18 e rules, S, Se, Te and their organic/inorganic compound e.g. alkyl/metal chalcogenides.
Chemistry of energetic compounds: Synthetic methods of advanced energetic compounds & their properties.

Biochemical Processes: Fermentation processes, biodiesel.

Fine Specialty Chemicals: Hydrazines, nitrogen rich compounds

Medicinal Chemistry: Introduction, Drug Chemistry, Bio-molecules, Antimicrobial properties

Technology of Dyes: Introduction, Types of Dyes, Application, Toxicity and Treatment

Chemistry of Natural Products & Industrial Applications: Types of Natural products, Extraction, Analysis, Industrial applications.

TUTORIALS/PRACTICALS/SEMINAR:

- Detection of toxic elements in waste effluents by use of ion chromatography and absorption spectroscopy
- Synthesis of Energetic chemicals (basic lead azide, tetryl)

TEXT/REFERENCES:-


AC-602: POLYMER SCIENCE & TECHNOLOGY

Introduction to polymer chemistry: Definition, classification and characteristic, Condensation and addition polymers

Advanced Polymers: Conducting Polymers, Photoactive Polymers, Thermoplastic and Thermosetting polymers.

Polymer blends: Polymer networks, processing and application of blends,

Functional polymers: Composite formulation, electronics application, textiles, foul release, impact, adhesion, sealing, energy storage, energy devices, microwave / EMI shielding etc.

Polymers for defence applications: Kevlar, HTPB, EPDM etc.

Bio, Biodegradable and Biomedical polymers: Natural and synthetic biodegradable polymers, catalytic biodegradation, chitosan and polylactic acid based copolymers

Polymers for commercial applications: Acrylics, nylon, nano-composites.

Rubber, Elastomer & Properties of Polymers (Thermal, Electrical etc.)

TUTORIALS/PRACTICALS/SEMINAR:

- Synthesis of polymers and their analysis e.g. viscosity
- Polymers film casting and its analysis by IR and UV-Visible spectroscopy

TEXT/REFERENCES:-

AC-603 : THERMODYNAMICS & COMBUSTION PROCESS

General equations of equilibrium: Vapor - liquid equilibrium in miscible Binary and multicomponent systems, methods for equilibria in complex multireaction systems, Homogeneous Closed Systems, Homogeneous Open Systems, Equilibrium in a Heterogeneous Closed System,


Combustion: An introduction, thermodynamics of combustion chemistry, combustion chemistry modeling combustion instability, flame, Combustion of solid rocket propellants, liquid propellants

Chain reaction or specific reactions: Hydrogen-oxygen, carbon monoxide oxidation, hydrocarbon oxidation

TUTORIALS/PRACTICALS/SEMINAR:

- Thermal properties of materials e.g. Polymers, organic compounds and nanocomposites (Thermo Gravimetric Analysis)
- Simulation studies of thermal properties of propellants and explosives

TEXT/REFERENCES:-

5. Basic Chemical Thermodynamics, E Brian Smith, World Scientific Publishing Company, 2004

AC-604 : CHEMICAL PROCESS DESIGN

Screening of processes and analysis: The nature of process synthesis and analysis, Product life cycle, Cost diagrams and quick screening of process alternatives
Membrane based separation systems: Equilibrium & non equilibrium processes (MF, UF, RO, PV, Liquid Membranes and gas separation processes).

Developing a conceptual design: Finding the best flow-sheet, Input information and batch vs. continuous, Input output structure of the flow sheet.

Other Topics: Heat Exchanger networks; Process development for energy harvesting, Recycle structure of the flow-sheet Computational methods in process design, Case study

TUTORIALS/PRACTICALS/SEMINAR:
- Process designing for large scale synthesis of organic compounds/nanoparticles.
- Separation of mixtures using distillation techniques.

TEXT/REFERENCES:-

AC-605: ADVANCED ANALYTICAL TECHNIQUES

Instrumental Analysis: Qualitative analysis, genesis of instrumental analysis, hyphenated techniques

Polymeric Techniques: Rheology Techniques, Molecular weight determination

Thermal Techniques: ThermoGravimetry (TG), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC)

Chromatographic Techniques: Gas Chromatography (GC), High Performance Liquid Chromatography (HPLC), Thin Layer Chromatography (TLC), Ion chromatography.

Spectroscopy: Ultra Violet-Visible Spectroscopy UV-VIS, Infra-Red spectroscopy (IR), Nuclear Magnetic Resonance (NMR), Mass spectroscopy, Atomic Absorption Spectroscopy (AAS)

XRD and SEM techniques

Analytical techniques for defence: Types and Implementations.

TUTORIALS/PRACTICALS/SEMINAR:
- Handling and demonstration of FTIR, UV-visible spectrophotometer, Mass spectrometer, LCMS, HPLC and GC.
- Analysis of organic compounds by IR and UV-Visible spectroscopy

TEXT / REFERENCES:
AC-606: ADVANCED CHEMICAL REACTION ENGINEERING

Non-Catalytic Fluid-particle reactions: Mechanism and examples
Catalyst for reactions: Homogeneous and Heterogeneous catalyst, Design of gas – solid catalytic reactors
Kinetics of reactions: Kinetics of Solid Catalyzed Reactions.
Classification of multiphase reactors: Qualitative description, examples of industrial importance.
Performance of multiphase reactors: Bubble columns, packed bubble columns, sectionalized bubble columns, plate columns, internal loop and external loop air-lift reactors, jet loop fixed beds, static mixers, Solid-Liquid and Gas – Solid fluidised Beds and solid-gas transport reactors, Stirred tank reactors.
Microreactors

Other Topics: Mass transfer with Chemical Reaction in Fluid – Fluid systems. Model contactors, pilot plants, and collection of scale-up data, Hydrodynamics, process design.

TUTORIALS/PRACTICALS/SEMINAR

TEXT/REFERENCES:

5. Chemical Reaction Engineering, O. Levenspiel, John Wiley & sons

AC-607: NANO-CHEMICAL TECHNOLOGY

Introduction: Definition and concept- dimensionality and size dependent phenomena.
Nano and Mesopores materials: Chemistry of size dependent variation in nanomaterials, reactivity etc.
Nano-fluids: Basic chemistry of nano-fluids, preparation of nano-fluids, analysis of nano-fluids, applications of nano-fluids.
Nanostructures: Chemistry of Quantum dots, nanowires and nanotubes, 2D films.

Nano-catalysts: Surface chemistry of nanoparticles, examples, photo-catalysis

Polymer nano-composites and hybrid materials: Preparation, Characterization, Applications

Nanotechnology for chemical industry: Application in pharmaceuticals, Paint, Coatings, rubber and polymers.

Nanomaterials for Energy applications: Thermo electricity, Solar, Photonics.

Other Topics: Application of nanochemistry/ nanomaterials in civil and defence sector, Characterization of nanoparticles by various analytical techniques

TUTORIALS/PRACTICALS/SEMINAR:
- Synthesis of metal nanoparticles & analysis by particle size distribution and UV-Visible spectroscopy
- Synthesis of quantum dots and analysis by UV-Visible spectroscopy and Photoluminescence spectroscopy

TEXT/REFERENCES:-
10. Nanotechnology – Edited by Gregory Timp
12. Nanocomposite Materials, Prof. Goyal

AC- 608: SAFETY, HEALTH & HAZARD MANAGEMENT

Chemical Safety: Standards and regulations of chemical safety in Industries or Laboratories, Storage of hazardous chemicals, Compatibility and classification codes, Chemical risk analysis and management, Fire triangle and Handling of Toxic, Industrial Gases

Hazard Management: HAZOP and HAZAN techniques, Hazard in manufacture, Hazard prevention measures, Disposal of hazardous materials

Warfare: Classifications of explosives based on hazards, Nuclear, biological and chemical warfare safety

Health: Assessment of human factors, Health & Environment safety, Nano materials safety (Toxicology study)
TUTORIALS/PRACTICALS/SEMINAR:
- Handling & demonstration of air-sensitive, pyrophoric and toxic chemicals
- Monitoring of effluents through Gas Chromatography/Ion Chromatography

TEXT/REFERENCES:
5. Safety and accident prevention in chemical operations John Wiley and sons, New York, 1982

AC-609: NBC WARFARE (CONCEPTS & REMEDIATION)

Nuclear science: Structure of nucleus, Mass defect, Binding energy, Nuclear reaction, Fission & Fusion nuclear reactions, Controlled & uncontrolled release of nuclear energy, Concepts of critical mass & critical volume, Principle of operation of fission reactor

Nuclear weapons: Principle, Effects: Blast, thermal and radiation, Nuclear bombs (Fission & Fusion Type) Yield of weapon, Protection against nuclear weapons

Chemical & Biological weapons: Different chemical warfare agents, Their tactical roles / effects, Delivery systems, Biological warfare agents & their effects, Protection against biological, chemical warfare agents

TUTORIALS/PRACTICALS/SEMINAR:

TEXT/REFERENCES:
5. Chemical warfare agents, 1992, S.M.Somai
6. Biological weapons, 1999, Joshua Lederberg

AC-610: RECENT ADVANCES IN CHEMISTRY

Introduction: Background and eminent discoveries in Chemical Technology
Frontiers in Electrochemistry: Equilibrium properties of electrolytes, electrode potential, electro analytical techniques.
Green Chemistry: Principals of green chemistry, sustainability, selected examples of green synthesis.
Chemistry of smart materials: Smart materials, their properties, distribution by type chemistry of macromolecules, phase change materials
TUTORIALS/PRACTICALS/SEMINAR

TEXT/REFERENCES:


AC-611: TECHNOLOGY OF ENERGETIC COMPOUNDS: (EXPLOSIVES, PROPELLANTS & PYROTECHNIQUES)

Energetic Compounds: Introduction, Classification, Nature of Energetic compounds
Burning, Deflagration & Detonation
Explosives: Initiation theories of explosives, Thermo chemistry of explosives and various performance parameters of explosives
Rocket propellants: Definition and classification, Propellant ingredients & their properties/role, Performance parameters of rocket propellants,
Other Propellants: Liquid Propellants, High Energy (or nitramine) propellant, LOVA Propellant, Surface coated, double base, extruded impregnated (EI) gun propellant
Pyrotechniques: Definition, classification, Ingredient, Various compositions of Pyrotechniques, Applications like color, smoke, sound, heat, etc. Recent Trends
Other Topics: Insulation, Linear & inhibition system, Classification and service requirements, Combustible Cartridge Case (CCC) & Bi-modular change systems (BMCS).

TUTORIALS/PRACTICALS/SEMINAR:

- Synthesis of secondary explosives
- Identification of secondary explosive by IR, UV etc.
- Thermal Analysis of explosives

TEXT/REFERENCES:


AC-612: CATALYTIC PROCESSES
Introduction: Catalyst and Catalysis, Adsorption, Diffusion, Heterogeneous catalysis, Homogeneous catalysis, Organocatalysis, Bio catalysis, photocatalysis, Electrocatalysis

Kinetics of reactions: Kinetics and reaction on surfaces

Catalysis of transition metals: Mo, Co, Ni, Cr, Pt, Pd, etc. Supported metal catalysts.

Application: Catalyst for defence applications, Catalysis in petrochemical Industry, Functionality concepts for control of reaction selectivity and microkinetic models, Industrial processes based on solid catalysts.

TUTORIALS/PRACTICALS/SEMINAR:
- Catalytic Polymerization of styrene or methyl methacrylate
- Catalytic Organic reactions
- Catalytic Inorganic reactions
- Identification of catalysts by various Analytical techniques

TEXT/REFERENCES:

AC-614: ENVIRONMENTAL SCIENCE & TECHNOLOGY


Water pollution and treatment: Background, water chemistry & microbiology, water quality and pollution, water treatments.

Solid waste management: Solid Waste Management Pyramid – Key Technologies for SWM, relevant environmental regulations for waste disposal, site investigations.

Advance oxidation processes: Established AOP technologies e.g. H_2O_2/O_3, O_3/UV, emerging technologies.

Other Topics: Remediation of soil, Bioremediation and Biodegragration.

TUTORIALS/PRACTICALS/SEMINAR:
- Toxic dye degradation
- Testing of drinking water quality
- Determination of heavy metals in waste water

TEXT/REFERENCES:
AC-615: TECHNOLOGY OF PROPELLANTS


**TUTORIALS/PRACTICALS/SEMINAR**

**TEXT/REFERENCES:**


AC- 616: TECHNOLOGY OF PAINTS, PIGMENTS AND VARNISHES

**Topics:** Resin chemistry, The components and properties of paints, including resins, pigments, solvents and additives, Types of pigments, varnishes; preparation & their applications, The chemical composition, physical properties, function, wear characteristics and properties of PPV, Color standards, metamerism and color matching, Powder coating, Spray and electro-deposition techniques, Curing, testing methods for finished materials and quality control techniques, Dye technology, Degradation of Paint surfaces

**TUTORIALS/PRACTICALS/SEMINAR**

**TEXT/REFERENCES:**


AC-617: EXPLOSIVES AND PYROTECHNIQUES

Pyrotechniques: Definition, classification, Ingredient, Various compositions, Performance parameters of pyro stores, Pyrotechnique combustion theory, Manufacture of pyro stores, Applications like color, smoke, sound, heat, etc. Recent Trends

TUTORIALS/PRACTICALS/SEMINAR

TEXT/REFERENCES:


AC-618: ROCKET AND GUN PROPELLANTS

Rocket Propellants: Definition and classification of Rocket propellants, Performance parameters of rocket propellants, Propellant ingredients & their properties/role, Liquid Propellants, gel propellants, Solid Rocket propellants: Processing techniques, Insulation, Linear & inhibition system

Gun Propellants: Classification and service requirements, High Energy (or nitramine) propellant, LOVA Propellant, Surface coated, double base, extruded impregnated (EI) gun propellant, Combustible Cartridge Case (CCC) & Bi-modular change systems (BMCS).

TUTORIALS/PRACTICALS/SEMINAR

TEXT/REFERENCES:

- Solid Rocket Propulsion Technology, Alain Devanas, Pergamon Press, 1992
- Rocket Propulsion Elements, G.P. Sutton, John Wiley & SONS.

AC-619: COMPUTATIONAL TECHNIQUES FOR PERFORMANCE EVALUATION OF HIGH ENERGY MATERIALS

406
Topics: Conventional computational Techniques (Methods) for performance evaluation of explosives and propellants and their limitations. Performance evaluation of Explosives & Propellants by different computer software / programmes.

TUTORIALS/PRACTICALS/SEMINAR:

TEXT/REFERENCES:
7. BKW software for evaluation of performance and parameters of Explosives
8. NASA-CEC-711 programme

AC-620: INORGANIC CHEMISTRY AND SOLID STATE CHEMISTRY

Topics: Nature of solids, Chemical bonding in solid, Types of crystal structure, Chemistry and physical properties of Boron/Boron Hydrides, Aluminum, Ammonium Perchlorate and their role as energetic material, Crystalline Imperfections: Points line and volume imperfections, Properties of solids, Theories of Mechanical Imperfections, Role of dislocations in plastic deformations, Phase Rule: Factors affecting crystal growth, Various inorganic compounds used in energetic formulations

TUTORIALS/PRACTICALS/SEMINAR:

TEXT/REFERENCES:

AC-621: NUCLEAR AND RADIATION CHEMISTRY, PHOTOCHEMISTRY

Photochemistry: Interaction between electromagnetic radiation and matter, photo physical processes in electronically excited molecules. Photochemistry of nitro compounds, Laser photochemistry

Nuclear and Radiation Chemistry: Introduction to radiochemistry, radioactive disintegration, radiations induced decay, effects of radiations on explosives and propellants.

TUTORIALS/PRACTICALS/SEMINAR:

TEXT/REFERENCES:
AC-622: ADVANCED MOMENTUM, HEAT AND MASS TRANSFER

- Fundamentals of mass transfer: Molecular diffusion in fluids, mass transfer coefficients, and interface mass transfer, steady state theories of mass transfer, Whitman's two-film theory, and its variations.
- Derivation of equation of momentum, energy, mass transfer in curvilinear coordinate system, constitutive equation (Newtonian & Non Newtonian fluids), Flow in some simple cases - Flow between two concentric cylinders, flow between two concentric rotating cylinders, hydrodynamics of bearings lubrication, steady flow around a sphere (theory of very slow motion).
- Singular perturbation theory, derivation of bounder layer equations (using singular perturbation theory), similar and non similar solutions for some forced, mixed and natural convection problems (using bounder layer theory).
- Flow stability, theory of ordinary diffusion in liquids, diffusion with homogenous chemical reaction, diffusion into falling liquids films (forced convection mass transfer).

TUTORIALS/PRACTICALS/SEMINAR

TEXT/REFERENCE BOOKS:


AC-623: SURFACTANT TECHNOLOGY

- Introduction to surfactants
- Classification and application of colloids
- Interfacial phenomena and solution properties
- Various surfactant technologies
- Wetting, spreading and capillary flow, surfactant adsorption
- Nanoemulsions, microemulsions and liposomes, niosomes
- Applications of surfactants in nanomaterials

TUTORIALS/PRACTICALS/SEMINAR

TEXT/REFERENCES:

Department of Metallurgical and Materials Engineering
DEPARTMENT OF METALLURGICAL MATERIALS ENGINEERING

About the department:

**Brief Description:** The Department of Materials Engineering aims to develop a core competence in teaching and research in the areas of materials engineering and its applications to Defence technologies and products. The department offers M.Tech in Materials Engineering, M.Tech in Materials Science and Technology and M.Tech in Corrosion Technology. The programme consists of courses in the areas related to Materials Engineering, Metallurgy, Defence applications, Corrosion Engineering, Corrosion Prevention and Control, Practical, Seminars, and Dissertation Work. The curriculum of the programme was formulated to meet the needs of the Defence R&D Organization, and Industries. Being in Defence University, the Department offers M. Tech and Ph. D. programs in materials engineering and engaged in conducting various short term courses to DRDO and Defence Officers. The main focus of our research is to investigate the structure-property performance relationship of various materials for Defence applications.

This programme is open for DRDO Scientists/Officers and Officers from Tri-services, Defence public sector undertaking, Industry personal and civilian students.

At present, the Department is equipped with characterization facilities such as:

- High Resolution Transmission electron microscope (TEM) with STEM, Lorentz, HAADF and EDAX facilities
- Field emission scanning electron microscope (FESEM) with EDS
- Small angle x-ray scattering (SAXS)
- Wear and friction measurement equipment
- Micro-Hardness Tester
- Brinnel and Rockwell Hardness Tester
- Automatic grinding and polishing machines
- Optical polarizable microscope with image analyzer
- Surface Area Analyzer • Impedance Analyzer and Electrochemical workstation
- Piezometer
- Corona Poling Unit
- UV-Visible Spectroscopy
- Contact Angle measurement unit

Many materials synthesis facilities also available in the Department such as:

- Spray Pyrolysis set-up
- High-Temperature Furnace
- Centrifuge
- Autoclave
Vacuum Oven
Orbital Shaker
Twin screw extruder
Plastography
Two roll mill
Hydraulic press
Electro spinning unit
Homogenizer
Sonicator 26

The development of know-how and manufacturing technologies of many strategic and advanced materials like intelligent textiles, biosensors, electrospinning, magnetic materials, engineering adhesives, structural composites, hybrid supercapacitors, functional materials, biomaterials for prosthetics, tissue engineering, plastics processing, piezoelectric materials, super critical foaming technology are taken up by the faculties and students. The Department is working on many sponsored research projects and the researchers have developed a range of products, including propellers for fuel cells, encapsulated drugs on fibers, magnetic alloys, inorganic oxides for drug delivery, encapsulation and sustained release of anti-cholesterol drugs, polymeric beads and membranes for toxic and heavy metal adsorption (effluent treatment), carbon foams for high temperature applications and open cell polyurethane foams for automobile applications. Moreover, the Department participates extensively in R&D activities in collaboration with Defence Labs and Establishments of India. International collaborative work is being carried out with Naval Post-graduate School (NPS), California, Cranfield University, UK, Loughborough University, UK, National Ding Hwa University, Taiwan, Weizmann Institute of Science, Israel etc.

Eligibility: The eligibility for the postgraduate programme is B.E. / B. Tech or equivalent in Metallurgy/ Materials Science/ Materials Engineering/ Mechanical Engineering/ Production / Ceramic Engineering/ Chemical Engineering/Industrial Engineering/Marine Engineering/Manufacturing Engineering/Polymer Engineering/ Nanotechnology; M.Sc or equivalent in Physics/Chemistry/Environmental Science/Applied Chemistry/ Polymer Chemistry.

Organization: The programme is of four-semester duration. In first and second semester have six courses respectively. Third and Fourth semesters comprises the dissertation work. In the second semester the students have options to choose elective courses. In the first and second semesters there will be three mid semester examination and a final examination for theory subjects. After the second semester, scholarship students are encouraged do a summer internship for about one and half months at their place of choice. This will be entirely based student’s own arrangements and expenses. The Department will not sponsor for this; except official arrangements, like issuing no-objection certificate etc. As part of the dissertation work in the third semester, the dissertation work will be evaluated by the expert committee at the end of the third semester. At the end of the final semester, students will submit their thesis before going for final evaluation and present their project works before the expert committee (consists of External / Internal members from various R&D organisations / Universities etc.). No credits are counted for attending an audit course.
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Note: 04 weeks Practice school during summer vacation for scholarship students.

**Semester III**

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**Semester IV**

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412
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* 1 Credit in Theory/Tutorial means 1 contact hour and 1 credit in practice/Project Thesis means 2 contact hours in a week.

**Contact Hours/week

List of Electives

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Detailed Contents

Introduction to Materials

MS 601

413
Unit I: Introduction, classification of materials; atomic structure, bonding in solids, bonding forces and energies; crystal structure, unit cells, crystal systems, crystallographic points, directions, and planes.

Unit II: Crystalline and non-crystalline materials, anisotropy; Structure of crystalline solids: metallic crystal structure, ceramic crystal structure, polymer crystal structure, determination of crystal structure.

Unit III: Imperfection in solids: point defects, linear defects, interfacial defects, bulk or volume defects, defects in polymer; phase diagrams: definition and basic concept, phase equilibria, one-component phase diagram, Binary phase diagrams.

Unit: Ceramic preparation and processing – sol-gel, hydrothermal and solid state route

Text/Reference Books:
2. Elements of Materials Science and Engineering by Lawrence H. van Vlack.

Materials Characterization

MS 602

Unit I: Mechanical Characterization: Tension, Compression, Hardness, Impact, Creep Tests.

Unit II: Microstructure and microscopy: Optical Microscope, SEM, TEM, Electron Diffraction; X-ray characterization: XRD, SAXS.

Unit III: Thermal Analysis: TGA, DTA, DSC; Electrical Properties: Impedance spectroscopy.

Unit: SEM, Thin film preparation – spin-coating and sputtering

Text/References Books:

Materials Processing

MS 603

Unit I: Processing of Polymers- Extrusion, compounding, fibre spinning, injection moulding, compression moulding

Unit II: Processing of ceramics- Sol-gel, solid state processing, compaction, moulding, sintering, hydrothermal, co-precipitation, refractory manufacturing processes, glass manufacturing techniques.

Unit III: Processing of Metals- Casting, Hot working, Cold working, Rolling, Annealing, Forging, Extrusion, Wire drawing, Sheet metal forming, Joining Techniques, Friction stir welding, Powder Metallurgy
Unit: Metal processing – rolling, annealing, Polymer processing – extrusion,

Text/Reference Books:

3. Concise encyclopedia of plastics, Rosato, Marlene G, 2005

Thermodynamics of Materials

MS 604

Unit I: Simple and composite systems, stable equilibrium states. Adiabatic work interaction, heat interaction, internal energy, First law, Reversible processes, heat engines,

Unit II: Second law, Theorem of Clausius, entropy, combined first and second law. Legendre transforms, representations of the fundamental equation. Equilibrium: extremum principles, membrane, phase and reaction equilibria.


Unit: X-ray diffraction, small-angle X-ray scattering

Text/Reference Books:


Modern Materials for Defence Applications

MS 605

Unit I: Polymers, Classification of Polymers, Co Polymers, Thermoset Plastics, Thermoplastics, Crystalline and Amorphous Polymers, Polymerization, Degree of Polymerization, Polymerization Techniques, Steps of Polymerisation, Ceiling Temperature, Important techniques of polymerisation such as emulsion, bulk, solution and suspension Functionality, Tacticity & Stereochemistry of Polymers, Melting Temperature, Glass transition Temperature & its effect,
Molecular weight of polymer and determination by GPC, viscosity, light scattering and Osmometry. Physical methods of polymer analysis such as IR, NMR, X-ray analysis etc.


Unit III: Composites, Metal Matrix Composites, Carbon and Carbon-Carbon Composites, Ceramic Matrix Composites, Intermetallic Matrix Composites and Polymer Matrix Composites. Applications of composites.

Unit: Compression molding, electrospinning and characterization

Text/Reference Books:

1. V.R. Gowariker, Polymer Science, Wiley Eastern, 1995
5. Elements of Ceramics: F.H Norton
6. Fundamentals of Ceramics: Barsoum

Advanced Physical and Mechanical Metallurgy

MS 606

Unit I: Microstructure and properties, Iron-Carbon diagram, Cu, Al, Ti phase diagram.

Unit II: Phase transformation, TTT, CCT, Recovery, Recrystallization & Grain growth, Martensitic transformations, Elastic and plastic behavior of metals.

Unit III: Theory of plasticity and dislocation, Strengthening mechanisms, Work hardening, Yield Point phenomenon, Creep, twinning, Superplasticity.

Text/Reference Books:


Design of Materials

MS 607

Unit I: Metals and Alloys- Equilibrium shapes of grains and phases, microstructure and property correlations in Metallic alloys, solidification, dendrites and segregation, kinetics of nucleation, diffusive and non-diffusive phase transformations, fine grain castings, age-hardening and thermal stability

Unit II: Ceramics- Ceramics and glasses, structure of ceramics, sintering, processing and mechanical properties, Case studies of fractures, Applications of high performance ceramics.

Unit III: Polymers and composites- thermoplastics, thermosets, elastomers, natural polymers and design data, Effect of time and temperature on structure, modulus and strength of polymers, Polymer alloys, Fibrous, particulate and foamed composites, effect on strength and stiffness. Case studies in Defence applications- Turbine blades, uses of metal matrix composites and carbon-carbon composites, camouflage materials, intelligent textiles and explosive reactive armor.

Text/Reference Books:


Fatigue, Fracture and Failure Analysis

MS 608

Unit I: Stress cycles, Interpretation of Fatigue Data. Endurance Limit, Effect of Mean Stress on Fatigue, Cyclic Stress-Strain Curve, Low Cycle Fatigue, Plastic Strain & Fatigue Life, Effect of Structural Features, Fatigue Crack Propagation,

Unit II: Stress Concentration & Fatigue, Size & Surface Effect, Effect of Metallurgical Variables & Enhancement of Fatigue Life, Classification of Fracture, Theoretical Strength of Metals, Griffith Theory of Brittle Fracture,

Electronic Materials

**MS 609**

**Unit I: Electrical and Thermal Condition in Solids** - The Drude Model, Temperature Dependence of Resistivity, Matthiessen’s and Nordheim’s Rules, The Hall Effect and Hall Devices, Thermal Conductivity

**Unit II: Elementary Quantum mechanics** - Electron as a wave, Electron wave function, Schrödinger Equations, Tunneling Phenomenon Potential Box: Three Quantum Number, Space Quantization, Electron Spin and Intrinsic Angular Momentum, Hund’s Rule


**Unit IV: Semiconductors and Devices** - Intrinsic Semiconductors, Extrinsic Semiconductors, Temperature Dependence of Conductivity, Recombination and Minority Carriers, Continuity Equations, Optical Absorption, Ideal pn Junction and Band Diagram, Metal-Oxide-Semiconductor Field Effect Transistor (MOSFET),

**Text/Reference Books:**

1. Electronic materials and Devices: S. O. Kasap, Tata MacGraw-Hill

**Materials for High-Temperature Applications**

**MS 610**

**Unit I:** Melt processing of Superalloy, Single crystal Superalloy, Processing of Superalloy, Alloqing effect.

**Unit II:** Hot Deformation, Powder Metallurgy and Oxide Dispersion Processing, Oxide Dispersion Strengthened Alloy.

**Unit III:** Fiber Reinforced Composite Superalloy, Processing and properties of Structural Ceramics.

**Text/Reference Books:**

Advanced Functional Materials

**MS 611**

**Unit I: Shape memory and Superelastic alloys**- shape memory effect, thermodynamics of martensitic transformation, Stress induced martensite and superelasticity, Ni-Ti and Ni-Al based alloys and their applications.

**Unit II: Magnetic materials**- Soft and hard magnetic materials, remnant magnetic material, rare earth magnets, Finemet alloys.

**Unit III: Opto-electronic Materials**- Optical properties of semiconductors, absorption and emission processes, Electronic materials such as GaAs and GaN.

**Unit IV: Sensor**- Metal oxide based sensors, Principles of operation

Text/Reference Books:


Non-Destructive Evaluations

**MS 612**

**Unit I**: Visual Inspection, Liquid Penetrant Testing, Magnetic Particle Testing, Eddy Current Testing

**Unit II**: Ultrasonic Testing, Acoustic Emission Technique, Radiography Technique, Residual Stress Analysis.

**Unit III**: In-situ Metallography, Automation and Robot in NDT, Case study: Grain Size, Weldment and other Structural Components.

Text/Reference Books:


Advanced Steel Technology

**MS 613**
Unit I: 
Strengthening mechanisms: Work hardening, Solid solution strengthening, Grain size refinement, Dispersion strengthening

Unit II: 
**Low Carbon steels**- Austenite to ferrite transformation, High strength low alloys steels, Interstitial free steels, Dual phase and TRIP steels

Unit III: 
**Medium and high carbon steels**- Austenite to pearlite transformation, Ferritic-pearlitic microstructures in medium carbon steels, Austenite to Cementite transformation, Fully pearlitic microstructures: Rail steels, high strength steel wires.

Unit IV: 
**Special steels**- Bainite- Upper and lower Bainite microstructures, Bainite transformation mechanisms and transition, nanostructured Bainite; Maraging steels, Stainless steel, TWIP steels, ultra-high strength steels, Electrical steels.

**Text/Reference Books:**

1. Steels: Processing, Structure, and Performance, George Krauss; ASM International

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**Electrical and Electronic Ceramics**

**MS 614**

Unit I: 
Introduction, Basic properties of dielectrics, Capacitance, Dielectric strength, Loss factor. Equivalent circuit description of linear dielectrics, Power factor, Dielectric polarisation, Polarisation mechanisms, Polarisation vs. frequency, Dielectric loss & break down, ceramic capacitors and insulators.

Unit II: 
Supercapacitors, Types of supercapacitor. Ceramic substrates (Al2O3, SiC, BeO, AlN, Glass ceramic etc.), Processing of Thick Film, Thin Film, Multi layer Packages, Properties of Ceramic Insulators, Ceramic Capacitor

Unit III: 

**Text/Reference Books:**

1. Introduction to Ceramics: W.D.Kingery
2. Fundamentals of Ceramics: Barsoum
3. Physical Ceramics for Engineers: VanVlack
4. Handbook of Ceramics: Editor S. Kumar Ceramic
Heat-treatment

MS 615

Unit I: Steel Heat-Treatment, Annealing, Stress relief annealing, Process annealing, Normalizing, Spheroidizing, Tempering,

Unit II: Quenching. Hardening, TTT curve, Hardenability, Case hardening, Carburizing, Nitriding, boronizing, flame hardening, Induction hardening, laser hardening, Electron beam hardening,

Unit III: Heat treatment of Aluminium, Titanium and Magnesium Alloys.

Text/Reference Books:


Advanced Magnetic Materials

MS 616

Unit I: Origin of magnetic moments: Moment of a current loop, Orbital angular momentum and magnetic moments, Spin magnetic moment, gyromagnetic ratio, Vector atom model.

Unit II: Diamagnetism and Paramagnetism: Classical diamagnetism, Superconductors, Paramagnetic momnets, classical paramagnetism.


Unit V: Soft and Hard magnetic materials: Hysteresis loop measurement and classification of soft and hard magnetic materials, Eddy Currents and losses, Low and High frequency applications, Finemet alloys, Permanent magnets: Rare earth magnets and figure of merit, Hexagonal Ferrites.

Text/Reference Books:

### M. Tech. in Materials Engineering

#### Semester I

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**Semester IV**

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* 1 Credit in Theory/Tutorial means 1 contact hour and 1 credit in practice/Project Thesis means 2 contact hours in a week.

**Contact Hours/ week**

**List of Electives**

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<td>MS 613</td>
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Detailed Contents

*Introduction to Materials for Combat*

**MS 617**

**Unit I:** Introduction, classification of materials; atomic structure, bonding in solids, bonding forces and energies; crystal structure, unit cells, crystal systems, crystallographic points, directions, and planes.

**Unit II:** Crystalline and non-crystalline materials, anisotropy; Structure of crystalline solids: metallic crystal structure, ceramic crystal structure, polymer crystal structure, determination of crystal structure.

**Unit III:** Imperfection in solids: point defects, linear defects, interfacial defects, bulk or volume defects, defects in polymer; phase diagrams: definition and basic concept, phase equilibria, one-component phase diagram; Brief history of arms, armour and combat.

**Unit:** Ceramic preparation and processing – sol-gel, hydrothermal and solid state route

**Text/Reference Books:**

*Advanced Characterization Techniques*

**MS 618**

**Unit I:** Structural: X-ray diffraction, Small angle X-ray scattering; Microscopy: Optical microscope, Scanning electron microscope, transmission electron microscopy, Electron back scattered diffraction.

**Unit II:** Mechanical: Tensile, compression, hardness, impact, creep tests; Spectroscopy: Energy dispersive X-ray analysis, X-ray photoelectron spectroscopy, UV-Visible spectroscopy, Fourier transform infrared spectroscopy, Raman Spectroscopy.
Unit III: Thermal-TG-DTA, DSC and thermal conductivity; Electrical: Broad band dielectric impedance spectroscopy.

Unit: SEM, Thin film preparation – spin-coating and sputtering

Text/References Books:

Processing of Defence Components

MS 619

Unit I: Processing of Polymers- Extrusion, compounding, fibre spinning, injection moulding, compression moulding

Unit II: Processing of ceramics- Sol-gel, solid state processing, compaction, moulding, sintering, hydrothermal, co-precipitation, refractory manufacturing processes, glass manufacturing techniques.

Unit III: Processing of Metals- Casting, Hot working, Cold working, Rolling, Annealing, Forging, Extrusion, Wire drawing, Sheet metal forming, Joining Techniques, Friction stir welding, Powder Metallurgy

Unit IV: Case studies: processing of combustible cartridge, gun barrels, bullet proof jacket, armor body, high explosive squash head, aerospace air frame, processing of rocket casing, processing of propellants.

Unit: Metal processing – rolling, annealing, Polymer processing – extrusion, compression molding, electrospinning and characterization

Text/Reference Books:
5. Concise encyclopedia of plastics, Rosato, Marlene G, 2005

Metallurgical Thermodynamics

MS 620
Unit I: Simple and composite systems, stable equilibrium states. Adiabatic work interaction, heat interaction, internal energy, First law, Reversible processes, heat engines,

Unit II: Second law, Theorem of Clausius, entropy, combined first and second law. Legendre transforms, representations of the fundamental equation. Equilibrium: extremum principles, membrane, phase and reaction equilibria.


Unit: X-ray diffraction, small-angle X-ray scattering

Text/Reference Books:


Military Metallurgy-I

MS 622

Unit I: Overview metallic materials for military application. Brass and steel cartridge cases: Introduction to cased ammunition, Cartridge case functional requirements and manufacture, Stress corrosion cracking

Unit II: Steel shell bodies – High explosive squash head- Some background ferrous metallurgy, HESH details. Steel guns barrels- Direct fire tank guns, Indirect fire artillery guns, Temperature rise during firing, Muzzle brake, Autofrettage, Wear and erosion, lubricants, possible anti-erosion measures, Future developments

Unit III: Heavy metal kinetic Energy penetrator- Armour piercing discarding Sabot Penetrators, Armour piercing fin stabilised discarding Sabot penetrators, Long rod penetrators against spaced targets, Hydrodynamic penetration

Unit IV: Copper charge penetrators- Conical shaped charge liners, Cone Collapse, Target penetration, Penetration equation, Copper Cone manufacture, Some liner materials research, Variables affecting penetration performance, Shaped charge Weapons systems

Unit: Polishing, microstructure - optical microscopy

Texts/Reference Books:
Advanced Physical and Mechanical Metallurgy

**MS 606**

**Unit I:** Microstructure and properties, Iron-Carbon diagram, Cu, Al, Ti phase diagram.

**Unit II:** Phase transformation, TTT, CCT, Recovery, Recrystallization & Grain growth, Martensitic transformations, Elastic and plastic behavior of metals.

**Unit III:** Theory of plasticity and dislocation, Strengthening mechanisms, Work hardening, Yield Point phenomenon, Creep, twinning, Superplasticity.

**Text/Reference Books:**


Design of Materials

**MS 607**

**Unit I:** Metals and Alloys- Equilibrium shapes of grains and phases, microstructure and property correlations in Metallic alloys, solidification, dendrites and segregation, kinetics of nucleation, diffusive and non-diffusive phase transformations, fine grain castings, age-hardening and thermal stability

**Unit II:** Ceramics- Ceramics and glasses, structure of ceramics, sintering, processing and mechanical properties, Case studies of factures, Applications of high performance ceramics.

**Unit III:** Polymers and composites- thermoplastics, thermosets, elastomers, natural polymers and design data, Effect of time and temperature on structure, modulus and strength of polymers, Polymer alloys, Fibrous, particulate and foamed composites, effect on strength and stiffness. Case studies in Defence applications- Turbine blades, uses of metal matrix composites and carbon-carbon composites, camouflage materials, intelligent textiles and explosive reactive armor.

**Text/Reference Books:**
Military Metallurgy-II

MS 623

Unit I: Ferrous fragmenting projectiles: Cast iron mortar bomb bodies, Steel 155 mm anti-personnel artillery shell body, Metallurgical quality control for fragmentation

Steel armour for main battle tanks: Steel armour plate, Armour failure mechanisms against kinetic energy attack, Complex multi-layered frontal armour, The Milne De Marre graph

Unit II: Aluminium alloy armour for light armoured vehicles: M113 Armoured personnel carrier armour, Scorpion combat reconnaissance vehicle armour, Warrior infantry fighting vehicle armour, Possible alternative armour materials for light vehicles

Unit III: Alloys for military bridges: Mild steel - Bailey bridge and heavy girder bridge, Aluminium alloy – Medium girder bridge and BR 90, Maraging steel- Armoured vehicle launched bridge, Possible alternative alloys and CFRP-future bridges, Typical properties of bridge materials

Unit IV: Alloys for gun carriages and tank track links: 105mm Light gun trail, 155mm FH 70 Gun trail, 155mm UFH gun trail, Main battle tank track links and pins; Dynamic behaviour of alloys at high strain rate: Effect of strain rate on mechanical properties, Adiabatic heating effects

Texts/Reference Books:

1. Alistair Doig, Military metallurgy, Maney publishing, 2002
2. Steels: Microstructure and Properties HKDH Bhadeshia and Sir R. Honeycomb

Fatigue, Fracture and Failure Analysis

MS 608

Unit I: Stress cycles, Interpretation of Fatigue Data. Endurance Limit, Effect of Mean Stress on Fatigue, Cyclic Stress-Strain Curve, Low Cycle Fatigue, Plastic Strain & Fatigue Life, Effect of Structural Features, Fatigue Crack Propagation,

Unit II: Stress Concentration & Fatigue, Size & Surface Effect, Effect of Metallurgical Variables & Enhancement of Fatigue Life, Classification of Fracture, Theoretical Strength of Metals, Griffith Theory of Brittle Fracture,

Text / Reference Books:


Materials for Hostile Environments

**MS 610**

**Unit I:** Melt processing of Superalloy, Single crystal Superalloy, Processing of Superalloy, Alloying effect, Hot Deformation.

**Unit II:** Powder Metallurgy and Oxide Dispersion Processing, Oxide Dispersion Strengthened Alloy, Fiber Reinforced Composite Superalloy.

**Unit III:** Processing and properties of Structural Ceramics, defrosting techniques, protective clothing, insulation techniques.

Text/Reference Books:


Non-Destructive Evaluations

**MS 612**

**Unit I:** Visual Inspection, Liquid Penetrant Testing, Magnetic Particle Testing, Eddy Current Testing

**Unit II:** Ultrasonic Testing, Acoustic Emission Technique, Radiography Technique, Residual Stress Analysis.

**Unit III:** In-situ Metallography, Automation and Robot in NDT, Case study: Grain Size, Weldment and other Structural Components.

Text/Reference Books:

Physical Metallurgy of alloy steels

**MS 613**

**Unit I:** Low Carbon steels- Austenite to ferrite transformation, High strength low alloys steels, Interstitial free steels, Dual phase and TRIP steels

**Unit II:** Medium and high carbon steels- Austenite to pearlite transformation, Ferritic-pearlitic microstructures in medium carbon steels, Austenite to Cementite transformation, Fully pearlitic microstructures: Rail steels, high strength steel wires

**Unit III:** Special steels; Bainite- Upper and lower Bainite microstructures, Bainite transformation mechanisms and transition, nanostructured Bainite; Marraging steels, Stainless steel, TWIP steels, ultra-high strength steels, Electrical steels.

**Text/Reference Books:**

1. Steels: Processing, Structure, and Performance, George Krauss; ASM International

Modern Materials for Defence Applications

**MS 605**

**Unit I:** Polymers, Classification of Polymers, Co Polymers, Thermoset Plastics, Thermoplastics, Crystalline and Amorphous Polymers, Polymerization, Degree of Polymerization, Polymerization Techniques, Steps of Polymerisation, Ceiling Temperature, Important techniques of polymerisation such as emulsion, bulk, solution and suspension Functionality, Tacticity & Stereochemistry of Polymers, Melting Temperature, Glass transition Temperature & its effect, Molecular weight of polymer and determination by GPC, viscosity, light scattering and Osmometry. Physical methods of polymer analysis such as IR, NMR, X-ray analysis etc.

Unit III: Composites, Metal Matrix Composites, Carbon and Carbon-Carbon Composites, Ceramic Matrix Composites, Intermetallic Matrix Composites and Polymer Matrix Composites. Applications of composites.

Text/Reference Books:

1. V.R. Gowariker, Polymer Science, Wiley Eastern, 1995
5. Elements of Ceramics: F.H Norton
6. Fundamentals of Ceramics: Barsoum

Corrosion and Control of Defence Components
MS 624

Unit I: Galvanic Cell, Types of Corrosion cells, Electrode Potentials, Standard Electrode Potentials, Nernst Equation, Pourbaix Diagram,

Unit II: Galvanic Series in Sea Water, Polarization, Causes of Polarization, Passivation, Pitting Corrosion.

Unit III: General Methods of Corrosion Prevention, Cathodic Protection, Metallic and Non Metallic Coatings, Corrosion Prevention by Alloying, Stress Corrosion Cracking; Antifouling coating, thermal barrier coating.

Text/Reference Books:


Welding Technology
MS 625

Unit I: Overview of welding processes, study of welding arc characteristics, metal transfer during arc welding, heat flow during welding, gas -metal and slag -metal reactions, weldpool solidification, effect of welding process parameters on the macro -and micro-structure of weld metal.

431
Unit II: Thermal cycles in the heat affected zone. Phase transformations in the weld metal and the heat affected zone. Phenomena of hot-cracking and cold cracking. Residual stresses and distortion during and after welding.

Unit III: Application of above principles to welding of carbon and alloy steels, cast irons, stainless steels, aluminium and titanium alloys. Fatigue and fracture of weldments; welding methods: oxy-acetylene, TIG, MIG, Spot, Arc, Laser beam and friction stir.

Texts/Reference Books:


Computational Methods for Engineering Materials

MS 626


Unit II: Molecular Dynamics, Continuum modeling. Computational micro-mechanics Multiscale coupling.


Text/Reference Books:


Nanomaterials and their application in Defence

MS 627

Unit I: Overview of Nanostructures and Nanomaterials; Synthesis of Nanomaterials: Types and strategies for synthesis of nanomaterials depending on end applications; Crystalline nanomaterials and defects therein; Hybrid nanomaterials; Multiscale hierarchical structures built out of nanosized building blocks (nano to macro).

Unit II: Nanomaterials in Nature: Nacre, Gecko, Teeth; Nanostructures: Carbon Nanotubes, Fullerenes, Nanowires, Quantum Dots. Applications of nanostructures: Reinforcement in Ceramics, Drug delivery, Giant magnetoresistance, etc.; Cells response to Nanostructures; Surfaces and interfaces in nanostructures, Ceramic interfaces, Superhydrophobic surfaces, Grain boundaries in Nanocrystalline materials, Defects associated with interfaces.
Unit III: Thermodynamics of Nanomaterials; Overview of properties of nanostructures and nanomaterials; Overview of characterization of nanostructures and nanomaterials; Deformation behaviour of nanomaterials: Fracture and creep; Nanomechanics and nanotribology; Electrical, Magnetic and Optical properties; Applications of Nanotechnology in various fields: Defence, Aerospace and Marine Nanotechnology, Renewable energy, solar energy, fuel cells etc.

Text/Reference Books:


Heat-treatment of metals and alloys

MS 628

Unit I: Steel Heat-Treatment, Annealing, Stress relief annealing, Process annealing, Normalizing, Spheroidizing.

Unit II: Tempering, Quenching, Hardening, TTT curve, Hardenability, Case hardening, Carburizing, Nitriding, boronizing, flame hardening, Induction hardening, laser hardening, Electron beam hardening,

Unit III: Process Annealing of Aluminium, Titanium and Magnesium Alloys.

Text/Reference Books:

## M. Tech. in Corrosion Technology

### Semester I

<table>
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<tr>
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<td>Concepts in Materials</td>
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<td>2</td>
<td>MCE 602</td>
<td>Introduction to Corrosion</td>
<td>3</td>
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<td>3</td>
<td>MCE 603</td>
<td>Welding Science and Technology</td>
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<td>MCE 604</td>
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*Note:* 04 weeks Practice school during summer vacation for scholarship students.

### Semester II

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* 1 Credit in Theory/Tutorial means 1 contact hour and 1 credit in practice/Project Thesis means 2 contact hours in a week.
**Contact Hours/week

List of Electives

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<td>MS 606 Advanced Physical and Mechanical Metallurgy</td>
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<td>MS 607 Design of Materials</td>
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<tr>
<td>3</td>
<td>MS 606 Fatigue and Fracture, and Failure Analysis</td>
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<td>4</td>
<td>MS 610 Materials for high temperature applications</td>
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<td>4</td>
<td>MS 612 Non-destructive Evaluations (NDT)</td>
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<td>5</td>
<td>MS 615 Heat treatment</td>
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<td>6</td>
<td>MCE 607 Advanced Coating</td>
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<tr>
<td>7</td>
<td>MCE 608 Surface Science and Engineering</td>
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<td>8</td>
<td>MCE 609 Materials for defence applications</td>
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<td>9</td>
<td>MS 619 Processing of Defence Components</td>
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<tr>
<td>10</td>
<td>MCE610 Reliability Engineering</td>
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</table>

Open Electives from other departments
MCE 601: Concepts in Materials:
Unit 1: Introduction, classification of materials; atomic structure, bonding in solids, bonding forces and energies; crystal structure, unit cells, crystal systems, crystallographic points, directions, and planes, crystalline and non-crystalline materials, anisotropy;
Unit 2: Structure of crystalline solids: metallic crystal structure, ceramic crystal structure, polymer crystal structure, determination of crystal structure;
Unit 3: Imperfection in solids: point defects, linear defects, interfacial defects, bulk or volume defects, defects in polymer; phase diagrams: definition and basic concept, phase equilibria, one-component phase diagram, Binary phase diagrams, Selection of materials.

Reference Books:
2. Elements of Materials Science and Engineering by Lawrence H. van Vlack.

MCE 602 Introductions to Corrosion

Reference Books:

MCE 603 Welding Science and Technology
Unit 1: Overview of welding processes, study of welding arc characteristics, metal transfer during arc welding, heat flow during welding, gas-metal and slag-metal reactions, weld pool solidification, effect of welding process parameters on the macro- and micro-structure of weld metal.
Unit 2: Thermal cycles in the heat affected zone. Phase transformations in the weld metal and the heat affected zone. High power density processes such as laser and electron beam welding.
Unit 3: Welding metallurgy under high cooling rates. Phenomena of hot-cracking and cold cracking. Residual stresses and distortion during and after welding.
Unit 4: Application of above principles to welding of carbon and alloy steels, cast irons, stainless steels, aluminium and titanium alloys. Fatigue and fracture of weldments. Weld decay, problems associated with welding of metals and alloys.
Unit 5: Pre and post welding Heat treatment processes

**Reference Books:**

**MCE 604: Corrosion Characterization**
Unit 1: Mechanical Characterization: Tension, Compression, Hardness, Impact, Creep Tests;
Unit 2: Microstructure and microscopy: Optical Microscope, SEM, TEM, Electron Diffraction;
Unit 3: X-ray characterization: XRD, SAXS;
Unit 4: Thermal Analysis: TGA, DTA, DSC;
Unit 5: Electrochemical polarization characterization, Electrochemical Impedance spectroscopy.
Gravimetry techniques, electrical resistance techniques, sensors for corrosion monitoring, cathodic protection monitoring, localised corrosion monitoring methods (SECM, SEVT), stress corrosion measurement techniques.

**Reference Books:**

**MCE 605 High Temperature Corrosion:**
Unit 1: Introduction, high temperature gaseous reaction (dry), single metal-single oxidant systems, aspects of thermodynamics, kinetics, transport properties, scale morphologies, electrochemical emphasis, various forms of high temperature corrosion including molten salt corrosion, thermodynamic phase stability in metal/gas systems-predominance area diagrams;
Unit 2: Theory of point defects in corrosion products, stoichiometry and non-stoichiometry in crystalline compounds, equilibria involving both ionic and electronic defects, defect interactions, scale growth kinetics and mechanisms, Wagner's parabolic scale growth process, other types of kinetics laws and mechanisms, morphological aspects in the growth of thick scales.
Unit 3: Corrosion product evaporation, analyses of kinetic data; alloy oxidation-kinetics, mechanisms, morphology; binary and ternary alloys in single oxidant and in mixed environments; internal oxidation-examples; hot corrosion of metals and alloys-mechanisms and examples.
Unit 5: Practical: High Temperature Corrosion Testing.

**Reference Books:**

**MS 606: Fatigue, Fracture and Failure Analysis**
Unit 1: Stress cycles, Interpretation of Fatigue Data. Endurance Limit, Effect of Mean Stress on Fatigue, Cyclic Stress-Strain Curve, Low Cycle Fatigue, Plastic Strain & Fatigue Life,
Unit 2: Effect of Structural Features, Fatigue Crack Propagation, Stress Concentration & Fatigue, Size & Surface Effect, Effect of Metallurgical Variables & Enhancement of Fatigue Life,

**Reference Books :**

**MCE 606: Corrosion Prevention and Control:**
Unit 2: Cathodic Protection – principles & classifications, Cathodic protection – influencing factors and Monitoring, Design aspects for Cathodic protection.
Unit 4: Stray current corrosion, Passivity – definition & influencing parameters, Application & Mixed potential theory, design of corrosion resistant alloys.
Unit 5: Materials selection, modification of environment and case studies.
Unit 6: Practical: Electro plating, Surface coating

**Reference Books:**

**MCE 607 Advanced Coatings**
Unit 1: Requirement of protective coatings, classification of organic, polymeric and inorganic coatings, conversion coatings, metallic coatings, electrodeposition and electroless coatings. Paint coatings for corrosion protection, role of resins, pigment, additives and solvents.
Unit 2: Application techniques: Surface preparation and its importance in coating, role of coating selection & design of coating, failure mechanism, maintenance coatings, industrial paint systems, modern paint coating systems and specific examples.
Unit 3: Coatings for underground pipelines, storage tanks, overhead pipelines, offshore structures, ship hulls, risers, reinforced bars and concrete structures. Testing and evaluation.
Unit 4: Case studies

**Reference Books:**

**MS 612: Non-Destructive Evaluations**
Unit 1: Visual Inspection, Liquid Penetrant Testing, Magnetic Particle Testing, Eddy Current Testing, Ultrasonic Testing, Acoustic Emission Technique, Radiography Technique,
Unit 2: Residual Stress Analysis, In-situ Metallography, Automation and Robot in NDT,
Unit 3: Case study: Grain Size, Weldment and other Structural Components.

**Reference Books:**

**MCE 608 Surface Science and Engineering**
Unit 1: Theory of surface reconstructions, electronic properties of surfaces, interfaces and over layers. Characterisation of surfaces by photons, electrons and ions as probes. The effect of substrate surface structure on the overlayer properties. Theoretical and experimental evaluation of surface energies,
Unit 2: Solid liquid and solid-gas interfaces-surface potentials, colloids, sedimentation, adsorption and reaction on surfaces. Damage of the surfaces by corrosion and wear.
Unit 3: Wear mechanisms and categories of wear. Surface modifications by diffusion, heat treatment and by coatings, Surface Processing laser, electrons and ions.
Unit 4: Physical and vapour deposition, CVD, ion-implantation, thermal spray coating.

**Reference Books:**
**MS 607: Design of Materials**
Unit 1: Metals and Alloys: Equilibrium shapes of grains and phases, microstructure and property correlations in Metallic alloys, solidification, dendrites and segregation, kinetics of nucleation, diffusive and non-diffusive phase transformations, fine grain castings, age-hardening and thermal stability
Unit 2: Ceramics: Ceramics and glasses, structure of ceramics, sintering, processing and mechanical properties, Case studies of fractures, Applications of high performance ceramics.
Unit 3: Polymers and composites: thermoplastics, thermosets, elastomers, natural polymers and design data, Effect of time and temperature on structure, modulus and strength of polymers, Polymer alloys, Fibrous, particulate and foamed composites, effect on strength and stiffness.
Unit 4: Case studies in Defence applications: Turbine blades, bullet-proof vests, uses of metal matrix composites and carbon-carbon composites.

**Reference Books:**
2. Michale F. Ashbey and David R. H. Jones; Butterworth-Heinmann, Elsevier Publications

**MS 619: Processing of Defence Components**
Unit 1: Processing of Polymers- Extrusion, compounding, fibre spinning, injection moulding, compression moulding
Unit 2: Processing of ceramics: Sol-gel, solid state processing, compaction, moulding, sintering, hydrothermal, co-precipitation, refractory manufacturing processes, glass manufacturing techniques.
Unit 3: Processing of Metals- Casting, Hot working, Cold working, Rolling, Annealing, Forging, Extrusion, Wire drawing, Sheet metal forming, Joining Techniques, Friction stir welding, Powder Metallurgy
Unit 4: Case studies: processing of combustible cartridge, gun barrels, bullet proof jacket, armour body, high explosive squash head, aerospace air frame, processing of rocket casing, processing of propellants.

**Text/References**
6. Concise encyclopedia of plastics, Rosato, Marlene G, 2005

**MCE 609: Materials for defence applications:**
Unit 1: Polymers, Classification of Polymers, Co Polymers, Thermoset Plastics, Thermoplastics, Crystalline and Amorphous Polymers, Polymerization, Degree of Polymerization, Polymerization Techniques, Steps of Polymerisation, Ceiling Temperature Functionality, Tacticity & Stereochemistry of Polymers, Melting Temperature, Glass transition Temperature & its effect,
Unit 2: Definition & scope of ceramic materials, classification of ceramic materials–conventional and advanced, Areas of applications. Refractories: Classification of Refractories, Modern trends and developments, Basic raw materials, Elementary idea of manufacturing process technology, Flow diagram of steps necessary for manufacture, basic properties and areas of application. Ceramic Coatings: Types of glazes and enamels

Unit 3: Glass: Definition of glass, Basic concepts of glass structure, Batch materials and minor ingredients and their functions, Elementary concept of glass manufacturing process, Different types of glasses. Application of glasses.
Unit 5: Corrosion resistance metals and alloys, case studies on corrosion resistance materials
Unit 6: Case studies on corrosion resistant materials

Reference Books:

1. V.R. Gowariker, Polymer Science, Wiley Eastern, 1995

MCE 610: Reliability Engineering

Unit-I: Basic Probability Theory Basic concepts, Rules for combining Probabilities of events, Failure Density and Distribution functions, Bernoulli’s trials, Binomial distribution, Expected value and standard deviation for binomial distribution – Examples
Unit-2: Failure Mode and Effect Analysis (FMEA) Basic Principles and General Fundamentals of FMEA Methodology
Unit-3: Design of Experiments Analysis of Variance Technique-Strategy of Experimental Design

Reference Books:


MS 606: Advanced Physical and Mechanical metallurgy

Reference Books:

MS 610: Materials for High-Temperature Applications
Unit 1: Melt processing of Superalloy, Single crystal Superalloy, Processing of Superalloy, Unit 2: Alloying effect, Hot Deformation, Powder Metallurgy and Oxide Dispersion Processing, Oxide Dispersion Strengthened Alloy, Fiber Reinforced Composite Superalloy Unit 3: Processing and properties of Structural Ceramics.

Reference Books:

MS 615: Heat-treatment
Unit 1: Steel Heat-Treatment, Annealing, Stress relief annealing, Process Annealing, Normalizing, Spheroidizing, Tempering, Quenching, Hardening, TTT Curve, Hardenability, Unit 2: Case hardening, carburizing, Nitriding, Boronizing, Flame hardening, Induction hardening, Laser hardening, Electron beam hardening, Unit 3: Heat treatment of Aluminium, Titanium and Magnesium Alloys. Unit 4: Deformation and annealing

Reference Books:

M.Sc. Food Technology
Defence Institute of Advanced Technology (DU)
M.Sc. Food Technology
Department of Applied Chemistry
(In association with DFRL, Mysore)

Semester I

443
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<td>ACFT 510</td>
<td>Technology of Fruits, Vegetables and Plantation Crops</td>
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<td>ACFT 511</td>
<td>Technology of Cereals, Pulses and Oil Seeds</td>
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<td>Technology of Meat, Poultry &amp; Fish Processing</td>
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**Semester IV**

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Credits Total: 85

(Semester I & II will be conducted at DIAT, Pune, and semester III & IV will be conducted at DFRL Mysore).

**Elective I**

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<td>AC-607</td>
<td>Nano Chemical Technology</td>
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<td>AC-610</td>
<td>Recent Advances in Chemistry</td>
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<td>DRC-601</td>
<td>Research Methodology</td>
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**Elective II**

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<td>AC-604</td>
<td>Chemical Process Design</td>
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<td>ACFT 515</td>
<td>Advanced Food Technology</td>
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<td>4</td>
<td>MS-601</td>
<td>Introduction to Materials</td>
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**DETAILED SYLLABUS**

**FOOD CHEMISTRY (ACFT 501)**

Water: Physical properties of Water and Ice, Dispersed systems and surface phenomena.

Carbohydrates: Classification, structure, sources, Physico-chemical, functional properties of sugars and polysaccharides in foods & their applications.


Enzymes as biocatalysts: Classifications, chemistry, classification, mode of action, specificity, assay techniques, isolation and purification, stabilization, enzyme kinetics. Applications of enzymes.

Vitamins and Minerals: Classifications, chemistry, structure, biological importance and functions, Role of vitamins in food industry, fortification of foods.

Anti-nutritional factors & natural toxins: Types, Chemistry, structure and physico-chemical properties of anti-nutritional factors & natural toxins present in foods.

Practical
1. Principles and working of common instruments.
2. Analysis of water with respect to pH, TS, TSS, hardness, chlorine, etc.
3. Estimation of moisture, ash and fats
4. Estimation of proteins by various methods,
5. Estimation of sugars, starch and other polysaccharides
6. Estimation of crude and dietary fibres
7. Estimation of minerals and vitamins
8. Determination of minerals-calcium, phosphorus, iron and vitamins
9. Analysis of lipids-saponification value, acid value and iodine value.

References

FOOD MICROBIOLOGY (ACFT-502)

Introduction to Microbiology: Historical developments, food microbiology and it’s scope, structure, growth & nutrition and reproduction of bacteria, yeast, fungi, algae and viruses- A brief account.

Factors affecting the growth of microorganisms in food - Intrinsic and extrinsic parameters that affect microbial growth. Cultivation of microorganisms.

Microbial spoilage of foods: Different types of spoilage and their control for various foods.
Microorganisms and public health - Food poisoning, types and importance of food poisoning. Bacterial agents of food borne illness; non-bacterial agents of food borne illness - poisonous algae, fungi and food borne viruses - A brief account.

Physical and chemical factors influencing the destruction of microorganisms including thermal death time, Z, F and D values. Principles of food preservation; control of water activity.

Determination of microorganisms and their products in food: Sampling plan, sample collection, transport and storage, sample preparation for analysis. Microscopic and culture dependent methods.

Food hygiene and sanitation: Contamination during handling and processing and its control; indicator organisms; Rapid methods in detection of microorganisms.

Practicals
1. Principles and working of common instruments.
2. Staining techniques - Monochrome staining, negative staining, gram staining, acid fast staining, spore staining, capsule staining and motility of bacteria.
3. Pure culture techniques: Different methods for isolation of pure cultures from spoiled food:
4. Growth characteristics: Methods for determination of microbial numbers – direct and plate count; Generation time; various factors influencing microbial growth.
5. Microbiological quality evaluation of processed food products: a) Water; b) Milk and milk products. c) Fruits and vegetables. d) Egg, meat and fish products; e) canned/ retort processed food and other commonly consumed processed and street foods.
6. Pathogenic microorganisms: Different methods for isolation of pathogenic bacteria and fungi from contaminated foods.

References

FOOD AND NUTRITION (ACFT 503)

Introduction to Nutrition: Nutritive value of food, recommended dietary allowance, interrelationship between nutrients, nutritional aspects of carbohydrates, lipids, proteins, vitamins, minerals, fibre, water and electrolyte balance, digestion and absorption of food, energy value of foods, and energy requirements for various conditions, nutrition of infants, children’s, adolescents, mother and geriatric nutrition, high altitude nutrition. Military nutrition

Nutritional requirements & disease control: Therapeutic nutrition & formulation of special dietary foods; Relation of food and diseases; Deficiencies of essential nutrients; Assessment of nutritional status & RDA; Effect of processing on nutrients; Functional foods with attributes to control cardiovascular diseases, cancer, obesity, ageing etc.,


Introduction to Nutraceuticals: definitions, synonymous terms, basis of claims for a compounds as a nutraceutical, regulatory issues for nutraceuticals.
PRINCIPLES OF FOOD PROCESSING AND PRESERVATION (ACFT 504)

Scope and Importance: Introduction to food processing and preservation. National and international perspectives. Historical development of food processing and preservation.

Principles of Food Preservation: Basic principles of food preservation. Drying and Dehydration, Freezing, Ionizing and non-ionizing radiations, Chemical preservation.

Food processing methods: Blanching, pasteurization, sterilization, UHT, aseptic processing, canning. Thermal processing and process time calculations.

Chilling, freezing & Refrigeration: Storage of fresh foods, major requirements of a refrigeration plant, freezing point of selected foods, influence of freezing and freezing rate on quality of food products, methods of freezing, storage and thawing of frozen foods. Freeze drying (lyophilisation) and freeze concentration.


Natural preservation methods using sugar, high salt and fermentation.

Practical
1. Preparation of intermediate moisture & HT foods,
2. Osmotic dehydration of food
3. Modified and controlled atmosphere packaging,
4. Demonstration of food processing machines.
5. Calculation of $D$ and $z$ values

References

FOOD ANALYSIS & SENSORY EVALUATION (ACFT 505)

Food Component Analysis: Proximate composition includes protein, fat, moisture ash etc. Analysis of minerals & vitamins & nutritional component. Use of Analytical Techniques in Food Science; Basics, Principles and Applications of UV – Vis Spectrophotometer, Gas Chromatography(GC), High Pressure Liquid Chromatography (HPLC), Atomic Absorption Spectroscopy (AAS), Fourier Transform Infrared Spectroscopy (FTIR), Differential Scanning Calorimetry (DSC) and Thermo Gravimetric Analysis (TGA). Microwave and IR techniques.

Introduction to quality attributes of food: Appearance, flavour, textural factors and additional quality factors. Chemical dimensions of basic tastes- sweet, salt, sour, bitter and umami

Principles and working of common instruments.

Practical
1. Analysis of minerals by using Atomic Absorption Spectroscopy (AAS)/ICP
2. Fatty acid analysis by using GC
3. Determination of vitamins by chromatography
4. Taste evaluation
5. Evaluation of Taste thresholds
6. Taste evaluation by overall acceptability (OAA)

References

SEMESTER- II

TECHNOLOGY OF FERMENTED FOODS (ACFT 506)

Scope and Importance: History and Introduction to fermentation Technology, Types of Fermentation, Fermentor Designs.

Fermentation process: Media formulations, sterilization, Starter cultures and their maintenance. Factors influencing fermentation process. Downstream process. Primary and secondary metabolites


GM foods: Genetically modified microorganisms and foods. Bio-safety, ethics and risk assessment

Practical
1. Media preparation and sterilization
2. Fermentation of lactic acid at flask level.
3. Fermentation involving lactic acid bacteria.
4. Identification of simple secondary metabolites such as lactic acid bacteriocins.
5. Fermentation of molasses for ethanol production.

References

FOOD STANDARDS AND SAFETY MANAGEMENT (ACFT 507)

Importance and functions of quality control: Concept and meaning of food quality and food Safety, food adulteration, food hazards.

Food laws and regulations – International and National scenario& law, standards and governing bodies such as FSSAI, USFDA, BIS, AGMARK. Quality management systems in India; Food Safety and Standards Act, 2006; Domestic regulations; various organizations (both global and domestic) dealing with inspection, traceability and authentication, certification and quality assurance.

Sampling procedures and plans, specification of raw materials and finished products, Labeling issues; regulations for waste disposals; Concept of Codex Almentarious.USFDA. Quality assurance, Total Quality Management; GMP/GHP; GLP, GAP; Sanitary and hygienic practices; Quality manuals, documentation and audits, Indian & International quality systems and standards like ISO Overview of ISO, structure, interpretation and case studies of food safety and Quality management.

History, structure, principles, HACCP applications, HACCP based SOPs. Export import policy,; Laboratory quality procedures and assessment of laboratory performance; Applications in different food industries; Food adulteration and food safety.

CASE STUDIES

References
TECHNOLOGY OF MILK AND MILK PRODUCTS (ACFT 508)

Introduction: Present status of milk & milk products in India and Abroad; market milk- Composition of milk of various species, quality evaluation and testing of milk, procurement, transportation and processing of market milk, standardization, toning of milk, homogenization, pasteurization, sterilization, storage, transportation and distribution of milk. Cleaning & sanitization of dairy equipments. Special milks such as flavoured, sterilized, recombined & reconstituted toned & double toned. Judging and grading of milk and its products.

Condensed milk- Definition, methods of manufacture, evaluation of condensed & evaporated milk; dried milk- Definition, methods of manufacture of skim & whole milk powder, instantization, physiochemical properties, evaluation, defects in dried milk powder.

Cream- Definition, classification, composition, cream separation, sampling, neutralization, sterilization, pasteurization & cooling of cream, evaluation, defects in cream;

Butter- Definition, composition, classification, methods of manufacture, theories of churning, evaluation, defects in butter.

Ice cream- Definition, composition and standards, nutritive value, classification, methods of manufacture, evaluation, defects in ice cream, and technology aspects of softy manufacture.

Cheese: Definition, composition, classification, methods of manufacture, cheddar, Gouda, cottage and processed cheese, evaluation, defects in cheese.


Practical
1. Study on basics of reception of milk at the plant; platform test of milk, physico-chemical, microbiological and sensory analysis of milk and milk products
2. Estimation of fat by Gerbers’ method and SNF in milk;
3. Homogenization of milk.
4. Preparation of curd/lassi.
5. Operation of LTLT & HTST Pasteurization;
7. Preparation of special milks;
8. Cream separation.
10. Preparation and evaluation of table butter, ice cream, cheese and indigenous milk product such as khoa, chhana, paneer, ghee, rosogolla, gulabjamun, shrikhand, lassi, burfi etc.;
11. Determination of adulterants in milk by milk testing kit.

References

FUNDAMENTALS OF FOOD ENGINEERING (ACFT-509)

Fundamental Concepts and Definitions: Introduction to food engineering, Dimensions and units, thermodynamic systems (closed, open and isolated), intensive and extensive properties, equilibrium state, density, specific volume, specific weight, specific heat, enthalpy, entropy, pressure, temperature scales.

Material Balances: Principles, process flow diagrams, total mass balance, component mass balance, material balance problems involved in dilution, concentration and dehydration; heat balance calculations.

Energy Balances: Principles, energy terms, specific heat of solids and liquids, properties of saturated and superheated steam, heat balances.

Heat Transfer
Conduction: Fourier’s law, thermal conductivity, resistances in series, heat flow through cylinder.
Convection: Natural convection and force convection, film coefficient, overall heat transfer coefficients, dimensionless numbers – pandtl number and nusselt and heat transfer from condensing vapours to boiling liquids, heat exchange equipment applied to food industries – jacketed pans, heaters, coolers – tubular heat exchangers, scrapped surface heat exchangers and plate heat exchangers.
Thermal process calculations: Commercially sterile concept, concept of D, F and Z values, reference F value; effect of temperature on thermal inactivation of micro-organisms, thermal process calculation for canned foods; calculation of processing time in continuous flow systems.
Evaporation: Properties of liquid, heat and mass balance, single and multiple effect evaporation, steam economy, heat recovery, efficiency, process calculations, equipment, accessories and systems. Application of evaporators in food industries.

Mechanical operations


Extrusion Cooking: Theory and applications, extrusion cookers and cold extrusion, single and twin screw extruders, design considerations.

Distillation: Vapour-liquid relationships, Raoult’s law, Henery’s law, boiling point diagram, classification of distillation – batch distillation, steam distillation, vacuum distillation and rectification and their application to food industries.

Drying: Theory and Mechanism of drying, moisture and drying rate curves, free moisture content, critical moisture content, equilibrium moisture content, constant and falling rate periods, spray, drum, bin, cabinet, tunnel, vacuum shelf dryer, through flow dryer, fluidized bed dryers, batch and continuous operational, osmotic dehydration, freeze drying and their respective applications in food industries.

Chilling, refrigeration and freezing: Shelf life extension requirements for various products, theories, characteristics curve, cooling rate calculations. Chilling and freezing equipment, cryogenics. Freezing – technological principles of freezing operations, freezing systems – direct contact and indirect contact system; influence of freezing rate on food system; freezing time calculations.

Crystallization: Solubility, nucleation, super saturation, heat of crystallization, type of crystallization, equipment and applications

Practicals

- Mechanical drawing
- Refrigeration plant
- Boiler house
- Pilot plant
- Electrical laboratory
- Instrumentation
- Pumps and Flow meters
- Mass and energy balance
- Determination of water activity
- Heat treatment: pasteurization and sterilization
- Thermal Process calculations
- Canning operations
- Dehydration of fruits and vegetables – drying rate curves
- Numerical Problem based on Mass balance
- Size determination
- Mixing, kneading, blending
- Extrusion products
- Filtration and centrifugation
- Freezing curve

Recommended Books

SEMESTER – III

TECHNOLOGY OF FRUITS, VEGETABLES & PLANTATION CROPS
(ACFT 510)

Introduction to fruits & vegetables: History, scope and importance of fruits and vegetables processing and preservation, National and international perspectives. Post harvest technologies of fruits and vegetables. Factors affecting fruits and vegetables preservation (intrinsic and extrinsic factors). Nature and types of spoilage in fruits and vegetables.

Post harvest Handling & Storage of Fresh Fruits & Vegetables: Chemical composition; pre and postharvest changes, desirable characteristics of fruits and vegetables for processing. Ripening of climacteric and non climacteric fruits, Maturity indices and standards for selected fruits and vegetables, method of maturity determination, Principles of storage, Types of storage: natural, ventilated low temperature storage, CA and MA storages. Hypobaric storage, pre-cooling and cold storage, Zero energy cool chamber, Physiological disorders: chilling injury and diseases, Factor affecting post harvest losses

Fruits & vegetables processing: Role of enzymes in fruits and vegetable processing. Browning in fruits and vegetables, Theory of gel formation, pectin and related compounds, and products Fermented and non-fermented beverages, Fruit and vegetable, beverages and fruit based formulations, commodity specific products.

Scope, principle, history, mechanism, advantages and disadvantages of drying and dehydration, methods of dehydration of commercial products, selection of methods based on characteristics of foods to be produced, advantages and disadvantages of different methods. Physical and chemical changes during drying, control of chemical changes, desirable and undesirable changes. Packaging and storage of dehydrated products.

Plantation crops: Importance of plantation crops, chemical composition and processing of tea, coffee, Cocoa and their quality assessment. Instant coffee and tea, monsoon coffee, cocoa
beverage. Cocoa processing and chocolate. Spices and volatiles. Minor spices and spice production, processing of spices.

**Practical:**
1. Equipment for fruits and vegetable processing & plant-layout,
2. Preparation of fruit juices, squashes, syrups and ready-to-serve beverages.
4. Preparation of jams, jellies, marmalade, preserves, and candies.
5. Preparation of pickles, chutneys.
6. Tomato products
7. Drying of fruits and vegetables,
10. Estimation of Browning enzymes, PPO & POD.
12. Determination of salt content.

**References**

**TECHNOLOGY OF CEREALS, PULSES AND OIL SEEDS (ACFT 511)**

General introduction and production and utilization trends; Structure and composition of common cereals, pulses and oilseeds. Postharvest storage of grains.

**Wheat:** Structure, types and physicochemical characteristics; wheat milling - products and by products; factors affecting quality parameters; physical, chemical and rheological tests on wheat flour; additives used in bakery products; flour improvers and bleaching agents; manufacture of bakery products, pasta products and various processed cereal-based foods.

**Rice:** Structure, classification, physicochemical characteristics; cooking quality; rice milling technology; by- products of rice milling and their utilization; Parboiling of rice- technology and effect on quality characteristics; aging of rice - quality changes; processed products based on rice.

**Maize:** Structure, Classification, chemical properties.

**Millets:** Structure, Bajra, Jowar and Ragi etc.,

**Bakery:** Bakery and confectionary industry; raw materials and quality parameters; dough development; methods of dough mixing; dough chemistry; rheological testing of dough. Technology for the manufacture of bakery products and the effect of variations in formulation
and process parameters on the quality of the finished product; quality consideration and parameters; Staling and losses in baking; machineries used in bakery industry.

**Legumes and oilseeds**: composition, anti-nutritional factors, processing and storage; processing for production of edible oil, meal, flour, protein concentrates and isolates; extrusion cooking technology; snack foods; development of low cost protein foods.

**Practical:**
1. Physical characteristics of grains
2. Texture analysis of grains
3. Oil extraction from oilseed
4. Oil content of oilseeds
5. Free fatty acids, Iodine value
6. Saponification value
7. Peroxide Value
8. Preparation of biscuits
9. Dough rheology
10. Estimation of gluten content, Amylographic studies, Starch damage etc

**References**

**TECHNOLOGY OF MEAT, POULTRY AND FISH PROCESSING (ACFT 512)**

**Meat**: Sources of meat and meat products in India, its importance in national economy. Selection of animals for slaughtering, importance of traceability, ante-mortem inspection, grading and safety protocols. Effect of feed, breed and management on meat production and quality. Chemical composition and muscle structure, post-mortem muscle chemistry; meat colour and flavours; meat microbiology and safety.

Modern abattoirs/ meat plants, typical layout and features, design of Ante-mortem handling facilities; hoisting rail and travelling pulley system; stunning methods; Slaughtering of animals and poultry. Steps in slaughtering and dressing; offal handling and inspection; inedible by-
products; operational factors affecting meat quality: Rigor mortis, pH changes, colour changes, effects of processing on meat tenderization; abattoir equipment and utilities. Meat quality evaluation, inspection, grading of meat. Mechanical deboning, Meat plant sanitation and safety, By-product utilization. Chilling and freezing of carcass and meat/poultry; factors responsible for effective chilling and freezing, importance of cold chain facilities, quality changes during chilling and freezing, cold shortening, ripening, DFD and PSE. Factors affecting post-mortem changes - properties and shelf-life of meat. Processing of meat – pickling, curing and smoking; thermal and non thermal processing methods of preservation – retort processing, different dehydration techniques, high pressure processing, hurdle processing and irradiation. Restructured and designed meat products. Intermediate moisture and dried meat products; meat plant hygiene – GMP and HACCP; Packaging of meat products. 

Poultry: classification, composition, preservation methods and processing. Poultry industry in India, measuring the yields and quality characteristics of poultry products, microbiology of poultry meat, spoilage factors; Layout and design of poultry processing plants, Plant sanitation; Poultry meat processing operations, equipment used – Defeathering, bleeding, scalding etc.; Packaging of poultry products, refrigerated storage of poultry meat and by-products


Fish: Types of fish, composition, structure, post-mortem changes in fish. Handling of fresh water fish. Canning, smoking, freezing and dehydration of fish. Preparation of fish products, fish sausage and home makings. Commercially important marine products from India; product export and its sustenance; basic biochemistry and microbiology; preservation of postharvest fish freshness; transportation in refrigerated vehicles; deodorization of transport systems; design of refrigerated and insulated trucks; grading and preservation of shell fish; pickling and preparation of fish protein concentrate, fish oil and other by-products.

Practical
1. Slaughtering and dressing of meat animals;
2. Study of post-mortem changes;
3. Meat cutting and handling; evaluation of meat quality;
4. Preservation by dehydration, freezing, canning, curing, smoking and pickling of fish and meat;
5. Shelf-life studies on processed meat products;
6. Evaluation of quality of eggs;
7. Preservation of shell eggs;
8. Estimation of meat: bone ratios;
9. Preparation of meat products- barbecued sausages, loaves, burger, fish finger;
10. Application of meat testing kits for quality evaluation.
11. Visit to meat processing plants / modern abattoir

References
FOOD PACKAGING TECHNOLOGY (ACFT 513)

Introduction to food packaging: Definition, objectives, functions and roles of food packaging, Packaging design and development, Packaging environment, Factors influencing the selection of packaging.

Packaging materials and their properties; Paper: pulping, fibrillation and beating, types of papers. Glass: composition, properties, types of closures, methods of bottle making; Metals: types of cans, tin and aluminium based cans, lacquers; Plastics & polymers used in packaging, their chemical structure and properties.

Testing of packaging materials: Mechanical properties their methods of testing and evaluation; Barrier properties of packaging materials: Theory of permeability, and its measurement, water vapour transmission rate (WVTR) and its measurement, prediction of shelf life of foods using different packaging materials.

Migration from packaging materials, Physical process, Partition Coefficient and sorption process, Determination of migration, food stimulants, Flavour adsorption and sorption, Packaging flavour interaction.

Different forms of packaging: rigid, semi rigid and flexible, Liquid and powder filling machines; bottling machines, Form fill seal and multilayer aseptic packaging machines, Packaging Systems and methods, Packaging systems for dehydrated foods, frozen foods, Fats and Oils, dairy products, fresh fruits and vegetables, meat, poultry and sea foods. Role of packaging in food marketing, aesthetic and graphic design of labels; Coding and marking; nutrition labelling, RFID tag, bar coding, Packaging Laws and regulations, safety aspects of packaging materials; Overall and specific migration, Packaging material residues in food products; Environmental& Economic issues, recycling and waste disposal.

Practical
1. Identification and testing of packaging materials, Determination of Grammage, water proofness,
2. Testing of lacquered tin plate sheets;
3. Measurement of tin coating weight; sulphide stain test;
4. Determination of equilibrium moisture content;
5. Grading of glass bottles for alkalinity;
6. Determination of physico – mechanical properties of polymer packaging materials,
7. Determination of water vapour and gas transmission rate of packaging material.
8. Determination of gas composition by Head space analyser.

References


ELECTIVE – I

AC-607: NANO-CHEMICAL TECHNOLOGY


TRAINING AND PRACTICALS: Synthesis of metal nanoparticles & analysis by particle size distribution and UV-Visible spectroscopy Synthesis of quantum dots and analysis by UV-Visible spectroscopy and Photoluminescence— spectroscopy

REFERENCES


RECENT ADVANCES IN CHEMISTRY (AC-610)

Introduction: Background and eminent discoveries in Chemical Technology
Frontiers in Electrochemistry: Equilibrium properties of electrolytes, electrode potential, electroanalytical techniques.

Green Chemistry: Principals of green chemistry, sustainability, selected examples of green synthesis.


Chemistry of smart materials: Smart materials, their properties, distribution by type, chemistry of macromolecules, phase change materials

REFERENCES

RESEARCH METHODOLOGY (DRC-601)


ELECTIVE – II

ADVANCED ANALYTICAL TECHNIQUES (AC-605)

Instrumental Analysis: Qualitative analysis, genesis of instrumental analysis, hyphenated techniques
Polymeric Techniques: Rheology Techniques, Molecular weight determination
Thermal Techniques: Thermo Gravimetry (TG), Differential Thermal Analysis (DTA), Differential Scanning Calorimetry (DSC)


REFERENCES:

CHEMICAL PROCESS DESIGN (AC-604)

1. A strategy for process synthesis and analysis: The nature of process synthesis and analysis; Engineering Economics; Economic decision making.
2. Cost diagrams and quick screening of process alternatives.
3. Recycle structure of the flow-sheet
4. Separation system;
5. Heat Exchanger networks; Process development for energy harvesting
6. Developing a conceptual design and finding the best flow-sheet: Input information and batch vs. continuous; Input output structure of the flow sheet
7. Computational methods in process design

REFERENCES


ADVANCED FOOD TECHNOLOGY (ACFT 515)

Introduction, Scope and importance of advanced techniques in food technology, Importance and types of thermal and non thermal processing techniques.
Dielectric heating, Microwave heating, Ohmic heating, Infrared heating, RF heating, Extrusion cooking (Introduction, processing equipment and design, Mode of action, Biological effect and application in food processing).
High hydrostatic pressure in food processing, High intensity pulsed electric field processing, High pressure CO2 processing, Ozone (O3) processing, Electron beam processing, Pulsed light processing, Ultrasonication, Combination processing, Plasma processing, (Introduction, processing equipment and design, Mode of action, Biological effect and application in food processing).
Application of nanotechnology in food systems, Introduction and applications in foods human nutrition, preservation, processing. Packaging

References

INTRODUCTION TO MATERIALS (MS 601)

Introduction, classification of materials; atomic structure, bonding in solids, bonding forces and energies; crystal structure, unit cells, crystal systems, crystallographic points, directions, and planes, crystalline and non-crystalline materials, anisotropy; Structure of crystalline solids: metallic crystal structure, ceramic crystal structure, polymer crystal structure, determination of crystal structure; imperfection in solids: point defects, linear defects, interfacial defects, bulk or volume defects, defects in polymer; phase diagrams: definition and basic concept, phase equilibria, one-component phase diagram, Binary phase diagrams.

REFERENCES:

PG DIPLOMA IN FIRE ENGINEERING AND INTEGRATED SAFETY

SEMESTER WISE COURSE STRUCTURE

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**Semester II**

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<td>FE – 511</td>
<td>Explosive safety: Accident investigation and control measures</td>
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<td>FE – 512</td>
<td>Elective II A. Human Factors and Behaviour based safety</td>
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**SYLLABUS DETAILS**

**Semester I**

**AM – 501 : PROBABILITY, STATISTICAL & SIMULATION TECHNIQUES**

**UNIT I  PROBABILITY AND RANDOM VARIABLE**

**UNIT II  ESTIMATION THEORY**

**UNIT III  TESTING OF HYPOTHESIS**
Sampling distributions – Test based on Normal, t-distribution, chi-square, and F-distributions – Analysis of variance – One-way and two way classifications.

**UNIT IV  INTRODUCTION TO SIMULATION:**
Introduction to modelling and simulation, Classification of systems into continuous and discrete, Structural characterization of mathematical model and validation techniques.

**REFERENCES**
ME - 502 : COMBUSTION AND HEAT TRANSFER:

UNIT I
Basic principles including chemical equilibrium, Arrhenius law, and Rankine-Hugoniot relations. Multi-component conservation equations with chemical reaction will be introduced. Combustion of fuel in premixed flames and in non-premixed flames gaseous fuels, liquid fuels, and solid fuels.

UNIT II
Various characteristics of premixed and diffusion flames which covers flame structure, flame stability, flame stabilization, flammability limit, quenching distance, and thermal explosion.

UNIT III
Combustion phenomena in gas turbines, gasoline engines, diesel engines and power plants. A matched asymptotic expansion technique and its application in analyzing flame structures.

UNIT IV MODES OF HEAT TRANSFER


Textbook:
1. "Combustion – Physical and Chemical principles, Modelling and Simulation, Experiments, Pollutant formation " by Warnatz, Maas and Dibble

New Delhi,
MS/CF – 503 : INDUSTRIAL SAFETY

UNIT I  PHYSICAL HAZARDS
Noise, compensation aspects, noise exposure regulation, properties of sound, occupational
damage, risk factors, sound measuring instruments, octave band analyzer, noise networks, noise
surveys, noise control program, industrial audiometry, hearing conservation programs- vibration,
types, effects, instruments, surveying procedure, permissible exposure limit.
Ionizing radiation, types, effects, monitoring instruments, control programs, OSHA standard-
nonionizing radiations, effects, types, radar hazards, microwaves and radio-waves, lasers, TLV-
cold environments, hypothermia, wind chill index, control measures- hot environments, thermal
comfort, heat stress indices, acclimatization, estimation and control

UNIT II  CHEMICAL HAZARDS
Recognition of chemical hazards-dust, fumes, mist, vapour, fog, gases, types, concentration,
Exposure vs. dose, TLV - Methods of Evaluation, process or operation description, Field Survey,
Sampling methodology, Comparison with OSHAS Standard. Air Sampling instruments, Types,
Measurement Procedures, Instruments Procedures, Gas and Vapour monitors, dust sample
collection devices, personal sampling, Methods of Control - Engineering Control, Design
maintenance considerations, design specifications - General Control Methods.

UNIT III  OCCUPATIONAL PHYSIOLOGY
Man as a system component – allocation of functions – efficiency – occupational work capacity
– aerobic and anaerobic work – evaluation of physiological requirements of jobs – parameters of
rest pauses – shift work – personal hygiene.

UNIT IV  PERSONAL PROTECTION
Concepts of personal protective equipment – types – selection of PPE – invisible protective
barriers – procurement, storage, inspection and testing – quality – standards – ergonomic
considerations in personal protective equipment design.

UNIT V  INDUSTRIAL SAFETY AUDITS

A. INTRODUCTION
Components of safety audit, types of audit, audit methodology, non conformity reporting (NCR),
audit checklist and report – review of inspection, remarks by government agencies, consultants,
experts –perusal of accident and safety records, formats – implementation of audit indication -
liaison with departments to ensure co-ordination – check list – identification of unsafe acts of
workers and unsafe conditions in the shop floor.

B. SPECIFICATIONS FOR SAFETY AUDIT
BIS : 14489: Objective ,scope and procedure of occupational safety and health audit, Making of
check list and survey

REFERENCE
UNIT I CONCEPTS AND STATUTORY REQUIREMENTS
Introduction – electrostatics, electro magnetism, stored energy, energy radiation and electromagnetic interference – Working principles of electrical equipment-Indian electricity act and rules-statutory requirements from electrical inspectorate-international standards on electrical safety – first aid-cardiopulmonary resuscitation(CPR).

UNIT II ELECTRICAL HAZARDS
Primary and secondary hazards-shocks, burns, scalds, falls-human safety in the use of electricity.Energy leakage-clearances and insulation-classes of insulation-voltage classifications-excess energy current surges-Safety in handling of war equipment-over current and short circuit current-heating effects of current-electromagnetic forces-corona effect-static electricity – definition, sources, hazardous conditions, control, electrical causes of fire and explosion-ionization, spark and arc ignition energy-national electrical safety code ANSI.Lightning, hazards, lightning arrester, installation – earthing, specifications, earth resistance, earth pit maintenance.

UNIT III PROTECTION SYSTEMS
Fuse, circuit breakers and overload relays – protection against over voltage and under voltage – safelimits of amperage – voltage – safe distance from lines-capacity and protection of conductor-joints-and connections, overload and short circuit protection-no load protection-earth fault protection.FRLS insulation-insulation and continuity test-system grounding-equipment grounding-earth leakage circuit breaker (ELCB)-cable wires-maintenance of ground-ground fault circuit interrupter-use of low voltage-electrical guards-Personal protective equipment – safety in handling hand held electrical appliances tools and medical equipment.

UNIT IV SELECTION, INSTALLATION, OPERATION AND MAINTENANCE
Role of environment in selection-safety aspects in application - protection and interlock-self diagnostic features and fail safe concepts-lock out and work permit system-discharge rod and earthing devices safety in the use of portable tools-cabling and cable joints-preventive maintenance.Classification of hazardous zones-intrinsically safe and explosion proof electrical apparatus-increase safe equipment-their selection for different zones-temperature classification-grouping of gases-use of barriers and isolators-equipment certifying agencies.

TEXT BOOK:
3. Indian Electricity Act and Rules, Government of India.
A. ENVIRONMENT SAFETY

UNIT I AIR POLLUTION
Classification and properties of air pollutants – Pollution sources – Effects of air pollutants on human beings, Animals, Plants and Materials - automobile pollution-hazards of air pollution-concept of clean coal combustion technology - ultra violet radiation, infrared radiation, radiation from sun-hazards due to depletion of ozone - deforestation-ozone holes-automobile exhausts-chemical factory stack emissions-CFC.

UNIT II WATER POLLUTION
Classification of water pollutants-health hazards-sampling and analysis of water-water treatment different industrial effluents and their treatment and disposal -advanced wastewater treatment effluent quality standards and laws- chemical industries, tannery, textile effluents-common treatment.

UNIT III HAZARDOUS WASTE MANAGEMENT

UNIT IV ENVIRONMENTAL MEASUREMENT AND CONTROL

UNIT V POLLUTION CONTROL IN PROCESS INDUSTRIES

REFERENCES

B. NUCLEAR AND RADIATION SAFETY

UNIT I INTRODUCTION

UNIT II REACTOR CONTROL
Control requirements in design considerations – means of control – control and shut down rods – their operation and operational problems – control rod worth – control instrumentation and monitoring – online central data processing system.

**UNIT III REACTOR TYPES**
Boiling water reactors – radioactivity of steam system – direct cycle and dual cycle power plants, pressurized water reactors and pressurized heavy water reactors – fast breeder reactors and their role in power generation in the Indian context – conversion and breeding – doubling time – liquid metal coolants – nuclear power plants in India.

**UNIT IV SAFETY OF NUCLEAR REACTORS**

**UNIT V RADIATION CONTROL**

**REFERENCES**

**MS – 506 INDUSTRIAL SAFETY LABORATORY**

**UNIT I NOISE LEVEL MEASUREMENT AND ANALYSIS**
Measurement of sound pressure level in dB for Impact, continuous and intermittent sources at various networks, peak and average values.

**UNIT II FRICTION TEST**
Explosive materials like barium nitrate, gun powder, white powder, amores composition etc.

**UNIT III IMPACT TEST**
Explosive materials like gun powder, white powder, ameres composition etc.
Burst strength test of packaging materials like paper bags, corrugated cartoons, wood etc.
Auto ignition temperature test.

**UNIT IV EXHAUST GAS MEASUREMENT AND ANALYSIS**
Measurement of SOx, NOx, COx, and hydrocarbons.
UNIT V  ENVIRONMENTAL PARAMETER MEASUREMENT
Dry Bulb Temperature, Wet Bulb Temperature, Determination of relative humidity, wind flow and effective corrective effective.  
Particle size Measurement  
Air sampling analysis  

UNIT VI Static charge testing  
on plastic, rubber, ferrous and non-ferrous materials.  

UNIT VII Illumination testing  
by lux meter and photo meter.  

UNIT VIII Electrical safety  
Insulation resistance for motors and cables  
Estimation of earth resistance  
Earth continuity test  
Sensitivity test for ELCB  

UNIT IX  Softwares : Introduction and Use  
Accident Analysis  
Safety Audit Packages  
Consequence Analysis (CISCON)  
Fire, Explosion and Toxicity Index (FETI)  
Reliability Analysis for Mechanical system and Electrical System  
Failure Mode Analysis  

Equipment Required  
1. Noise level meter  
2. Friction tester  
3. Impact tester  
4. Exhaust gas analyser  
5. High volume sampler  
6. PPE Set  
7. Static charge tester  
8. First aid kit  
9. Software : CISION, FETI and Failure Mode analysis  

CF – 507 : FIRE SAFETY  

UNIT I  PHYSICS AND CHEMISTRY OF FIRE  
Sources of ignition – fire triangle – fire tetrahedron - principles of fire extinguishment - various classes of fires – types of fire extinguishing medias and fire extinguishers – foam making equipment, their method of use  

UNIT II FIRE PREVENTION AND PROTECTION
Active and passive fire protection systems, Advanced / latest fire prevention and fire protection systems. Fire accidents in the past and their case studies. Explosion – case studies.

UNIT III  INDUSTRIAL FIRE PROTECTION SYSTEMS
Sprinkler-hydrants-stand pipes – special fire suppression systems like deluge and emulsifier, Water mist system. Selection criteria of the above installations, reliability, maintenance, evaluation and standards –Fire detection and alarm systems. Other suppression systems – CO2 system, foam system, dry chemical powder (DCP) system, halon system – need for halon replacement –halon alternatives - smoke venting. Portable fire extinguishers – flammable liquids tank farms, firefighting systems.

UNIT IV  EXPLOSION PROTECTING SYSTEMS
Principles of explosion-detonation and blast waves-explosion parameters – Explosion Protection, Containment, Flame Arrestors, isolation, suppression, venting, explosion relief of large enclosure explosion venting-inert gases, plant for generation of inert gas-rupture disc in process vessels and lines explosion, suppression system based on carbon dioxide (CO2) and halons-hazards in LPG, ammonia (NH3), sulphur dioxide (SO2), chlorine (Cl2) etc.

REFERENCES
4. DinkoTuhtar, “Fire and explosion protection”

CF – 508 : DISASTER MANAGEMENT

UNIT I Meaning and types of disasters:
1. Manmade and natural – earthquakes, volcanoes, landslides, floods, cyclones, tsunamis, anthropogenic, industrial, chemical and environmental, fire etc. Stages of a disaster mitigation plan- pre-disaster planning, disaster preparedness, monitoring phase, emergency response or damage assessment, recovery and relief phase.

2. Earthquakes: Causative factors, hazard assessment, selection of factors, creation of thematic data layers, preparation of seismic hazard zonation maps, regional risk assessment, risk mitigation plans; Tsunami and its impact, Case studies

3. Landslides: Causative factors, hazard assessment, selection of factors – triggering and nontriggering, creation of thematic data layers, preparation of landslide hazard zonation maps, regional and site specific risk assessments, risk mitigation plans; Case studies

4. Cyclones and Flooding: Cyclone: cyclone related parameters and effects on land and sea – damage assessment. Flooding: causes, flood prone area demarcation, analysis and management, risk assessment; Case studies
5. Drought and Desertification: Types of droughts, factors influencing droughts, identification of variables, delimiting drought prone areas, processes of desertification, over utilization of water and land resources. Case studies.


UNIT II Introduction to disaster management:
1. Definition and Introduction to disaster management, Disaster management before, during and after disaster event, disaster management cycle, preparedness, prevention, mitigation and response, relief, rehabilitation activities. Disaster management in India. Disaster as an opportunity for development, Disasters Vs development: Disaster-development linkages, interaction of socio-economic developmental activities and disasters, development plans incorporating disaster risks.

2. Emerging approaches in disaster management: 1. Pre- disaster stage (preparedness) (a) Preparing hazard zonation and maps, Predictability/ forecasting & warning (b) Preparing disaster preparedness plan (c) Land use and zoning (d) Preparedness through (IEC) Information, education & Communication. 2. Emergency Stage (a) Rescue training for search & operations at national & regional level (b) Immediate relief (c) Assessment surveys Post Disaster stage-Rehabilitation. Disaster Mitigation: Warning and evacuation, do’s and don’t about disaster, damage survey for designing aid package and detailed survey for reconstruction, repair and retrofitting, post disaster surveys, long term measures- Disaster resistant construction, retrofitting cost-benefit analysis


4. Standardization of the assessment of economic and social aspects: Standardization of the assessment of economic, social and environmental aspects/losses of disaster management for comparative purposes and for an approach that reflects the reality on the community level. Community-based disaster management. Risk sharing and risk transfer (Insurance). Valuation of losses. Response strategies at National, Regional and community level.

5. Knowledge Management: Disaster knowledge management at international, national and regional level and strategies of handling disasters. Sharing of disaster handling strategies at all levels. Case studies focusing on socio-economic and technical issues related to disasters about India, China, Indonesia and other Asian countries who have suffered from disasters.

6. Strategic Disaster Management: Understanding the application of the principles and procedures of strategic management in the domain of disaster mitigation and management. Strategy formulation, understanding strategic intent, vision, mission for better forecasting of disaster threats and their prevention and strategic management of disaster. Strategic management
principles, methods and tools, planning, organizing, leadership and monitoring and evaluation of all role-players in disaster management.

7. **Information Technology in Disaster Management:** Understanding the link between information and decision-making. Understanding and classifying information systems that can have an impact on the dynamic disaster environment

8. **Disaster Management Act:** Disaster management policy; Techno legal aspect: Techno-Legal and Techno-Financial work development control regulations and building bye-laws registration, qualification and duties of professionals, disaster response policy

**UNIT III. Post disaster issues and sustainable development**

1. Post Disaster Reconstruction and recovery for sustainable development, issues and policies


**UNIT IV. CBRN**

1. Bioterrorism – Bioterror agents: Bacterial and viral; bioterrorism- introduction of plant and animal diseases

2. Infectious diseases – Infectious agents, mortality due to major bacterial outbreaks, spread of bacterial infections and the never ending fight, pathogens and multiple drug resistance, means of detecting and mitigating bacterial pathogens

3. Viral diseases - Outbreaks and incidences; Viral outbreaks – SARS, Bird flu, Swine flu and HIV, detection and mitigation of viral agents


5. Radiation emergencies: Nuclear radiation leakage, Chernobyl disaster and implications on biological systems, effect on genetic material; Mutations - chromosomal

6. Biotechnology and Biodiversity: Issues of Biodiversity, value of biodiversity; Emergence of Biotechnology; Biotechnology and promises to society; Biotechnology Techniques; Managing the Hazards of Genetic Engineering, regulations and control of biotechnology; Biosafety

**REFERENCES**

4. Siwach, Raj Kumar Voluntary Organizations and Social Welfare, Shanker Publications, Delhi, 2004
CF – 509  SAFETY MANAGEMENT AND SHE LEGISLATION

UNIT I  CONCEPTS AND TECHNIQUES

UNIT II  ACCIDENT INVESTIGATION AND REPORTING

UNIT III  SAFETY PERFORMANCE MONITORING
Recommended practices for compiling and measuring work injury experience – permanent total disabilities, permanent partial disabilities, temporary total disabilities - Calculation of accident indices, frequency rate, severity rate, frequency severity incidence, incident rate, accident rate, safety score, safety activity rate – problems.

UNIT IV  SAFETY EDUCATION AND TRAINING
Importance of training-identification of training needs-training methods – programmes, seminars, conferences, competitions – method of promoting safe practice - motivation – communication - role of government agencies and private consulting agencies in safety training
– creating awareness, awards, celebrations, safety posters, safety displays, safety pledge, safety incentive scheme, safety campaign – Domestic Safety and Training.

UNIT VI SHE LEGISLATIONS

(A) FACTORIES ACT – 1948

Statutory authorities – inspecting staff, health, safety, provisions relating to hazardous processes, welfare, working hours, employment of young persons – special provisions – penalties and procedures-Tamilnadu Factories Rules 1950 under Safety and health chapters of Factories Act 1948

(B) ENVIRONMENT ACT – 1986


(C) CHEMICAL RULES 1989


(D) OTHER ACTS AND RULES


(E) INTERNATIONAL ACTS AND STANDARDS


REFERENCES
7. Relevant Indian Standards and Specifications, BIS, New Delhi.
11. The Factories Act 1948
12. The Environment Act (Protection) 1986
15. The Indian boilers act 1923.

MS/CF – 510 : RISK AND HAZARD ASSESSMENT

UNIT I : HAZARD, RISK ISSUES AND HAZARD ASSESSMENT
Introduction, hazard, hazard monitoring-risk issue, group or societal risk, individual risk, voluntary and involuntary risk, social benefits Vs technological risk, approaches for establishing risk acceptance levels, Risk estimation, Hazard assessment, procedure, methodology; safety audit, checklist analysis, what-if analysis, safety review, preliminary hazard analysis (PHA), human error analysis, hazard operability studies (HAZOP), safety warning systems.

UNIT II : COMPUTER AIDED INSTRUMENTS
Applications of Advanced Equipment and Instruments, Thermo Calorimetry, Differential Scanning Calorimeter(DSC), Thermo Gravimetric Analyser(TGA), Accelerated Rate Calorimeter(ARC), Reactive Calorimeter(RC), Reaction System Screening Tool(RSST) - Principles of operations, Controlling parameters, Applications, advantages, Explosive Testing, Deflagration Test, Detonation Test, Ignition Test, Minimum ignition energy Test, Sensitiveness Test, Impact Sensitiveness Test(BAM) and Friction Sensitiveness Test (BAM), Shock Sensitiveness Test, Card Gap Test.

UNIT III : RISK ANALYSIS QUANTIFICATION AND SOFTWARES
Fault Tree Analysis and Event Tree Analysis, Logic symbols, methodology, minimal cut set ranking - fire explosion and toxicity index(FETI), various indices - Hazard analysis(HAZAN)- Failure Mode and Effect Analysis(FMEA)- Basic concepts of Reliability- Software on Risk analysis, CISCON, FETI, HAMGARS modules on Heat radiation, Pool fire, Jet, Explosion. Reliability softwares on FMEA for mechanical and electrical systems.

UNIT IV : CONSEQUENCES ANALYSIS
Logics of consequences analysis- Estimation- Hazard identification based on the properties of chemicals- Chemical inventory analysis- identification of hazardous processes- Estimation of source term, Gas or vapour release, liquid release, two phase release- Heat radiation effects, BLEVE, Pool fires and Jet fire- Gas/vapour dispersion- Explosion, UVCE and Flash fire, Explosion effects and confined explosion- Toxic effects- Plotting the damage distances on plot plant/layout.

UNIT V : CREDIBILITY OF RISK ASSESSMENT TECHNIQUES
Past accident analysis as information sources for Hazard analysis and consequences analysis of chemical accident, Mexico disaster, Flixborough, Bhopal, Seveso, Pasadena, Feyzindisaster(1966),Port Hudson disaster- convey report, hazard assessment of non-nuclear installation- Rijnmond report, risk analysis of size potentially Hazardous Industrial objects- Rasmussen masses report, Reactor safety study of Nuclear power plant

REFERENCES
6. Hazop and Hazom, by Trevor AKlett, Institute of Chemical Engineering.
7. Quantitative Risk assessment in Chemical Industries, Institute of Chemical Industries, Centre for Chemical process safety.

**CF – 511 ACCIDENT INVESTIGATION & REPORTING: CASE STUDIES**

**UNIT I**
Concept of an accident, reportable and non-reportable accidents, unsafe act and condition principles of accident prevention,

**UNIT II**
Supervisory role- Role of safety committee – Accident causation models - Cost of accident.

**UNIT III**
Overall accident investigation process - Response to accidents, India reporting requirement, Planning document, Planning matrix,

**UNIT IV**
Investigators Kit, functions of investigator, four types of evidences, Records of accidents, accident reports.

**CF – 512 : ELECTIVE II**

**(A) HUMAN FACTORS AND BEHAVIOUR BASED SAFETY**

**UNIT I ERGONOMICS AND ANATOMY**
Introduction to ergonomics: The focus of ergonomics, ergonomics and its areas of application in the work system, a brief history of ergonomics, attempts to humanize work, modern ergonomics, future directions for ergonomics Anatomy, Posture and Body Mechanics: Some basic body mechanics, anatomy of the spine and pelvis related to posture, posture stability and posture adaptation, low back pain, risk factors for musculoskeletal disorders in the workplace, behavioural aspects of posture, effectiveness and cost effectiveness, research directions

**UNIT II HUMAN BEHAVIOR**

**UNIT III ANTHROPOMETRY AND WORK DESIGN FOR STANDING AND SEATED WORKS**
Designing for a population of users, percentiles, sources of human variability, anthropometry and its uses in ergonomics, principals of applied anthropometry in ergonomics, application of anthropometry in design, design for everyone, anthropometry and personal space, effectiveness and cost effectiveness. Fundamental aspects of standing and sitting, an ergonomics approach to work station design, design for standing workers, design for seated workers, work surface design, visual display units, guidelines for design of static work, effectiveness and cost effectiveness, research directions

UNIT IV  MAN - MACHINE SYSTEM AND REPETITIVE WORKS AND MANUAL HANDLING TASK
Applications of human factors engineering, man as a sensor, man as information processor, man as controller – Man vs Machine.
Ergonomics interventions in Repetitive works, handle design, key board design- measures for preventing in work related musculoskeletal disorders (WMSDs), reduction and controlling, training Anatomy and biomechanics of manual handling, prevention of manual handling injuries in the work place, design of manual handling tasks, carrying, postural stability

UNIT V  HUMAN SKILL AND PERFORMANCE AND DISPLAY, CONTROLS AND VIRTUAL ENVIRONMENTS
A general information-processing model of the users, cognitive system, problem solving, effectiveness.Principles for the design of visual displays- auditory displays- design of controls-combining displays and controls- virtual (synthetic) environments, research issues.

REFERENCES
1. Introduction to Ergonomics, R.S. Bridger, Taylor and Francis
2. Ergonomic design for organizational effectiveness, Michael O’Neill
3. Human factors in engineering and design, MARK S.SANDERS
4. The Ergonomics manual, Dan Mc Leod, Philip Jacobs and Nancy Larson

(B) : AVIATION FIRE SAFETY

UNIT I CATEGORISATION OF AIRPORT AND HALIPAD

2. Categorisation of Heliports and level of Fire Protection. Other Rescue & fire fighting facilities at Heliports.

UNIT II AIRCRAFT CONSTRUCTION, AIRCRAFT ENGINES AND FUEL HAZARDS
2. Types of Aircraft Engines and Hazards associated with each type.
3. Types of Aviation fuels used and their fire hazards.

UNIT III EMERGENCY PLANNING & PROCEDURES
Preplanning for Emergencies, Categorization of Emergencies at Airports, Emergency organizations and procedure for responding to the emergency.

UNIT IV AIRCRAFT FIRE FIGHTING AND RESCUE PROCEDURE

**UNIT V  HAZARDS OF MILITARY AIRCRAFT**

**UNIT VI  POST ACCIDENT MANAGEMENT**
Introduction and Significance, Removal of bodies, Movement of wreckage, Preservation of evidence etc.

**UNIT VII  FIRE PROTECTION OF AIRPORT TERMINAL BUILDINGS AND HANGARS**
2. Classification of Hangars, Fire Hazards and Fire Safety arrangements.

**UNIT VII  CRASH FIRE TENDER DRILLS (PRACTICALS)**

*Manning a Crash Fire Tender*-
- working with a Monitor on approach to Crashed Aircraft.
- Working twin Monitors on approach.
- Working on Monitor and two sidelines.
- Getting two sidelines to work on Crashed Aircraft.

*Replenishing the water tank of Air Crash Fire Tender from:*
- Water Tender
- Water Bowser
- Airport Hydrants

Fire Pumps (Supporting Appliances)

**UNIT VIII  RESCUE FROM CRASHED AIRCRAFT**
Standard Drills using different rescue techniques & equipment.

**REFERENCES:**
1. ICAO standards
2. Hand book by NFPA

(C) :EXPLOSIVE SAFETY

**UNIT I  PROPERTIES OF EXPLOSIVE CHEMICALS**
Fire properties – potassium nitrate (KN03), potassium chlorate (KCl03), barium nitrate (BaNO3), calcium nitrate (CaNO3), Sulphur (S), Phosphorous (P), antimony (Sb). Pyro Aluminum (Al) powder- Reactions-metal powders, Borax, ammonia (NH3) – Strontium Nitrate, Sodium Nitrate, Potassium per chloride. Fire and explosion, impact and friction sensitivity.

UNIT II STATIC CHARGE AND DUST
Dust: size-desirable, non-respirable-biologicalbarriers-hazards-personal protective equipment, pollution prevention.

UNIT III PROCESS SAFETY

UNIT IV MATERIAL HANDLING
Manual handling – wheel barrows-trucks-bullock carts-automobiles-fuse handling – paper caps handling-nitric acid handling in snake eggs manufacture-handling the mix in this factory-material movement-godown-waste pit.

UNIT V TRANSPORTATION:
Packing-magazine-design of vehicles for explosive transports loading into automobiles-transport restrictions-case studies-overhead power lines-driver habits-intermediate parking-fire extinguishers, loose chemicals handling and transport.

UNIT VI WASTE CONTROL AND USER SAFETY
Consumer anxiety-hazards in display-methods in other countries-fires, burns and scalds-sales outlets-restrictions-role of fire service.

REFERENCES
5. Bill of once, “Fireworks Safety manual”
7. A.Chelladurai, “Fireworks related accidents”
8. A.Chelladurai, “Fireworks principles and practice”

CF – 513 : PRACTICALS – FIRE SAFETY
UNIT I: FIRST AUD FIRE EXTINGUISHER DRILL
UNIT II : PUMP DRILL AND HYDRANT DRILL WITH HOSES AND ALL TYPES OF
BRANCHES AND FOAM MAKING EQUIPMENT

UNIT III: FIRE TENDER DRILL
UNIT IV: UNIT IV BA SET DRILL
UNIT V: INTRODUCTION AND OPERATION OF DISASTER MANAGEMENT EQUIPMENT

CF - 514 : SAFETY IN PROCESSING INDUSTRIES

UNIT I SAFETY IN WELDING AND GAS CUTTING
Gas welding and oxygen cutting, resistances welding, arc welding and cutting, common hazards, personal protective equipment, training, safety precautions in brazing, soldering and metalizing – explosive welding, selection, care and maintenance of the associated equipment and instruments – safety in generation, distribution and handling of industrial gases-colour coding – flashback arrestor – leak detection-pipe line safety-storage and handling of gas cylinders.

UNIT II SAFETY IN COLD FARMING AND HOT WORKING OF METALS
Cold working, power presses, point of operation safe guarding, auxiliary mechanisms, feeding and cutting mechanism, hand or foot-operated presses, power press electric controls, power press set up and die removal, inspection and maintenance-metal sheers-press brakes, Hot working safety in forging, hot rolling mill operation, safe guards in hot rolling mills – hot bending of pipes, hazards and control measures. Safety in gas furnace operation, cupola, crucibles, ovens, foundry health hazards, work environment, material handling in foundries, foundry production cleaning and finishing foundry processes.

UNIT III SAFETY IN FINISHING, INSPECTION AND TESTING
Heat treatment operations, electro plating, paint shops, sand and shot blasting, safety in inspection and testing, dynamic balancing, hydro testing, valves, boiler drums and headers, pressure vessels, air leak test, steam testing, safety in radiography, personal monitoring devices, radiation hazards, engineering and administrative controls, Indian Boilers Regulation. Health and welfare measures in engineering industry-pollution control in engineering industry industrial waste disposal.

UNIT IV SAFETY IN PROCESS DESIGN AND PRESSURE SYSTEM DESIGN
Design process, conceptual design and detail design, assessment, inherently safer design-chemical reactor, types, batch reactors, reaction hazard evaluation, assessment, reactor safety, operating conditions, unit operations and equipment, utilities. Pressure system, pressure vessel design, standards and codes- pipe works and valves- heat exchangers- process machinery-over pressure protection, pressure relief devices and design, fire relief, vacuum and thermal relief, special situations, disposal- flare and vent systems- failures in pressure system.

UNIT V PLANT COMMISSIONING INSPECTION AND OPERATIONS
Commissioning phases and organization, pre-commissioning documents, process commissioning, commissioning problems, post commissioning documentation Plant inspection, pressure vessel, pressure piping system, non-destructive testing, pressure testing, leak testing and monitoring- plant monitoring, performance monitoring, condition, vibration, corrosion, acoustic emission-pipe line inspection. Operating discipline, operating procedure and inspection, format, emergency procedures- hand over and permit system- start up and shut down operation, refinery units- operation of fired heaters, driers, storage- operating activities and hazards- trip systems- exposure of personnel

UNIT VI PLANT MAINTENANCE, MODIFICATION AND EMERGENCY PLANNING
Management of maintenance, hazards- preparation for maintenance, isolation, purging, cleaning, confined spaces, permit system- maintenance equipment- hot works- tank cleaning, repair and demolition- online repairs- maintenance of protective devices- modification of plant,
problems controls of modifications. Emergency planning, disaster planning, onsite emergency-offsite emergency.

REFERENCES

5. Indian Boiler acts and Regulations, Government of India.

MS/CF – 515 : QUALITY AND RELIABILITY ENGINEERING

UNIT I : RELIABILITY CONCEPT

UNIT II : FAILURE DATA ANALYSIS
Time to failure distributions – Exponential, normal, Gamma, Weibull, ranking of data – probability plotting techniques – Hazard plotting.

UNIT III : RELIABILITY PREDICTION MODELS

UNIT IV : QUALITY MANAGEMENT
Introduction to Quality-Principles and prescription-Needs, Requirements and Expectations-The Stakeholders-Defining Quality-The characteristics of Quality

UNIT V : AN OVERVIEW OF TOTAL QUALITY MANAGEMENT
Evolution of Quality, Definition, TQM concepts, The Deming Philosophy, Quality Gurus, TQM Principles, TQM organisation

REFERENCES

ELECTIVE III

(A): SAFETY IN HYDROCARBON INDUSTRIES

UNIT I
Simplified flow diagrams of a typical refinery – distillation unit, catalytic cracker, reformer, treating unit (hydro forming, gas purification, Sulphur recovery, lubricating oil unit) Simplified flow diagrams of Petrochemical Industry – steam cracking, butadiene extraction, ethane recovery, butyl rubber polymerization.

UNIT II
Potential fire hazards in petroleum and petrochemical industries (ignition by local sources, spark, flame, hot surface, ignition of oil mists and fumes.). Storage tank farms of petroleum and petrochemical industries – Identification of Hazards, Type of Tanks, Design, Layout, Fire prevention measures including lightning protection. Fire protection arrangements in large tank farms, Design concepts of various fixed fire protection systems like Foam- Water Systems, Halogen & DCP Systems. Lock out procedures. Salient features of codes / standards: NFPA, API, OISD and SHELL.

UNIT III

UNIT IV

References:
4. OISD guidelines.

(B): SAFETY IN POWDER HANDLING

UNIT I: INTRODUCTION
Powder classification-physical, chemical and other properties-metal powders—other non-metallic powders-handling methods-manual, mechanical, automatic-charges on powders-charge distribution charging of powders.
UNIT II : METAL POWDERS AND CHARACTERIZATION
Atomization, types – milling – electro deposition – spray drying, Production of iron powder, Aluminium powder, Titanium – screening and cleaning of metals – Explosivity and pyrophoricity – toxicity, Particle size and size distribution – measurement, types and significance – particle shape analysis, methods, surface area, density, porosity, flowrate – testing. Metal powders, applications as fuel, solid propellants, explosives, pyrotechnics.

UNIT III : DUST EXPLOSION

UNIT IV : DUST HANDLING PLANTS AND ELECTRO STATIC HAZARDS
Grinding mills, conveyors, bucket elevators, dust separators, dust filters, cyclones, driers, spray driers, silos, grain elevators, typical applications, hazards. Electrostatic charges-energy released-type of discharge-spark-carona-insulating powders-propagating brush discharge-discharge in bulk lightning hazards in powder coating-electroplating.

UNIT V : DUST EVALUATION AND CONTROL
Evaluation, methodology, Quantitative, sampling, measurements – control approaches and strategies– control of dust sources, dust transmission – role of workers, PPE and work practice – House keeping – storage –labelling – warning sign – restricted areas - Environmental protections.Evaluation procedures and control measures for particulates (Respirable), Asbestos and other fibres, silica in coal mine - NIOSH guide to the selection and use of particulate respirators – case studies

REFERENCES

(C) SAFETY IN MARINE SYSTEMS

DOCK SAFETY

UNIT I : HISTORY OF SAFETY LEGISLATION
History of dock safety statues in India-background of present dock safety statues- dock workers (safety, health and welfare) act 1986 and the rules and regulations framed there under, few cases laws to interpret the terms used in the dock safety statues. Responsibility of different agencies for safety, health and welfare involved in dock work –

UNIT II : WORKING ON BOARD THE SHIP
Types of cargo ships – working on board ships – Safety in handling of hatch beams – hatch covers including its marking, Mechanical operated hatch covers of different types and its safety features – safety in chipping and painting operations on board ships – safe means of accesses – safety in storage etc. – illumination of decks and in holds – hazards in working inside the hold of the ship and on decks – safety precautions needed – safety in use of transport equipment - internal combustible engines like fort-lift trucks-pay loaders etc. Working with electricity and electrical management – Storage – types, hazardous cargo.

UNIT III : LIFTING APPLIANCES
Different types of lifting appliances – construction, maintenance and use, various methods of rigging of derricks, safety in the use of container handling/lifting appliances like portainers, transtainer, top lift trucks and other containers – testing and examination of lifting appliances, portainers, transtainers, top lift trucks – derricks in different rigging etc. Use and care of synthetic and natural fibre ropes – wire rope chains, different types of slings and loose gears.

UNIT IV : TRANSPORT EQUIPMENT
The different types of equipment for transporting containers and safety in their use-safety in the use of self-loading container vehicles, container side lifter, fork lift truck, dock railways, conveyors and cranes. Safe use of special lift trucks inside containers – Testing, examination and inspection of containers – carriage of dangerous goods in containers and maintenance and certification of containers for safe operation
Handling of different types of cargo – loading and unloading of cargo identification of berths/walking for transfer operation of specific chemical from ship to shore and vice versa – restriction of loading and unloading operations.

UNIT V : EMERGENCY ACTION PLAN AND DOCK WORKERS (SHW) REGULATIONS
Emergency action Plans for fire and explosions - collapse of lifting appliances and buildings, sheds etc., - gas leakages and precautions concerning spillage of dangerous goods etc., - Preparation of onsite emergency plan and safety report.
Dock workers (SHW) rules and regulations 1990-related to lifting appliances, Container handling, loading and unloading, handling of hatch coverings and beams, Cargo handling, conveyors, dock railways, forklift.

REFERENCES
4. Srinivasan “Harbour, Dock and Tunnel Engineering”
5. Bindra SR “Course in Dock and Harbour Engineering.”