Model Curriculum for UG Degree Course in Mechatronics Engineering

ALL INDIA COUNCIL FOR TECHNICAL EDUCATION
NELSON MANDELA MARG, Vasant Kunj, New Delhi – 110070
www.aicte-india.org
MESSAGE

The quality of technical education depends on many factors but largely on outcome based socially and industrially relevant curriculum, good quality motivated faculty, teaching learning process, effective industry internship and evaluation of students based on desired outcomes. Therefore, it was imperative that a Model Curriculum be prepared by best experts from academia and industry, keeping in view the latest industry trends and market requirements and be made available to all universities / board of technical education and engineering institutions in the country. AICTE constituted team of experts to prepare the model curriculum of UG Degree Course in Mechatronics Engineering. Similar exercise is done for other UG, Diploma and PG level in engineering, MBA, PGDM, Architecture, etc.

It comprises of basic science and engineering courses, having focus on fundamentals, significant discipline level courses and ample electives both from the disciplines and cross disciplines including emerging areas all within a cumulative structure of 163 credits. Summer Internships have been embedded to make the student understand the industry requirements and have hands on experience. Virtual Labs has been introduced for few experiments. Also, most courses have been mapped to its equivalent SWAYAM/NPTEL Course to offer an alternative for learning that course online from SWAYAM. These features will allow students to develop a problem-solving approach to face the challenges in the future and develop outcome based learning approach.

As a major initiative by AICTE, a three-week mandatory induction program for students has also been designed and has to be given at the beginning of the course. The idea behind this is to make the students feel comfortable in their new environment, open them up, set a healthy daily routine, develop awareness, sensitivity and understanding of the self, people around them, society at large, and nature.

AICTE places on record, special thanks to Prof. Sunil Jha, Prof. S.D. Agashe, Prof. Ashiv Shah and Mr. Vikram Mattoo. We are sure that this Model Curriculum will help to enhance not just the employability skills but will also enable youngsters to become job creators.

We strongly urge the institutions / universities / boards of technical education in India to adopt this Model Curriculum at the earliest. This is a suggestive curriculum and the concerned university / institution / board should build on and exercise flexibility in readjustment of courses within the overall 163 credits.

(Prof. Anil D. Sahasrabudhe)
Chairman
All India Council for Technical Education
PREFACE

Taking cognisance of growing concern about quality of technical education in India, AICTE in its 49th council meeting held on 14.03.2017 approved a package of measures for improving quality of technical education - Revision of Curriculum, Mandatory Internship, and Student Induction Program were amongst the few.

AICTE constituted committee of academia industry experts to prepare model curriculum of UG Course in Mechatronics Engineering. During the development of curriculum, the employability and employment opportunities for graduates, future ready workforce who will be skilled enough to handle the rapid growth in the field of Mechatronics were kept in mind.

AICTE has introduced mandatory internship in the new curriculum which will equip the students with practical understanding and training about industry practices in a suitable industry or organization. In the course of development of model curriculum, the committee took feedback of industry experts on the draft curriculum and accordingly modified the draft before finalization. This exercise has ensured that essential emphasis on industry requirements and market trends, employability and problem solving approach is given.

After due deliberations, the scheme and syllabus have been formulated. Salient features of this model curriculum are enumerated as under:

- Reduced number of credits.
- Introduction of Student Induction Program.
- Well defined learning objectives & outcomes for each course.
- Inclusion of courses on socially relevant topics.
- Built-in flexibility to the students in terms of professional elective and open elective courses.
- Mandatory internship to equip the students with practical knowledge and provide them exposure to real time industrial environments.
- Virtual Labs.
- Mapping of Courses to its equivalent NPTEL/SWAYAM Course.
- Course on ‘Entrepreneurship and Startups’ to encourage entrepreneurial mindset.

I gratefully acknowledge the time and efforts of the members of the working group namely Prof. Sunil Jha of IIT Delhi; Prof. S.D. Agashe of College of Engineering, Pune; Prof. Ashiv Shah of AKG Engineering College and Mr. Vikram Mattoo of Mitsubishi Electric India Pvt. Ltd. We also appreciate the feedback on the draft received from Mr. Manoj Yadav of KUKA Robotics; Mr. Bipin Chandra of EDAG Production Solutions Pvt. Ltd., Mr. Chetan Rajdev of Hydac India, Mr. Brajesh Poddar of North SMC Corporation India, Mr. Sangeet of Adverb Technologies and Dr. O.P. Goel of Bosch India.

Special thanks to Prof. Anil D. Sahasrabudhe, Chairman; Prof. M.P. Poonia, Vice-Chairman; and Prof. Rajive Kumar, Member Secretary, AICTE who all have been instrumental and encouraging throughout the process of development of this model curriculum.
I appreciate the dedication put by the Dr. Neeraj Saxena, Adviser-II; Dr. Pradeep C. Bhaskar, Assistant Director (P&AP); Mr. Dharmesh Kumar Dewangan, Young Professional (P&AP); Mr. Rakesh Kumar Pandit Young Professional (P&AP); and other office staff of AICTE.

(Prof. Dileep N. Malkhede)  
Advisor – I  
Policy and Academic Planning Bureau  
All India Council for Technical Education
Committee for Model Curriculum

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Member Name</th>
<th>Designation &amp; Organization</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Prof. Sunil Jha</td>
<td>Professor, Department of Mechanical Engineering, IIT Delhi</td>
</tr>
<tr>
<td>2</td>
<td>Prof. S.D. Agashe</td>
<td>Professor, Department of Instrumentation and Control, College of Engineering, Pune</td>
</tr>
<tr>
<td>3</td>
<td>Prof. Ashiv Shah</td>
<td>Professor, Centre of Excellence in Industrial Automation &amp; Robotics, AKG Engineering College, Ghaziabad (U.P)</td>
</tr>
<tr>
<td>4</td>
<td>Mr. Vikram Mattoo</td>
<td>General Manager, Factory Automation Centre, Mitsubishi Electric India Pvt. Ltd, Haryana</td>
</tr>
</tbody>
</table>

Industrial Team who helped with their valuable feedback on the Draft Model Curriculum

<table>
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<tr>
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<th>Member Name</th>
<th>Designation &amp; Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Mr. Manoj Yadav</td>
<td>General Manager, KUKA Robotics India, Gurgaon</td>
</tr>
<tr>
<td>2</td>
<td>Mr. Bipin Chandra</td>
<td>Director Engineering, EDAG Production Solutions India Private Limited, Gurgaon</td>
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<td>3</td>
<td>Mr. Chetan Rajdev</td>
<td>National Manager, Hydac India, Bangalore</td>
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<td>4</td>
<td>Mr. Brajesh Poddar</td>
<td>Sr. Manager; North SMC Corporation India, Noida</td>
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<tr>
<td>5</td>
<td>Mr. Karun Jain</td>
<td>Academic Program Manager; North West East India, National Instruments, Bangalore</td>
</tr>
<tr>
<td>6</td>
<td>Mr. Sangeet</td>
<td>Founder Director, Addverb Technologies</td>
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<tr>
<td>13</td>
<td>Appendix III</td>
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<td>176</td>
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GENERAL COURSE STRUCTURE
& THEME
GENERAL COURSE STRUCTURE & THEME

A. Definition of Credit:

<table>
<thead>
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<th>Course Type</th>
<th>Credits</th>
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<tr>
<td>1 Hr. Lecture (L) per week</td>
<td>1 Credit</td>
</tr>
<tr>
<td>1 Hr. Tutorial (T) per week</td>
<td>1 Credit</td>
</tr>
<tr>
<td>1 Hr. Practical (P) per week</td>
<td>0.5 Credit</td>
</tr>
<tr>
<td>2 Hours Practical (P) per week</td>
<td>1 Credit</td>
</tr>
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</table>

B. Range of Credits: In the light of the fact that a typical Model Four-year UnderGraduate Degree program in Engineering has about 163 credits, the total number of credits proposed for the four-year UG Program (B.E. / B. Tech) in Mechatronics Engineering is 163.

C. Structure of Mechatronics Engineering program: The structure of Mechatronics Engineering program shall have essentially the following categories of courses with the breakup of credits as given:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Category</th>
<th>Breakup of Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Humanities &amp; Social Science Courses</td>
<td>12*</td>
</tr>
<tr>
<td>2.</td>
<td>Basic Science Courses</td>
<td>21*</td>
</tr>
<tr>
<td>3.</td>
<td>Mechatronics Engineering Core Courses</td>
<td>101*</td>
</tr>
<tr>
<td>4.</td>
<td>Professional Elective Courses (Branch Specific Electives)</td>
<td>6*</td>
</tr>
<tr>
<td>5.</td>
<td>Open Elective Courses (Cross Disciplines Elective)</td>
<td>6*</td>
</tr>
<tr>
<td>6.</td>
<td>Project work, Seminar and Internship in Industry or elsewhere</td>
<td>17*</td>
</tr>
<tr>
<td>7.</td>
<td>Audit Courses [Environmental Sciences, Indian Constitution]</td>
<td>(non-credit)</td>
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</table>

TOTAL 163*  

*Minor variation is allowed.

D. Course code and definition:

<table>
<thead>
<tr>
<th>Course code</th>
<th>Definitions</th>
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<tbody>
<tr>
<td>L</td>
<td>Lecture</td>
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<tr>
<td>T</td>
<td>Tutorial</td>
</tr>
<tr>
<td>P</td>
<td>Practical</td>
</tr>
<tr>
<td>C</td>
<td>Credits</td>
</tr>
<tr>
<td>MT</td>
<td>Engineering Core courses / Basic Science Courses / Laboratory Courses / Projects / Internships / Engineering Science Courses</td>
</tr>
<tr>
<td>MTPE</td>
<td>Professional Elective Courses</td>
</tr>
<tr>
<td>MTOE</td>
<td>Open Elective Courses</td>
</tr>
<tr>
<td>AU</td>
<td>Audit Courses</td>
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</table>
**Course level coding scheme:** Following terminology is used for subject code:

- **MT - Y0X** - Theory subjects
- **MT - Y1X** - Labs & Practical
- **MTPE - Y0X** - Professional Elective Subjects
- **MTOE - Y0X** - Open Elective Subjects
- **AU - Y0X** - Audit Subjects

- MT = Theory & Practical Subject/Projects/Internships/Seminar.
- MTPE = Professional Elective Subjects.
- MTOE = Open Elective Subjects.
- AU = Audit Courses.
- Y = Semester: 1 to 8.
- X = Theory & Practical Subject Serial Number: 1 to 9.

**Category-wise Courses**

**HUMANITIES & SOCIAL SCIENCES COURSES**

(i) Number of Humanities & Social Science Courses: 4  
(ii) Credits: 12

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Course Code</th>
<th>Course Title</th>
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<th>P</th>
<th>Semester</th>
<th>Credits</th>
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<tbody>
<tr>
<td>1</td>
<td>MT-204</td>
<td>English</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>II</td>
<td>3</td>
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<tr>
<td>2</td>
<td>MT-306</td>
<td>Effective Technical Communication</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>III</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>HSMC(H-102)</td>
<td>Universal Human Values 2: Understanding Harmony</td>
<td></td>
<td></td>
<td></td>
<td>III</td>
<td>3</td>
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<td>4</td>
<td>MT-506</td>
<td>Entrepreneurship and Startups</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>V</td>
<td>3</td>
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</table>

**Total Credits**

**BASIC SCIENCE COURSES**

(i) Number of Basic Sciences Courses: 5  
(ii) Credits: 21

<table>
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<tr>
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<th>Course Code</th>
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<th>P</th>
<th>Semester</th>
<th>Credits</th>
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<tr>
<td>1</td>
<td>MT-101</td>
<td>Physics-I</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>I</td>
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<tr>
<td>2</td>
<td>MT-102</td>
<td>Mathematics-I</td>
<td>3</td>
<td>1</td>
<td>0</td>
<td>I</td>
<td>4</td>
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<td>3</td>
<td>MT-201</td>
<td>Chemistry-I</td>
<td>3</td>
<td>1</td>
<td>3</td>
<td>II</td>
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<td>MT-202</td>
<td>Mathematics-II</td>
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<td>1</td>
<td>0</td>
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<td>5</td>
<td>MT-304</td>
<td>Physics-II</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>III</td>
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**Total Credits**

21
MECHATRONICS ENGINEERING CORE COURSES

(i) Number of Mechatronics Engineering Core Courses: 44
(ii) Credits: 101

<table>
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<tr>
<th>S. No.</th>
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<th>Semester</th>
<th>Credits</th>
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<td>MT-103</td>
<td>Basic Electrical Engineering</td>
<td>3</td>
<td>1</td>
<td>2</td>
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<td>MT-104</td>
<td>Engineering Graphics &amp; Design</td>
<td>1</td>
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<td>4</td>
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<td>MT-203</td>
<td>Programming for Problem Solving</td>
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<td>MT-211</td>
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<td>5</td>
<td>MT-301</td>
<td>Basic Concepts of Mechatronics</td>
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<td>0</td>
<td>0</td>
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<td>6</td>
<td>MT-302</td>
<td>Strength of Materials</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>III</td>
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<td>7</td>
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<td>8</td>
<td>MT-305</td>
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<td>MT-505</td>
<td>Kinematics and Theory of Machines</td>
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</table>
**PROFESSIONAL ELECTIVE COURSES [MTPE]**

(i) Number of Professional Elective Courses: 2
(ii) Credits: 6

<table>
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<tr>
<th>S. No.</th>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>Semester</th>
<th>Credits</th>
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<tr>
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<td>MTPE-60X</td>
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<td>Professional Elective II</td>
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</table>

**Total Credits** 6

For detailed syllabus of Professional Elective Course, Refer Appendix I.
OPEN ELECTIVE COURSES [MTOE]

(i) Number of Open Elective Courses: 2
(ii) Credits: 6

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Course Code</th>
<th>Course Title</th>
<th>L</th>
<th>T</th>
<th>P</th>
<th>Semester</th>
<th>Credits</th>
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<tbody>
<tr>
<td>1</td>
<td>MTOE-80X</td>
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Total Credits 6

For detailed syllabus of Open Elective Course, Refer Appendix II.

PROJECT WORK, SEMINAR, INDUSTRIAL VISIT AND INTERNSHIP

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<th>Semester</th>
<th>Credits</th>
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<td>IV</td>
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Total Credits 17

AUDIT COURSES [AU]

Note: These are mandatory non-credit courses.

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<th>T</th>
<th>P</th>
<th>Semester</th>
<th>Credits</th>
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Total Credits 0
INDUCTION PROGRAM

The Essence and Details of Induction program can also be understood from the ‘Detailed Guide on Student Induction program’, as available on AICTE Portal, (Link: https://www.aicteindia.org/sites/default/files/Detailed%20Guide%20on%20Student%20Induction%20program.pdf).

For more, Refer Appendix III.

<table>
<thead>
<tr>
<th>Induction program (mandatory)</th>
<th>Three-week duration</th>
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</table>
| Induction program for students to be offered right at the start of the first year. | ● Physical activity  
● Creative Arts  
● Universal Human Values  
● Literary  
● Proficiency Modules  
● Lectures by Eminent People  
● Visits to local Areas  
● Familiarization to Dept./Branch & Innovations |

E. Mandatory Visits/ Workshop/Expert Lectures:
   a. It is mandatory to arrange one industrial visit every semester.
   b. It is mandatory to conduct a One-week workshop during the winter break after fifth semester on professional/industry/entrepreneurial orientation.
   c. It is mandatory to organize at least one expert lecture per semester for each branch by inviting resource persons from domain specific industry.

F. Evaluation Scheme (Suggestive only):
   a. For Theory & Practical Courses: The weightage of Continuous Assessment (C.A.) and End Semester Assessment (E.S.A.) is mentioned for every subject. If not mentioned anywhere, then Continuous Assessment may be given 40% weightage and End Semester may be given 60% weightage. The student has to obtain at least 40% marks individually both in internal assessment and end semester exams to pass.

   b. For Internship / Projects / Seminar etc.: Evaluation is based on work done, quality of report, performance in viva-voce, presentation etc.

Note: The internal assessment is based on the student's performance in mid semester tests (two best out of three), quizzes, assignments, class performance, attendance, viva-voce in practical, lab record etc.
G. Mapping of Marks to Grades

Each course (Theory/Practical) is to be assigned 100 marks, irrespective of the number of credits, and the mapping of marks to grades may be done as per the following table:

<table>
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<th>Range of Marks</th>
<th>Assigned Grade</th>
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<td>AA/A+</td>
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<tr>
<td>81-90</td>
<td>AB/A</td>
</tr>
<tr>
<td>71-80</td>
<td>BB/B+</td>
</tr>
<tr>
<td>61-70</td>
<td>BC/B</td>
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<td>46-50</td>
<td>CD/C</td>
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<td>40-45</td>
<td>DD/D</td>
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<td>&lt;40</td>
<td>FF/F (Fail due to less marks)</td>
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<td>(Fail due to shortage of attendance and therefore, to repeat the course)</td>
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*******
SEMESTER WISE STRUCTURE
### SEMESTER I

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<tr>
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<th>T</th>
<th>P</th>
<th>Credit</th>
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</thead>
<tbody>
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<td>1</td>
<td>3</td>
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<td>2</td>
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<td>Mathematics-I</td>
<td>3</td>
<td>1</td>
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<tr>
<td>3</td>
<td>MT-103</td>
<td>Basic Electrical Engineering</td>
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<td>MT-104</td>
<td>Engineering Graphics &amp; Design</td>
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3 WEEKS COMPULSORY INDUCTION PROGRAM

### SEMESTER II

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<tr>
<td>3</td>
<td>MT-203</td>
<td>Programming for Problem Solving</td>
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<td>MT-211</td>
<td>Workshop/Manufacturing Practices</td>
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Mini Project or Internship (3-4 Weeks) shall be conducted during summer break after Semester II and will be assessed during Semester III.

Note: ^ represents related to Audit Course.

### SEMESTER III

<table>
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<tr>
<th>S. No.</th>
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<th>Course Title</th>
<th>Weekly Contact Hours</th>
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<th>T</th>
<th>P</th>
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**TOTAL** 28 18 2 8 25

Mini Project or Internship (3-4 Weeks) shall be conducted during summer break after Semester II and will be assessed during Semester III.

### SEMESTER IV

<table>
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<td>Industrial Visit</td>
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**TOTAL** 27+2^ 15+2^ 0 12 22
Mini Project or Internship (3-4 Weeks) shall be conducted during summer break after Semester IV and will be assessed during Semester V.
Note: ^ represent “Audit Course”.

**SEMMESTER V**

<table>
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Mini Project or Internship (3-4 Weeks) shall be conducted during summer break after Semester IV and will be assessed during Semester V.
^ represent “Audit Course”.

**SEMMESTER VI**

<table>
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<th>Course Title</th>
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<th>C</th>
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<tbody>
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</table>

Mini Project or Internship (3-4 Weeks) shall be conducted during summer break after Semester VI and will be assessed during Semester VII.

Any one course from following options can be opted under ‘Professional Elective I’:
1. Optimization Technique (MTPE-601)
2. Operation Research (MTPE-602)
3. Total Quality Management (MTPE-603)

**SEMMESTER VII**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Weekly Contact Hours</th>
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### SEMESTER VII

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**TOTAL** 22 11 1 10 18

Mini Project or Internship (3-4 Weeks) shall be conducted during summer break after Semester VI and will be assessed during Semester VII.

Any one course from following options can be opted under ‘Professional Elective II’:
1. Product Development (MTPE-701)
2. Rapid Prototyping (MTPE-702)
3. Machine Learning (MTPE-703)

### SEMESTER VIII

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Weekly Contact Hours</th>
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</table>

**TOTAL** 26 6 0 20 16

Any one course from following options can be opted under ‘Open Elective I’:
1. Virtual and Augmented Reality (MTOE-801)
2. Image Processing and Computer Vision (MTOE-802)
3. Wireless Network & Communication (MTOE-803)

Any one course from following options can be opted under ‘Open Elective II’:
1. Artificial Intelligence (MTOE-804)
2. Real Time System (MTOE-805)
3. Artificial Neural Network (MTOE-806)

*****
SEMESTER – I
SEMESTER I

<table>
<thead>
<tr>
<th>Course Code</th>
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<tr>
<td>Course Title</td>
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<tr>
<td>Course Contents in Physics (Any One)</td>
<td>Anyone from the below options</td>
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<tr>
<td></td>
<td>i. Introduction to Electromagnetic Theory</td>
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<tr>
<td></td>
<td>ii. Introduction to Mechanics</td>
</tr>
<tr>
<td></td>
<td>iii. Quantum Mechanics for Engineers</td>
</tr>
<tr>
<td></td>
<td>iv. Oscillation, Waves and Optics</td>
</tr>
</tbody>
</table>

Course Objectives: To enhance the fundamental knowledge in Physics and its applications relevant to various streams of Engineering and Technology.

<table>
<thead>
<tr>
<th>Introduction to Electromagnetic Theory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-requisites (if any): Mathematics course with vector calculus</td>
</tr>
</tbody>
</table>

Module I: Electrostatics in vacuum
Calculation of electric field and electrostatic potential for a charge distribution; Divergence and curl of electrostatic field; Laplace's and Poisson's equations for electrostatic potential and uniqueness of their solution and connection with steady state diffusion and thermal conduction; Practical examples like Faraday's cage and coffee-ring effect; Boundary conditions of electric field and electrostatic potential; method of images; energy of a charge distribution and its expression in terms of electric field.

Module II: Electrostatics in a linear dielectric medium
Electrostatic field and potential of a dipole. Bound charges due to electric polarization; Electric displacement; boundary conditions on displacement; Solving simple electrostatics problems in presence of dielectrics - Point charge at the centre of a dielectric sphere, charge in front of a dielectric slab, dielectric slab and dielectric sphere in uniform electric field.

Module III: Magnetostatics
Bio-Savart law, Divergence and curl of static magnetic field; vector potential and calculating it for a given magnetic field using Stokes’ theorem; the equation for the vector potential and its solution for given current densities.

Module IV: Magnetostatics in a linear magnetic medium
Magnetization and associated bound currents; auxiliary magnetic field H; Boundary conditions on B and H. Solving for magnetic field due to simple magnets like a bar magnet;
magnetic susceptibility and ferromagnetic, paramagnetic and diamagnetic materials; Qualitative discussion of magnetic field in presence of magnetic materials.

**Module V: Faraday's law**
Faraday's law in terms of EMF produced by changing magnetic flux; equivalence of Faraday's law and motional EMF; Lenz's law; Electromagnetic breaking and its applications; Differential form of Faraday's law expressing curl of electric field in terms of time-derivative of magnetic field and calculating electric field due to changing magnetic fields in quasi-static approximation; energy stored in a magnetic field.

**Module VI: Displacement current, Magnetic field due to time-dependent electric field and Maxwell's equations**
Continuity equation for current densities; Modifying equation for the curl of magnetic field to satisfy continuity equation; displacement current and magnetic field arising from time dependent electric field; calculating magnetic field due to changing electric fields in quasistatic approximation. Maxwell’s equation in vacuum and non-conducting medium; Energy in an electromagnetic field; Flow of energy and Pointing vector with examples. Qualitative discussion of momentum in electromagnetic fields.

**Module VII: Electromagnetic waves**
The wave equation; Plane electromagnetic waves in vacuum, their transverse nature and polarization; relation between electric and magnetic fields of an electromagnetic wave; energy carried by electromagnetic waves and examples. Momentum carried by electromagnetic waves and resultant pressure. Reflection and transmission of electromagnetic waves from a non-conducting medium-vacuum interface for normal incidence.

**Laboratory - Introduction to Electromagnetic Theory**
Choice of experiments from the following:
- Experiments on electromagnetic induction and electromagnetic braking;
- LC circuit and LCR circuit;
- Resonance phenomena in LCR circuits;
- Magnetic field from Helmholtz coil;
- Measurement of Lorentz force in a vacuum tube.

**TEXTBOOKS/REFERENCES:**
1. David Griffiths, Introduction to Electrodynamics
2. Halliday and Resnick, Physics
3. W. Saslow, Electricity, magnetism and light

**Alternative NPTEL/SWAYAM Course:**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
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<td>1</td>
<td>INTRODUCTION TO ELECTROMAGNETIC THEORY</td>
<td>PROF. MANOJ</td>
<td>IIT KANPUR</td>
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<td>HARBOLA</td>
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EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Experiment Name</th>
<th>Experiment Link(s)</th>
</tr>
</thead>
</table>
| 1      | LC circuit and LCR circuit;                                                     | 1. [http://vlab.amrita.edu/?sub=1&brch=75&sim=326&cnt=1](http://vlab.amrita.edu/?sub=1&brch=75&sim=326&cnt=1)  
|        |                                                                                | 2. [http://vlab.amrita.edu/?sub=1&brch=75&sim=330&cnt=1](http://vlab.amrita.edu/?sub=1&brch=75&sim=330&cnt=1)  
|        |                                                                                | 3. [http://vlab.amrita.edu/?sub=1&brch=75&sim=318&cnt=1](http://vlab.amrita.edu/?sub=1&brch=75&sim=318&cnt=1)  
|        |                                                                                | 4. [http://vlab.amrita.edu/?sub=1&brch=75&sim=325&cnt=1](http://vlab.amrita.edu/?sub=1&brch=75&sim=325&cnt=1)  
|        |                                                                                | 5. [http://vlabs.iitkgp.ernet.in/asn/exp12/index.htm](http://vlabs.iitkgp.ernet.in/asn/exp12/index.htm) |
| 2      | Resonance phenomena in LCR circuits                                            | [http://vlab.amrita.edu/?sub=1&brch=75&sim=325&cnt=1](http://vlab.amrita.edu/?sub=1&brch=75&sim=325&cnt=1) |

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Introduction to Mechanics

Pre-requisites (if any): High School Education

Module I
Transformation of scalars and vectors under Rotation transformation; Forces in Nature; Newton’s laws and its completeness in describing particle motion; Form invariance of Newton’s Second Law; Solving Newton’s equations of motion in polar coordinates; Problems including constraints and friction; Extension to cylindrical and spherical coordinates.

Module II
Potential energy function; F = - Grad V, equipotential surfaces and meaning of gradient; Conservative and non-conservative forces, curl of a force field; Central forces; Conservation of Angular Momentum; Energy equation and energy diagrams; Elliptical, parabolic and hyperbolic orbits; Kepler problem; Application: Satellite manoeuvres;

Module III
Non-inertial frames of reference; Rotating coordinate system: Five-term acceleration formula. Centripetal and Coriolis accelerations; Applications: Weather systems, Foucault pendulum;

Module IV
Harmonic oscillator; Damped harmonic motion – over-damped, critically damped and lightly-damped oscillators; Forced oscillations and resonance.
Module V
Definition and motion of a rigid body in the plane; Rotation in the plane; Kinematics in a coordinate system rotating and translating in the plane; Angular momentum about a point of a rigid body in planar motion; Euler’s laws of motion, their independence from Newton’s laws, and their necessity in describing rigid body motion; Examples.

Module VI
Introduction to three-dimensional rigid body motion — only need to highlight the distinction from two-dimensional motion in terms of (a) Angular velocity vector, and its rate of change and (b) Moment of inertia tensor; Three-dimensional motion of a rigid body wherein all points move in a coplanar manner: e.g. Rod executing conical motion with center of mass fixed — only need to show that this motion looks two-dimensional but is three-dimensional, and two-dimensional formulation fails.

Laboratory - Introduction to Mechanics
1. Suggested list of experiments from the following:
2. Coupled oscillators;
3. Experiments on an air-track;
4. Experiment on moment of inertia measurement,
5. Experiments with gyroscope;
6. Resonance phenomena in mechanical oscillators.

TEXTBOOKS/REFERENCES:
1. Engineering Mechanics, 2nd ed. — MK Harbola
3. Introduction to Mechanics — MK Verma
4. Elements of Mechanical Engineering - D.S. Bedi & M.P. Poonia
5. An Introduction to Mechanics — D Kleppner & R Kolenkow
9. Mechanical Vibrations — JP Den Hartog
10. Theory of Vibrations with Applications — WT Thomson

Alternative NPTEL/SWAYAM Course:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>ENGINEERING MECHANICS</td>
<td>PROF. MANOJ HARBOLA</td>
<td>IIT KANPUR</td>
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EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Experiment Name</th>
<th>Experiment Link(s)</th>
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<tbody>
<tr>
<td>1</td>
<td>Experiment on moment of inertia measurement.</td>
<td><a href="https://vlab.amrita.edu/?sub=1&amp;brch=74&amp;sim=571&amp;cnt=1">https://vlab.amrita.edu/?sub=1&amp;brch=74&amp;sim=571&amp;cnt=1</a></td>
</tr>
</tbody>
</table>
Quantum Mechanics for Engineers

Pre-requisites (if any): Mathematics Course on Differential equations & linear algebra

Module I: Wave nature of particles and the Schrodinger equation
Introduction to Quantum mechanics, Wave nature of Particles, Time-dependent and time independent Schrodinger equation for wave function, Born interpretation, probability current, Expectation values, Free-particle wave function and wave-packets, Uncertainty principle.

Module II: Mathematical Preliminaries for quantum mechanics
Complex numbers, Linear vector spaces, inner product, operators, eigenvalue problems, Hermitian operators, Hermite polynomials, Legendre's equation, spherical harmonics.

Module III: Applying the Schrodinger equation
Solution of stationary-state Schrodinger equation for one dimensional problems– particle in a box, particle in attractive delta-function potential, square-well potential, linear harmonic oscillator. Numerical solution of stationary-state Schrodinger equation for one dimensional problems for different potentials Scattering from a potential barrier and tunneling; related examples like alpha-decay, fieldionization and scanning tunneling microscope Three-dimensional problems: particle in three dimensional box and related examples, Angular momentum operator, Rigid Rotor, Hydrogen atom ground-state, orbitals, interaction with magnetic field, spin, Numerical solution stationary-state radial Schrodinger equation for spherically symmetric potentials.

Module IV: Introduction to molecular bonding
Particle in double delta-function potential, Molecules (hydrogen molecule, valence bond and molecular orbitals picture), singlet/triplet states, chemical bonding, hybridization.

Module V: Introduction to solids
Free electron theory of metals, Fermi level, density of states, Application to white dwarfs and neutron stars, Bloch's theorem for particles in a periodic potential, Kronig-Penney model and origin of energy bands Numerical solution for energy in one-dimensional periodic lattice by mixing plane waves.

Laboratory - Quantum Mechanics for Engineers
Suggested list of experiments:
- Frank-Hertz experiment;
- photoelectric effect experiment;
- Recording hydrogen atom spectrum.

TEXTBOOKS/REFERENCES:
1. Eisberg and Resnick, Introduction to Quantum Physics
2. D. J. Griffiths, Quantum mechanics
3. Richard Robinett, Quantum Mechanics
4. Daniel McQuarrie, Quantum Chemistry
Alternative NPTEL/SWAYAM Course:

<table>
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<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
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<td>INTRODUCTION TO</td>
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<td>IIT KANPUR</td>
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<td>THEORY</td>
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<td>QUANTUM MECHANICS I</td>
<td>PROF. P. RAMADEVI</td>
<td>IIT BOMBAY</td>
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EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

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<tbody>
<tr>
<td>1</td>
<td>Photoelectric effect experiment.</td>
<td><a href="http://mpv-au.vlabs.ac.in/modern-physics/Photo_Electric_Effect/">http://mpv-au.vlabs.ac.in/modern-physics/Photo_Electric_Effect/</a></td>
</tr>
</tbody>
</table>

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**Oscillations, waves and optics**

Pre-requisites (if any): Mathematics Course on Differential equations

**Module I: Simple harmonic motion, damped and forced simple harmonic oscillator**

Mechanical and electrical simple harmonic oscillators, complex number notation and phasor representation of simple harmonic motion, damped harmonic oscillator – heavy, critical and light damping, energy decay in a damped harmonic oscillator, quality factor, forced mechanical and electrical oscillators, electrical and mechanical impedance, steady state motion of forced damped harmonic oscillator, power absorbed by oscillator.

**Module II: Non-dispersive transverse and longitudinal waves in one dimension and introduction to dispersion**

Transverse wave on a string, the wave equation on a string, Harmonic waves, reflection and transmission of waves at a boundary, impedance matching, standing waves and their Eigen frequencies, longitudinal waves and the wave equation for them, acoustics waves and speed of sound, standing sound waves. Waves with dispersion, water waves, superposition of waves and Fourier method, wave groups and group velocity.

**Module III: The propagation of light and geometric optics**

Fermat’s principle of stationary time and its applications e.g. in explaining mirage effect, laws of reflection and refraction, Light as an electromagnetic wave and Fresnel equations, reflectance and transmittance, Brewster’s angle, total internal reflection, and evanescent wave. Mirrors and lenses and optical instruments based on them, transfer formula and the matrix method.
Module IV: Wave optics
Huygens’ principle, superposition of waves and interference of light by wave front splitting and amplitude splitting; Young’s double slit experiment, Newton’s rings, Michelson interferometer, Mach-Zehnder interferometer. Farunhofer diffraction from a single slit and a circular aperture, the Rayleigh criterion for limit of resolution and its application to vision; Diffraction gratings and their resolving power.

Module V: Lasers
Einstein’s theory of matter radiation interaction and A and B coefficients; amplification of light by population inversion, different types of lasers: gas lasers (He-Ne, CO2), solid-state lasers (ruby, Neodymium), dye lasers; Properties of laser beams: monochromaticity, coherence, directionality and brightness, laser speckles, applications of lasers in science, engineering and medicine.

Laboratory - Oscillations, waves and optics
Suggested list of experiments from the following:

- Diffraction and interference experiments (from ordinary light or laser pointers); measurement of speed of light on a table top using modulation; minimum deviation from a prism.

TEXTBOOKS/REFERENCES:
1. Ian G. Main, Oscillations and waves in physics
2. H.J. Pain, The physics of vibrations and waves
3. E. Hecht, Optics
4. A. Ghatak, Optics
5. O. Svelto, Principles of Lasers

Alternative NPTEL/SWAYAM Course:

<table>
<thead>
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<th>Host Institute</th>
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<td>1</td>
<td>WAVES AND OSCILLATIONS</td>
<td>PROF. M. S. SANTHANAM</td>
<td>IISER PUNE</td>
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EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Experiment Name</th>
<th>Experiment Link(s)</th>
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<tbody>
<tr>
<td>1</td>
<td>Diffraction and interference experiments (from ordinary light or laser pointers).</td>
<td><a href="http://ov-au.vlabs.ac.in/optics/Diffraction_Grating/">http://ov-au.vlabs.ac.in/optics/Diffraction_Grating/</a></td>
</tr>
<tr>
<td>2</td>
<td>Minimum deviation from a prism.</td>
<td><a href="http://ov-au.vlabs.ac.in/optics/Spectrometer_i_d_Curve/">http://ov-au.vlabs.ac.in/optics/Spectrometer_i_d_Curve/</a></td>
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</table>
Course Code : MT-102
Course Title : Mathematics - I
Number of Credits : 4 (L: 3, T: 1, P: 0)
Course Category : MT

Course Objectives: The goal of this course is to achieve conceptual understanding and to retain the best traditions of traditional calculus. The syllabus is designed to provide the basic tools of calculus mainly for the purpose of modelling the engineering problems mathematically and obtaining solutions. This is a foundation course which mainly deals with topics such as single variable and multivariable calculus and plays an important role in the understanding of science, engineering, economics and computer science, among other disciplines.

Course Contents:

Module I: Calculus
Evolutes and involutes; Evaluation of definite and improper integrals; Beta and Gamma functions and their properties; Applications of definite integrals to evaluate surface areas and volumes of revolutions. Rolle’s Theorem, Mean value theorems, Taylor’s and Maclaurin theorems with remainders; indeterminate forms and L’Hospital’s rule; Maxima and minima.

Module II: Sequences and Series
Convergence of sequence and series, tests for convergence; Power series, Taylor’s series, series for exponential, trigonometric and logarithm functions; Fourier series: Half range sine and cosine series, Parseval’s theorem.

Module III: Multivariable Calculus (Differentiation)
Limit, continuity and partial derivatives, directional derivatives, total derivative; Tangent plane and normal line; Maxima, minima and saddle points; Method of Lagrange multipliers; Gradient, curl and divergence.

Module IV: Matrices
Inverse and rank of a matrix, rank-nullity theorem; System of linear equations; Symmetric, skew-symmetric and orthogonal matrices; Determinants; Eigenvalues and eigenvectors; Diagonalization of matrices; Cayley-Hamilton Theorem, and Orthogonal transformation.

TEXTBOOKS/REFERENCES:

Alternative NPTEL/SWAYAM Course:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>ENGINEERING MATHEMATICS - I</td>
<td>PROF. JITENDRA KUMAR</td>
<td>IIT KGP</td>
</tr>
</tbody>
</table>

**Course Outcomes:** The objective of this course is to familiarize the prospective engineers with techniques in calculus, multivariate analysis and linear algebra. It aims to equip the students with standard concepts and tools at an intermediate to advanced level that will serve them well towards tackling more advanced level of mathematics and applications that they would find useful in their disciplines.

The students will learn:

- To apply differential and integral calculus to notions of curvature and to improper integrals. Apart from some other applications they will have a basic understanding of Beta and Gamma functions.
- To explain the fallouts of Rolle’s Theorem that is fundamental to application of analysis to Engineering problems.
- To discuss the tool of power series and Fourier series for learning advanced Engineering Mathematics.
- To deal with functions of several variables that are essential in most branches of engineering.
- To use the essential tool of matrices and linear algebra in a comprehensive manner.

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<table>
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<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>Course Title</td>
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<tr>
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<tr>
<td>Course Category</td>
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</tbody>
</table>

**Course Objective:** The objective of this Course is to provide the students with an introductory and broad treatment of the field of Electrical Engineering.

**Course Contents:**
Module I: D. C. Circuits covering, Ohm's Law and Kirchhoff's Laws; Analysis of series, parallel and series-parallel circuits excited by independent voltage sources; Power and energy; Electromagnetism covering, Faraday's Laws, Lenz's Law, Fleming's Rules, Statically and dynamically induced EMF; Concepts of self-inductance, mutual inductance and coefficient of coupling; Energy stored in magnetic fields;

Module II: Single Phase A.C. Circuits covering, Generation of sinusoidal voltage-definition of average value, root mean square value, form factor and peak factor of sinusoidal voltage and current and phasor representation of alternating quantities; Analysis with phasor diagrams of R, L, C, RL, RC and RLC circuits; Real power, reactive power, apparent power and power factor, series, parallel and series-parallel circuits; Three Phase A.C. Circuits covering, Necessity and Advantages of three phase systems, Generation of three phase power, definition of Phase sequence, balanced supply and balanced load; Relationship between line and phase values of balanced star and delta connections; Power in balanced three phase circuits, measurement of power by two wattmeter method;

Module III: Transformers covering, Principle of operation and construction of single phase transformers (core and shell types). EMF equation, losses, efficiency and voltage regulation; Synchronous Generators covering, Principle of operation; Types and constructional features; EMF equation;

Module IV: DC Machines covering, working principle of DC machine as a generator and a motor; Types and constructional features; EMF equation of generator, relation between EMF induced and terminal voltage enumerating the brush drop and drop due to armature reaction; DC motor working principle; Back EMF and its significance, torque equation; Types of D.C. motors, characteristics and applications; Necessity of a starter for DC motor;

Module V: Three Phase Induction Motors covering; Concept of rotating magnetic field; Principle of operation, types and constructional features; Slip and its significance; Applications of squirrel cage and slip ring motors; Necessity of a starter, star-delta starter.

Module VI: Sources of Electrical Power covering, Introduction to Wind, Solar, Fuel cell, Tidal, Geo-thermal, Hydroelectric, Thermal-steam, diesel, gas, nuclear power plants; Concept of cogeneration, and distributed generation;

TEXT/REFERENCE BOOKS:
Alternative NPTEL/SWAYAM Course:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>BASIC ELECTRIC CIRCUITS</td>
<td>PROF. ANKUSH SHARMA</td>
<td>IIT KANPUR</td>
</tr>
<tr>
<td>2</td>
<td>BASIC ELECTRICAL CIRCUITS</td>
<td>PROF. NAGENDRA KRISHNAPURA</td>
<td>IITM</td>
</tr>
<tr>
<td>3</td>
<td>FUNDAMENTALS OF ELECTRICAL ENGINEERING</td>
<td>PROF. DEBAPRIYA DAS</td>
<td>IIT KGP</td>
</tr>
</tbody>
</table>

**COURSE OUTCOMES:**
The students will learn:

1. To explain strong basics of Electrical Engineering and practical implementation of Electrical fundamentals.
2. To identify different applications of commonly used electrical machinery.

*****

<table>
<thead>
<tr>
<th>Course Code</th>
<th>MT104</th>
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</thead>
<tbody>
<tr>
<td>Course Title</td>
<td>Engineering Graphics &amp; Design</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>3 (L: 1, T: 0, P: 4)</td>
</tr>
<tr>
<td>Course Category</td>
<td>MT</td>
</tr>
</tbody>
</table>

**Course Objective(s):**
The objective of this Course is to provide the basic knowledge about Engineering Drawing. Detailed concepts are given in projections, technical drawing, dimensioning and specifications, so useful for a student in preparing for an engineering career.

**Course Contents:**

**Traditional Engineering Graphics:** Principles of Engineering Graphics; Orthographic Projection; Descriptive Geometry; Drawing Principles; Isometric Projection; Surface Development; Perspective; Reading a Drawing; Sectional Views; Dimensioning & Tolerances; True Length, Angle; intersection, Shortest Distance.

**Computer Graphics:** Engineering Graphics Software; -Spatial Transformations; Orthographic Projections; Model Viewing; Co-ordinate Systems; Multi-view Projection; Exploded Assembly; Model Viewing; Animation; Spatial Manipulation; Surface Modelling; Solid Modelling; Introduction to Building Information Modelling (BIM).

*Except the basic essential concepts, most of the teaching part can happen concurrently in the laboratory*

**Module I: Introduction to Engineering Drawing**
Principles of Engineering Graphics and their significance, usage of Drawing instruments, lettering, Conic sections including the Rectangular Hyperbola (General method only); Cycloid, Epicycloid, Hypocycloid and Involute; Scales – Plain, Diagonal and Vernier Scales;
Module II: Orthographic Projections
Principles of Orthographic Projections-Conventions - Projections of Points and lines inclined to both planes; Projections of planes inclined Planes - Auxiliary Planes;

Module III: Projections of Regular Solids
Covering those inclined to both the Planes- Auxiliary Views; Draw simple annotation, dimensioning and scale. Floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc.

Module IV: Sections and Sectional Views of Right Angular Solids
Prism, Cylinder, Pyramid, Cone – Auxiliary Views; Development of surfaces of Right Regular Solids - Prism, Pyramid, Cylinder and Cone; Draw the sectional orthographic views of geometrical solids, objects from industry and dwellings (foundation to slab only).

Module V: Isometric Projections
Principles of Isometric projection – Isometric Scale, Isometric Views, Conventions; Isometric Views of lines, Planes, Simple and compound Solids; Conversion of Isometric Views to Orthographic Views and Vice-versa, Conventions;

Module VI: Overview of Computer Graphics
Listing the computer technologies that impact on graphical communication, Demonstrating knowledge of the theory of CAD software [such as: The Menu System, Toolbars (Standard, Object Properties, Draw, Modify and Dimension), Drawing Area (Background, Crosshairs, Coordinate System), Dialog boxes and windows, Shortcut menus (Button Bars), The Command Line (where applicable), The Status Bar, Different methods of zoom as used in CAD, Select and erase objects.; Isometric Views of lines, Planes, Simple and compound Solids];

Module VII: Customization & CAD Drawing
Consisting of set up of the drawing page and the printer, including scale settings, setting up of Modules and drawing limits; ISO and ANSI standards for coordinate dimensioning and tolerancing; Orthographic constraints, Snap to objects manually and automatically; Producing drawings by using various coordinate input entry methods to draw straight lines, Applying various ways of drawing circles;

Module VIII: Annotations, layering & other functions
Covering applying dimensions to objects, applying annotations to drawings; Setting up and use of Layers, layers to create drawings, Create, edit and use customized layers; Changing line lengths through modifying existing lines (extend/lengthen); Printing documents to paper using the print command; orthographic projection techniques; Drawing sectional views of composite right regular geometric solids and project the true shape of the sectioned surface; Drawing annotation, Computer-aided design (CAD) software modeling of parts and assemblies. Parametric and non-parametric solid,
surface, and wireframe models. Part editing and two-dimensional documentation of models. Planar projection theory, including sketching of perspective, isometric, multiview, auxiliary, and section views. Spatial visualization exercises. Dimensioning guidelines, tolerancing techniques; dimensioning and scale multi views of dwelling;

**Module IX: Demonstration of a simple team design project that illustrates**

Geometry and topology of engineered components: creation of engineering models and their presentation in standard 2D blueprint form and as 3D wire-frame and shaded solids; meshed topologies for engineering analysis and tool-path generation for component manufacture; geometric dimensioning and tolerancing; Use of solid-modeling software for creating associative models at the component and assembly levels; floor plans that include: windows, doors, and fixtures such as WC, bath, sink, shower, etc. Applying colour coding according to building drawing practice; Drawing sectional elevation showing foundation to ceiling; Introduction to Building Information Modelling (BIM).

**Text/Reference Books:**
6. (Corresponding set of) CAD Software Theory and User Manuals.

**Alternative NPTEL/SWAYAM Course:**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
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<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>PROF. RAJARAM LAKKARAJU</td>
<td>IIT KGP</td>
<td>ENGINEERING DRAWING AND COMPUTER GRAPHICS</td>
</tr>
<tr>
<td>2</td>
<td>PROF. NIHAR RANJAN PATRA</td>
<td>IIT KANPUR</td>
<td>ENGINEERING GRAPHICS</td>
</tr>
</tbody>
</table>

**Course Outcomes:**

All phases of manufacturing or construction require the conversion of new ideas and design concepts into the basic line language of graphics. Therefore, there are many areas (civil, mechanical, electrical, architectural and industrial) in which the skills of the CAD technicians play major roles in the design and development of new products or construction. Students prepare for actual work situations through practical training in a new state-of-the-art computer designed CAD laboratory using engineering software. This course is designed to address:
● to prepare you to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
● to prepare you to communicate effectively
● to prepare you to use the techniques, skills, and modern engineering tools necessary for engineering practice

The students will learn:
● To describe engineering design and its place in society.
● To discuss the visual aspects of engineering design.
● To use engineering graphics standards.
● To illustrate solid modelling.
● To use computer-aided geometric design.
● To design creating working drawings.
● To inspect engineering communication.

*****
SEMESTER – II
Course Objective: The objective of the Chemistry I is to acquaint the students with the basic phenomenon/concepts of chemistry, the student faces during course of their study in the industry and Engineering field. The student with the knowledge of the basic chemistry, will understand and explain scientifically the various chemistry related problems in the industry/engineering field. The student will able to understand the new developments and breakthroughs efficiently in engineering and technology. The introduction of the latest (R&D oriented) topics will make the engineering student upgraded with the new technologies.

Course Content:

**Module I: Atomic and Molecular Structure**
Schroedinger equation. Particle in a box solutions and their applications for conjugated molecules and nanoparticles. Forms of the hydrogen atom wave functions and the plots of these functions to explore their spatial variations. Molecular orbitals of diatomic molecules and plots of the multicentre orbitals. Equations for atomic and molecular orbitals. Energy level diagrams of diatomic. Pi-molecular orbitals of butadiene and benzene and aromaticity. Crystal field theory and the energy level diagrams for transition metal ions and their magnetic properties. Band structure of solids and the role of doping on band structures.

**Module II: Spectroscopic techniques and applications**

**Module III: Intermolecular forces and potential energy surfaces**
Ionic, dipolar and van Der Waals interactions. Equations of state of real gases and critical phenomena. Potential energy surfaces of H3, H2F and HCN and trajectories on these surfaces.

**Module IV: Use of free energy in chemical equilibria (6 lectures)**
Thermodynamic functions: energy, entropy and free energy. Estimations of entropy and free energies. Free energy and emf. Cell potentials, the Nernst equation and applications.

**Module V: Periodic properties**
Effective nuclear charge, penetration of orbitals, variations of s, p, d and f orbital energies of atoms in the periodic table, electronic configurations, atomic and ionic sizes, ionization energies, electron affinity and electronegativity, polarizability, oxidation states, coordination numbers and geometries, hard soft acids and bases, molecular geometries.

**Module VI: Stereochemistry**
Representations of 3 dimensional structures, structural isomers and stereoisomers, configurations and symmetry and chirality, enantiomers, diastereomers, optical activity, absolute configurations and conformational analysis. Isomerism in transitional metal compounds.

**Module VII: Organic reactions and synthesis of a drug molecule**
Introduction to reactions involving substitution, addition, elimination, oxidation, reduction, cyclization and ring openings. Synthesis of a commonly used drug molecule.

**LABORATORY**
Choice of 10-12 experiments from the following:
1. Determination of surface tension and viscosity.
2. Thin layer chromatography.
3. Ion exchange column for removal of hardness of water.
4. Determination of chloride content of water.
5. Colligative properties using freezing point depression.
6. Determination of the rate constant of a reaction.
7. Determination of cell constant and conductance of solutions.
10. Saponification/acid value of an oil.
11. Chemical analysis of a salt.
12. Lattice structures and packing of spheres.
15. Determination of the partition coefficient of a substance between two immiscible liquids.
16. Adsorption of acetic acid by charcoal.
17. Use of the capillary viscosimeters to the demonstrate of the isoelectric point as the pH of minimum viscosity for gelatin sols and/or coagulation of the white part of egg.

**Text/Reference Books:**
1. University chemistry, by B. H. Mahan
3. Fundamentals of Molecular Spectroscopy, by C. N. Banwell
4. Engineering Chemistry (NPTEL Web-book), by B. L. Tembe, Kamaluddin and M. S. Krishnan
5. Physical Chemistry, by P. W. Atkins

**Alternative NPTEL/SWAYAM Course:**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CHEMISTRY - I</td>
<td>PROF. MANGALA SUNDER KRISHNAN</td>
<td>IITM</td>
</tr>
</tbody>
</table>

**EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Experiment Name</th>
<th>Experiment Link(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Determination of chloride content of water.</td>
<td><a href="http://vlabs.iitb.ac.in/vlabs-dev/labs/nitk_labs/Environmental_Engineering_1/experiments/determination-of-chloride-nitk/simulation.html">http://vlabs.iitb.ac.in/vlabs-dev/labs/nitk_labs/Environmental_Engineering_1/experiments/determination-of-chloride-nitk/simulation.html</a></td>
</tr>
<tr>
<td>4</td>
<td>Colligative properties using freezing point depression.</td>
<td><a href="http://pcv-au.vlabs.ac.in/physical-chemistry/Cryoscopy/">http://pcv-au.vlabs.ac.in/physical-chemistry/Cryoscopy/</a></td>
</tr>
<tr>
<td>5</td>
<td>Determination of the rate constant of a reaction.</td>
<td><a href="http://pcv-au.vlabs.ac.in/physical-chemistry/EMF_Measurement/">http://pcv-au.vlabs.ac.in/physical-chemistry/EMF_Measurement/</a></td>
</tr>
<tr>
<td>8</td>
<td>Saponification/acid value of an oil.</td>
<td><a href="http://biotech01.vlabs.ac.in/biochemistry/Estimation_of_Saponification_Value_of_Fats_or_Oils/">http://biotech01.vlabs.ac.in/biochemistry/Estimation_of_Saponification_Value_of_Fats_or_Oils/</a></td>
</tr>
<tr>
<td>9</td>
<td>Lattice structures and packing of spheres.</td>
<td><a href="https://vlab.amrita.edu/?sub=1&amp;brc=282&amp;sim=370&amp;cnt=1">https://vlab.amrita.edu/?sub=1&amp;brc=282&amp;sim=370&amp;cnt=1</a></td>
</tr>
</tbody>
</table>

**Course Outcomes:** The concepts developed in this course will aid in quantification of several concepts in chemistry that have been introduced at the 10+2 levels in schools.
Technology is being increasingly based on the electronic, atomic and molecular level modifications. Quantum theory is more than 100 years old and to understand phenomena at nanometre levels, one has to base the description of all chemical processes at molecular levels. The course will enable the students:

- To analyse microscopic chemistry in terms of atomic and molecular orbitals and intermolecular forces.
- To rationalise bulk properties and processes using thermodynamic considerations.
- To distinguish the ranges of the electromagnetic spectrum used for exciting different molecular energy levels in various spectroscopic techniques.
- To rationalise periodic properties such as ionization potential, electronegativity, oxidation states and electronegativity.
- To list major chemical reactions that are used in the synthesis of molecules.

**Laboratory Outcomes:** The chemistry laboratory course will consist of experiments illustrating the principles of chemistry relevant to the study of science and engineering. The students will learn:

- To estimate rate constants of reactions from concentration of reactants/products as a function of time.
- To measure molecular/system properties such as surface tension, viscosity, conductance of solutions, redox potentials, chloride content of water, etc.
- To synthesize a small drug molecule and analyze a salt sample.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>: MT-202</th>
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</thead>
<tbody>
<tr>
<td>Course Title</td>
<td>: Mathematics- II</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>: 4 (L: 3, T: 1, P: 0)</td>
</tr>
<tr>
<td>Course Category</td>
<td>: MT</td>
</tr>
</tbody>
</table>

**Course Objective:** Mathematics fundamental necessary to formulate, solve and analyze engineering problems.

**Course Content:**

**Module I: Multivariable Calculus (Integration)**

Multiple Integration: Double integrals (Cartesian), change of order of integration in double integrals, Change of variables (Cartesian to polar), Applications: areas and volumes, Center of mass and Gravity (constant and variable densities); Triple integrals (Cartesian), orthogonal curvilinear coordinates, Simple applications involving cubes, sphere and rectangular parallelepipeds; Scalar line integrals, vector line integrals, scalar surface integrals, vector surface integrals, Theorems of Green, Gauss and Stokes.

**Module II: First order ordinary differential equations**
Exact, linear and Bernoulli’s equations, Euler’s equations, Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut’s type.

**Module III: Ordinary differential equations of higher orders**
Second order linear differential equations with variable coefficients, method of variation of parameters, Cauchy-Euler equation; Power series solutions; Legendre polynomials, Bessel functions of the first kind and their properties.

**Module IV: Complex Variable – Differentiation**
Differentiation, Cauchy-Riemann equations, analytic functions, harmonic functions, finding harmonic conjugate; elementary analytic functions (exponential, trigonometric, logarithm) and their properties; Conformal mappings, Mobius transformations and their properties.

**Module V: Complex Variable – Integration**
Contour integrals, Cauchy-Goursat theorem (without proof), Cauchy Integral formula (without proof), Liouville’s theorem and Maximum-Modulus theorem (without proof); Taylor’s series, zeros of analytic functions, singularities, Laurent’s series; Residues, Cauchy Residue theorem (without proof), Evaluation of definite integral involving sine and cosine, Evaluation of certain improper integrals using the Bromwich contour.

**TEXT BOOKS/REFERENCES:**

**Alternative NPTEL/SWAYAM Course:**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
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<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>DIFFERENTIAL EQUATIONS FOR ENGINEERS</td>
<td>PROF. SRINIVASA MANAM</td>
<td>IITM</td>
</tr>
</tbody>
</table>
COURSE OUTCOMES: The objective of this course is to familiarize the prospective engineers with techniques in multivariate integration, ordinary and partial differential equations and complex variables. It aims to equip the students to deal with advanced level of mathematics and applications that would be essential for their disciplines.

The students will learn:
- To illustrate the mathematical tools needed in evaluating multiple integrals and their usage.
- To categorize the effective mathematical tools for the solutions of differential equations that model physical processes.
- To explain the tools of differentiation and integration of functions of a complex variable that are used in various techniques dealing engineering problems.

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<table>
<thead>
<tr>
<th>Course Code</th>
<th>MT-203</th>
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</thead>
<tbody>
<tr>
<td>Course Title</td>
<td>Programming for Problem Solving</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>5 (L: 3, T: 0, P: 4)</td>
</tr>
<tr>
<td>Course Category</td>
<td>MT</td>
</tr>
</tbody>
</table>

Course Objectives:
1. To learn the fundamentals of computers.
2. To understand the various steps in program development.
3. To learn the syntax and semantics of C programming language.
4. To learn the usage of structured programming approach in solving problems.
5. To understand and formulate algorithm for programming script
6. To analyze the output based on the given input variables

Course Contents:

**Module I:** Introduction to Programming; Introduction to components of a computer system (disks, memory, processor, where a program is stored and executed, operating system, compilers etc.)

Idea of Algorithm: steps to solve logical and numerical problems. Representation of Algorithm: Flowchart/Pseudocode with examples.

From algorithms to programs; source code, variables (with data types) variables and memory locations, Syntax and Logical Errors in compilation, object and executable code.

**Module II:** Arithmetic expressions and precedence.
**Module III:** Conditional Branching and Loops. Writing and evaluation of conditionals and consequent branching. Iteration and loops.

**Module IV:** Arrays, Arrays (1-D, 2-D), Character arrays and Strings

**Module V:** Basic Algorithms, Searching, Basic Sorting Algorithms (Bubble, Insertion and Selection), Finding roots of equations, notion of order of complexity through example programs (no formal definition required)

**Module VI:** Function, Functions (including using built in libraries), Parameter passing in functions, call by value, Passing arrays to functions: idea of call by reference

**Module VII:** Recursion, Recursion as a different way of solving problems. Example programs, such as Finding Factorial, Fibonacci series, Ackerman function etc. Quick sort or Merge sort.

**Module VIII:** Structures, Defining structures and Array of Structures

**Module IX:** Pointers, Idea of pointers, Defining pointers, Use of Pointers in self-referential structures, notion of linked list (no implementation)

**Module X:** File handling (only if time is available, otherwise should be done as part of the lab).

**PRACTICALS:**
1. Familiarization with programming environment
2. Simple computational problems using arithmetic expressions
3. Problems involving if-then-else structures
4. Iterative problems e.g., sum of series
5. 1D Array manipulation
6. Matrix problems, String operations
7. Simple functions
8. Programming for solving Numerical methods problems
9. Recursive functions
10. Pointers and structures
11. File operations

**TEXT/REFERENCE BOOKS:**

**Alternative NPTEL/SWAYAM Course:**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>INTRODUCTION TO PROGRAMMING IN C</td>
<td>PROF. SATYADEV NANDAKUMAR</td>
<td>IITK</td>
</tr>
</tbody>
</table>
EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Experiment Name</th>
<th>Experiment Link(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1D Array manipulation.</td>
<td><a href="http://cse02-iith.vlabs.ac.in/exp4/index.html">http://cse02-iith.vlabs.ac.in/exp4/index.html</a></td>
</tr>
<tr>
<td>5</td>
<td>Simple functions.</td>
<td><a href="http://cse02-iith.vlabs.ac.in/exp2/index.html">http://cse02-iith.vlabs.ac.in/exp2/index.html</a></td>
</tr>
</tbody>
</table>

COURSE OUTCOMES: The student will learn following through lectures:

- To formulate simple algorithms for arithmetic and logical problems.
- To translate the algorithms to programs (in C language).
- To test and execute the programs and correct syntax and logical errors.
- To implement conditional branching, iteration and recursion.
- To decompose a problem into functions and synthesize a complete program using divide and conquer approach.
- To use arrays, pointers and structures to formulate algorithms and programs.
- To apply programming to solve matrix addition and multiplication problems and searching and sorting problems.
- To apply programming to solve simple numerical method problems, namely root finding of function, differentiation of function and simple integration.
The student will learn following through Practicals:
- To formulate the algorithms for simple problems.
- To translate given algorithms to a working and correct program.
- To be able to correct syntax errors as reported by the compilers.
- To be able to identify and correct logical errors encountered at run time.
- To be able to write iterative as well as recursive programs.
- To be able to represent data in arrays, strings and structures and manipulate them through a program.
- To be able to declare pointers of different types and use them in defining self-referential structures.
- To be able to create, read and write to and from simple text files.

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**Course Objective:**
- To provide learning environment to practice listening, speaking, reading and writing skills.
- To assist the students to carry on the tasks and activities through guided instructions and materials.
- To effectively integrate English language learning with employability skills and training.
- To provide hands-on experience through case-studies, mini-projects, group and individual presentations.

**Course Content:**

**Module I: Vocabulary Building**
1.1. The concept of Word Formation
1.2. Root words from foreign languages and their use in English
1.3. Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives.
1.4. Synonyms, antonyms, and standard abbreviations.

**Module II: Basic Writing Skills**
1.1. Sentence Structures
1.2. Use of phrases and clauses in sentences
1.3. Importance of proper punctuation
1.4. Creating coherence
1.5. Organizing principles of paragraphs in documents
1.6. Techniques for writing precisely

**Module III: Identifying Common Errors in Writing**
1.1. Subject-verb agreement
1.2. Noun-pronoun agreement
1.3. Misplaced modifiers
1.4. Articles
1.5. Prepositions
1.6. Redundancies
1.7. Clichés

**Module IV**: Nature and Style of sensible Writing
1.1. Describing
1.2. Defining
1.3. Classifying
1.4. Providing examples or evidence
1.5. Writing introduction and conclusion

**Module V**: Writing Practices
1.1. Comprehension
1.2. Précis Writing
1.3. Essay Writing

**Module VI**: Oral Communication
(This Module involves interactive practice sessions in Language Lab)
- Listening Comprehension
- Pronunciation, Intonation, Stress and Rhythm
- Common Everyday Situations: Conversations and Dialogues
- Communication at Workplace
- Interviews
- Formal Presentations

**Text/Reference Books:**

**Alternative NPTEL/SWAYAM Course:**

<table>
<thead>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>ENGLISH LANGUAGE FOR COMPETITIVE EXAMS</td>
<td>PROF. AYSHA IQBAL</td>
<td>IIT MADRAS</td>
</tr>
<tr>
<td>2</td>
<td>TECHNICAL ENGLISH FOR ENGINEERS</td>
<td>PROF. AYSHA IQBAL</td>
<td>IITM</td>
</tr>
</tbody>
</table>

**Course Outcomes:** The student will acquire basic proficiency in English including reading and listening comprehension, writing and speaking skills.

*****
Course Code: MT-211
Course Title: Workshop/Manufacturing Practices
Number of Credits: 3 (L: 1, T: 0, P: 4)
Course Category: MT

Course Objective:
1. To provide exposure to the students with hands on experience on various basic engineering practices in Civil, Mechanical, Electrical and Electronics Engineering.
2. To have a study and hands-on-exercise on plumbing and carpentry components.
3. To have a practice on gas welding, foundry operations and fitting
4. To have a study on measurement of electrical quantities, energy and resistance to earth.
5. To have a practice on soldering.

Course Content:
Module I: Manufacturing Methods- casting, forming, machining, joining, advanced manufacturing methods.
Module II: CNC machining, Additive manufacturing.
Module III: Fitting operations & power tools.
Module IV: Electrical & Electronics.
Module V: Carpentry.
Module VI: Plastic moulding, glass cutting.
Module VII: Metal casting.
Module VIII: Welding (arc welding & gas welding), brazing.

Practicals:
1. Machine shop
2. Fitting shop
3. Carpentry
4. Electrical & Electronics
5. Welding shop (Arc welding + Gas welding)
6. Casting
7. Smithy
8. Plastic moulding & Glass Cutting

Examinations could involve the actual fabrication of simple components, utilizing one or more of the techniques covered above.

Suggested Text/Reference Books:

**EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Experiment Name</th>
<th>Experiment Link(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Welding shop (Arc welding + Gas welding)</td>
<td><a href="http://mm-coep.vlabs.ac.in/LaserSpotWelding/Theory.html?domain=Mechanical%20Engineering&amp;lab=Welcome%20to%20Micromachining%20laboratory">http://mm-coep.vlabs.ac.in/LaserSpotWelding/Theory.html?domain=Mechanical%20Engineering&amp;lab=Welcome%20to%20Micromachining%20laboratory</a></td>
</tr>
<tr>
<td>2</td>
<td>Casting</td>
<td><a href="http://fab-coep.vlabs.ac.in/exp7/Theory.html?domain=Mechanical%20Engineering&amp;lab=Welcome%20to%20FAB%20laboratory">http://fab-coep.vlabs.ac.in/exp7/Theory.html?domain=Mechanical%20Engineering&amp;lab=Welcome%20to%20FAB%20laboratory</a></td>
</tr>
</tbody>
</table>

**Course Outcomes:** Upon completion of this course, the students will gain knowledge of the different manufacturing processes which are commonly employed in the industry, to fabricate components using different materials.

**Laboratory Outcomes:**
- Upon completion of this laboratory course, students will be able:
  - To fabricate components with their own hands.
  - To relate practical knowledge of the dimensional accuracies and dimensional tolerances possible with different manufacturing processes.
  - To design small devices of their interest by assembling different components.

****

**Course Code:** AU102  
**Course Title:** Sports and Yoga  
**Number of Credits:** 0 (L: 2, T: 0, P: 0)  
**Course Category:** AU

**Course Objective(s):**
To make the students understand the importance of sound health and fitness principles as they relate to better health.

To expose the students to a variety of physical and yogic activities aimed at stimulating their continued inquiry about Yoga, physical education, health and fitness.

To create a safe, progressive, methodical and efficient activity based plan to enhance improvement and minimize risk of injury.

To develop among students an appreciation of physical activity as a lifetime pursuit and a means to better health.

Course Contents:

**Module I: Introduction to Physical Education**
- Meaning & definition of Physical Education
- Aims & Objectives of Physical Education
- Changing trends in Physical Education

**Module II: Olympic Movement**
- Ancient & Modern Olympics (Summer & Winter)
- Olympic Symbols, Ideals, Objectives & Values
- Awards and Honours in the field of Sports in India (Dronacharya Award, Arjuna Award, Dhayanchand Award, Rajiv Gandhi Khel Ratna Award etc.)

**Module III: Physical Fitness, Wellness & Lifestyle**
- Meaning & Importance of Physical Fitness & Wellness
- Components of Physical fitness
- Components of Health related fitness
- Components of wellness
- Preventing Health Threats through Lifestyle Change
- Concept of Positive Lifestyle

**Module IV: Fundamentals of Anatomy & Physiology in Physical Education, Sports and Yoga**
- Define Anatomy, Physiology & Its Importance

**Module V: Kinesiology, Biomechanics & Sports**
- Meaning & Importance of Kinesiology & Biomechanics in Physical Edu. & Sports
- Newton’s Law of Motion & its application in sports.
- Friction and its effects in Sports.

**Module VI: Postures**
- Meaning and Concept of Postures.
- Causes of Bad Posture.
- Advantages & disadvantages of weight training.
- Concept & advantages of Correct Posture.
- Common Postural Deformities – Knock Knee; Flat Foot; Round Shoulders; Lordosis, Kyphosis, Bow Legs and Scoliosis.
- Corrective Measures for Postural Deformities

**Module VII: Yoga**
- Meaning & Importance of Yoga
- Elements of Yoga
- Introduction - Asanas, Pranayama, Meditation & Yogic Kriyas
- Yoga for concentration & related Asanas (Sukhasana; Tadasana; Padmasana & Shashankasana)
- Relaxation Techniques for improving concentration - Yog-nidra

**Module VIII: Yoga & Lifestyle**
- Asanas as preventive measures.
- Hypertension: Tadasana, Vajrasana, Pavan Muktasana, Ardha Chakrasana, Bhujangasana, Sharasana.
- Back Pain: Tadasana, Ardh Matsyendrasana, Vakrasana, Shalabhasana, Bhujangasana.

**Module IX: Training and Planning in Sports**
- Meaning of Training
- Warming up and limbering down
- Skill, Technique & Style
- Meaning and Objectives of Planning.
- Tournament – Knock-Out, League/Round Robin & Combination.

**Module X: Psychology & Sports**
- Definition & Importance of Psychology in Physical Edu. & Sports
- Define & Differentiate Between Growth & Development
- Adolescent Problems & Their Management
- Emotion: Concept, Type & Controlling of emotions
- Meaning, Concept & Types of Aggressions in Sports.
- Psychological benefits of exercise.
- Anxiety & Fear and its effects on Sports Performance.
Motivation, its type & techniques.
Understanding Stress & Coping Strategies.

Module XI: Doping
- Meaning and Concept of Doping
- Prohibited Substances & Methods
- Side Effects of Prohibited Substances

Module XII: Sports Medicine
- First Aid – Definition, Aims & Objectives.
- Sports injuries: Classification, Causes & Prevention.
- Management of Injuries: Soft Tissue Injuries and Bone & Joint Injuries

Module XIII: Sports / Games
Following subtopics related to any one Game/Sport of choice of student out of: Athletics, Badminton, Basketball, Chess, Cricket, Kabaddi, Lawn Tennis, Swimming, Table Tennis, Volleyball, Yoga etc.
- History of the Game/Sport.
- Specifications of Play Fields and Related Sports Equipment.
- Important Tournaments and Venues.
- Sports Personalities.
- Proper Sports Gear and its Importance.

Text Books/References:
1. Modern Trends and Physical Education by Prof. Ajmer Singh.
2. Light On Yoga By B.K.S. Iyengar.
3. Health and Physical Education – NCERT (11th and 12th Classes)

Course Outcomes: On successful completion of the course the students will be able:
1. To practice Physical activities and Hatha Yoga focusing on yoga for strength, flexibility, and relaxation.
2. To learn techniques for increasing concentration and decreasing anxiety which leads to stronger academic performance.
3. To learn breathing exercises and healthy fitness activities
4. To understand basic skills associated with yoga and physical activities including strength and flexibility, balance and coordination.
5. To perform yoga movements in various combination and forms.
6. To assess current personal fitness levels.
7. To identify opportunities for participation in yoga and sports activities.
8. To develop understanding of health-related fitness components: cardiorespiratory endurance, flexibility and body composition etc.
9. To improve personal fitness through participation in sports and yogic activities.
10. To develop understanding of psychological problems associated with the age and lifestyle.

11. To demonstrate an understanding of sound nutritional practices as related to health and physical performance.

12. To assess yoga activities in terms of fitness value.

13. To identify and apply injury prevention principles related to yoga and physical fitness activities.

14. To understand and correctly apply biomechanical and physiological principles related to exercise and training.

******
SEMESTER – III
SEMESTER III

<table>
<thead>
<tr>
<th>Course Code</th>
<th>MT-301</th>
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</thead>
<tbody>
<tr>
<td>Course Title</td>
<td>Basic Concepts of Mechatronics</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>3 (L: 3; T: 0; P: 0)</td>
</tr>
<tr>
<td>Course Category</td>
<td>MT</td>
</tr>
</tbody>
</table>

Course Objective: This course aims at providing fundamental understanding about the basic elements of a mechatronics system, interfacing, and its practical applications.

Course Contents:


Module II: Sensors and transducers: classification, Development in Transducer technology, Opto- Electronics-Shaft encoders, CD Sensors, Vision System, etc.

Module III: Drives and Actuators: Hydraulic and Pneumatic drives, Electrical Actuators such as servo motor and Stepper motor, Drive circuits, open and closed loop control; Embedded Systems: Hardware Structure, Software Design and Communication, Programmable Logic Devices, Automatic Control and Real Time Control Systems

Module IV: Smart materials: Shape Memory Alloy, Piezoelectric and Magnetostrictive Actuators: Materials, Static and dynamic characteristics, illustrative examples for positioning, vibration isolation, etc.

Module V: Micromechatronic systems: Microsensors, Microactuators; Micro-fabrication techniques LIGA Process: Lithography, etching, Micro-joining etc. Application examples; Case studies Examples of Mechatronic Systems from Robotics Manufacturing, Machine Diagnostics, Road vehicles and Medical Technology.

Text/Reference Books:
Alternative NPTEL/SWAYAM Course:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Mechatronics &amp; Manufacturing Automation</td>
<td>Dr. Shrikrishna N. Joshi</td>
<td>IIT Guwahati</td>
</tr>
</tbody>
</table>

**Course Outcomes:** After undergoing this course the students is in a position to understand how mechatronics systems can be designed and developed.

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<table>
<thead>
<tr>
<th>Course Code</th>
<th>: MT-302</th>
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</thead>
<tbody>
<tr>
<td>Course Title</td>
<td>: Strength of Materials</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>: 3 (L: 2; T: 1; P: 0)</td>
</tr>
<tr>
<td>Course Category</td>
<td>: MT</td>
</tr>
</tbody>
</table>

**Course Objective:**
- To understand the nature of stresses developed in simple geometries such as bars, cantilevers, beams, shafts, cylinders and spheres for various types of simple loads.
- To calculate the elastic deformation occurring in various simple geometries for different types of loading.

**Course Contents:**

**Module I:** Deformation in solids- Hooke’s law, stress and strain- tension, compression and shear stresses- elastic constants and their relations- volumetric, linear and shear strains- principal stresses and principal planes- Mohr’s circle.

**Module II:** Beams and type’s transverse loading on beams- shear force and bend moment diagrams- Types of beam supports, simply supported and over-hanging beams, cantilevers. Theory of bending of beams, bending stress distribution and neutral axis, shear stress distribution, point and distributed loads.

**Module III:** Moment of inertia about an axis and polar moment of inertia, deflection of a beam using double integration method, computation of slopes and deflection in beams, Maxwell’s reciprocal theorems.

**Module IV:** Torsion, stresses and deformation in circular and hollow shafts, stepped shafts, deflection of shafts fixed at both ends, stresses and deflection of helical springs.

**Module V:** Axial and hoop stresses in cylinders subjected to internal pressure, deformation of thick and thin cylinders, deformation in spherical shells subjected to internal pressure.
Text/Reference Books:

Alternative NPTEL/SWAYAM Course:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Strength of Materials</td>
<td>Dr. Satish C Sharma</td>
<td>IIT Roorkee</td>
</tr>
</tbody>
</table>

Course Outcomes:
After completing the course, the students should be able:
• To recognize various types of loads applied on machine components of simple geometry and understand the nature of internal stresses that will develop within the components.
• To evaluate the strains and deformation that will result due to the elastic stresses developed within the materials for simple types of loading.

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<table>
<thead>
<tr>
<th>Course Code</th>
<th>MT-303</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>Electrical Machines</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>3 (L: 3; T: 0; P: 0)</td>
</tr>
<tr>
<td>Course Category</td>
<td>MT</td>
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</tbody>
</table>

Course Objective:
• Understand the concepts of magnetic circuits.
• Understand the operation of ac and dc machines.
• Analyze the differences in operation of different dc and ac machine configurations.

Course Contents:

**Module I: DC Machines-I:** Basic construction of a DC machine, magnetic structure - stator yoke, stator poles, pole-faces or shoes, air gap and armature core, visualization of magnetic field produced by the field winding excitation with armature winding open, air gap flux density distribution, flux per pole, induced EMF in an armature coil. Armature winding and commutation - Elementary armature coil and commutator, lap and wave windings, construction of commutator, linear commutation Derivation of back EMF
equation, armature MMF wave, derivation of torque equation, armature reaction, air gap flux density distribution with armature reaction.

**Module II: DC Machines –II:** Motoring and generation Armature circuit equation for motoring and generation, Types of field excitations - separately excited, shunt and series. Open circuit characteristic of separately excited DC generator, back EMF with armature reaction, voltage build-up in a shunt generator, critical field resistance and critical speed. V-I characteristics and torque-speed characteristics of separately excited shunt and series motors. Speed control through armature voltage. Losses, load testing and back-to-back testing of DC machines.


**Module IV: Single-phase induction motors:** Constructional features, double revolving field theory, equivalent circuit, determination of parameters. Split-phase starting methods and applications.

**Module V: Synchronous machines:** Constructional features, cylindrical rotor synchronous machine - generated EMF, equivalent circuit and phasor diagram, armature reaction, synchronous impedance, voltage regulation. Operating characteristics of synchronous machines, V-curves. Salient pole machine - two reaction theory, analysis of phasor diagram, power angle characteristics. Parallel operation of alternators - synchronization and load division.

**Text/Reference Books:**

**Alternative NPTEL/SWAYAM Course:**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Electrical Machines</td>
<td>Prof. G. Bhuvaneshwari</td>
<td>IIT Delhi</td>
</tr>
</tbody>
</table>
**Course Outcomes:** At the end of this course, students will demonstrate the ability
1. To understand the concepts of rotating magnetic fields.
2. To understand the operation of ac and dc machines.
3. To analyze performance characteristics of ac and dc machines.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>MT-304</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>Physics-II</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>2 (L: 2; T: 0; P: 0)</td>
</tr>
<tr>
<td>Course Category</td>
<td>MT</td>
</tr>
</tbody>
</table>

**Course Objective:**
- The course will provide the students about the electronic Components diode, transistor.
- This will provide the students the knowledge of IC fabrication.
- It gives an imp. Information about the optoelectronic devices.
- This course offered a variety of diodes like zener diode.
- It will give the knowledge of switching circuit.

**Course Contents:**

**Module I:** Review of semiconductor physics E-k diagram, Density of states, Occupation probability, Fermi level and quasi-Fermi level (variation by carrier concentration and temperature); p-n junction, Metal-semiconductor junction (Ohmic and Schottky); Carrier transport, generation, and recombination; Semiconductor materials of interest for optoelectronic devices, bandgap modification, heterostructures; Light-semiconductor interaction: Rates of optical transitions, joint density of states, condition for optical amplification.

**Module II:** Semiconductor light emitting diodes (LEDs) (6) Rate equations for carrier density, Radiative and non-radiative recombination mechanisms in semiconductors, LED: device structure, materials, characteristics, and figures of merit.

**Module III:** Semiconductor lasers (8) Review of laser physics; Rate equations for carrier- and photon-density, and their steady state solutions, Laser dynamics, Relaxation oscillations, Input-output characteristics of lasers. Semiconductor laser: structure, materials, device characteristics, and figures of merit; DFB, DBR, and vertical-cavity surface-emitting lasers (VECSEL), Tunable semiconductor lasers.

**Module IV:** Photodetectors (6) Types of semiconductor photodetectors -p-n junction, PIN, and Avalanche --- and their structure, materials, working principle, and characteristics, Noise limits on performance; Solar cells.
Module V: Low-dimensional optoelectronic devices (6) Quantum-well, -wire, and -dot based LEDs, lasers, and photodetectors.

Text/Reference Books:
2. B. E. A. Saleh and M. C. Teich, Fundamentals of Photonics, John Wiley & Sons.
6. Online course: "Semiconductor Optoelectronics" by M R Shenoy on NPTEL.
7. Online course: "Optoelectronic Materials and Devices" by Monica Katiyar and Deepak Gupta on NPTEL.

Course Outcomes: After the completion of the course, Students will be able
1. To learn IC fabrication using many circuits as for the electronic industry.
2. To demonstrate the conversion of energy, like light to electrical energy using Optoelectronic devices
3. To learn semiconductor devices in the electronic field.
4. To illustrate Zener diode to control the voltage.

Course Objective:
- To understand the elements of embedded system.
- The ability to interface different components of embedded system and its programming.

Course Contents: The concept of embedded systems design, embedded microcontroller cores, embedded memories. Examples of embedded systems, Technological aspects of embedded systems: interfacing between analog and digital blocks, signal conditioning, digital signal processing. Sub-system interfacing, interfacing with external systems, user interfacing. Design trade-offs due to process compatibility, thermal considerations, etc., Software aspects of embedded systems: real time programming languages and operating systems for embedded systems.

Text/Reference Books:

Alternative NPTEL/SWAYAM Course:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Embedded Systems</td>
<td>Prof. Shantanu Chaudhary</td>
<td>IIT Delhi</td>
</tr>
</tbody>
</table>

Course Outcomes: At the end of the course, students will demonstrate the ability:
1. To suggest design approach using advanced controllers to real-life situations.
2. To design interfacing of the systems with other data handling / processing systems.
3. To identify engineering constraints like energy dissipation, data exchange speeds etc.

****

Course Code : MT-306
Course Title : Effective Technical Communication
Number of Credits : 3 (L: 3; T: 0; P: 0)
Course Category : MT

Course Content:

**Module I: Information Design and Development** - Different kinds of technical documents, Information development life cycle, Organization structures, factors affecting information and document design, Strategies for organization, Information design and writing for print and for online media.

**Module II**: Technical Writing, Grammar and Editing - Technical writing process, forms of discourse, writing drafts and revising, Collaborative writing, creating indexes, technical writing style and language. Basics of grammar, study of advanced grammar, editing strategies to achieve appropriate technical style. Introduction to advanced technical communication, Usability, Human factors, Managing technical communication projects, time estimation, Single sourcing, Localization.

**Module III**: Self Development and Assessment - Self assessment, Awareness, Perception and Attitudes, Values and belief, Personal goal setting, career planning, Self-esteem. Managing Time; Personal memory, Rapid reading, taking notes; Complex problem solving; Creativity.
Module IV: Communication and Technical Writing- Public speaking, Group discussion, Oral; presentation, Interviews, Graphic presentation, Presentation aids, Personality Development. Writing reports, project proposals, brochures, newsletters, technical articles, manuals, official notes, business letters, memos, progress reports, minutes of meetings, event report.

Module V: Ethics- Business ethics, Etiquettes in social and office settings, Email etiquettes, Telephone Etiquettes, Engineering ethics, managing time, Role and responsibility of engineer, Work culture in jobs, Personal memory, Rapid reading, taking notes, Complex problem solving, Creativity.

Text/Reference Books:

Alternative NPTEL/SWAYAM Course:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL ID</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>102104061</td>
<td>INTRODUCTION TO PROFESSIONAL SCIENTIFIC COMMUNICATION</td>
<td>PROF. S. GANESH</td>
<td>IIT KANPUR</td>
</tr>
</tbody>
</table>

*****

Course Code : MT-311
Course Title : Basic Mechatronics Lab
Number of Credits : 1 (L: 0; T: 0; P: 2)
Course Category : MT

Course Objective:
- To synergies the combination of mechanical, electronics, control engineering and computer.
• Providing a focused laboratory environment to the engineering students to apply and absorb Mechatronics concepts.
• To provide a common ground where students could perform experimental study regarding fundamental sequence control by utilizing various sensors and actuators.

List of Experiments:
For first year students- Students can perform set of experiments as given below:
1. Identification and familiarization of the following components: resistors, inductors, capacitors, diodes, transistors, LED’s.
2. Familiarization with the following components: CRO, transformer, function generator, Multimeter, power supply.
3. Familiarization with the following electrical machines: Induction motors, DC motors, synchronous motors, single phase motors.
4. Familiarization with the following mechanical components: gears, gear train, bearings, couplings, tachometer
5. To study and design the PN junction diode and its use as half wave and full wave rectifier.
6. To design a voltage regulator using zener diode. Discuss the behavior of the regulator for various loads.
7. To verify truth tables of various logic gates and flip flops.
8. To study various sensors and transducers and compare with ideal characteristics.
9. To measure the characteristics of LVDT using linear displacement trainer kit.

Text/Reference Books:
2. Mahalik, “Principles, concepts and applications Mechatronics”, TMH.

EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Experiment Name</th>
<th>Experiment Link(s)</th>
</tr>
</thead>
</table>
| 1     | Identification and familiarization of the following components: resistors, inductors, capacitors, diodes, transistors, LED’s. | 1. [http://vlabs.iitkgp.ernet.in/be/exp1/index.html](http://vlabs.iitkgp.ernet.in/be/exp1/index.html)  
3. [http://vlabs.iitkgp.ernet.in/be/exp2/index.html](http://vlabs.iitkgp.ernet.in/be/exp2/index.html)  
<p>| 2     | Familiarization with the following electrical machines: Induction motors, DC motors, synchronous motors, single phase motors. | <a href="http://em-coep.vlabs.ac.in/Exp8/Theory.html?domain=Electrical%20Engineering&amp;lab=Welcome%20to%20Electrical%20Machines">http://em-coep.vlabs.ac.in/Exp8/Theory.html?domain=Electrical%20Engineering&amp;lab=Welcome%20to%20Electrical%20Machines</a> |</p>
<table>
<thead>
<tr>
<th></th>
<th>To study and design the PN junction diode and its use as half wave and full wave rectifier.</th>
<th><a href="http://ee-iitb.vlabs.ac.in/ee-iitb/exp1/index.html">http://ee-iitb.vlabs.ac.in/ee-iitb/exp1/index.html</a></th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>To design a voltage regulator using zener diode. Discuss the behavior of the regulator for various loads.</td>
<td><a href="http://vlab.amrita.edu/?sub=1&amp;brch=282&amp;sim=1207&amp;cnt=1">http://vlab.amrita.edu/?sub=1&amp;brch=282&amp;sim=1207&amp;cnt=1</a></td>
</tr>
<tr>
<td>6</td>
<td>To measure the characteristics of LVDT using linear displacement trainer kit.</td>
<td><a href="http://sl-coep.vlabs.ac.in/LinearVariableDifferentialTransformer/Theory.html?domain=Electrical%20Engineering&amp;lab=Welcome%20to%20Sensor%20Lab">http://sl-coep.vlabs.ac.in/LinearVariableDifferentialTransformer/Theory.html?do main=Electrical%20Engineering&amp;lab=Welcome%20to%20Sensor%20Lab</a></td>
</tr>
</tbody>
</table>

**Course Outcomes:** After completing the course, students will be able:
1. To identify the key elements of mechatronics system, representation into block diagram.
2. To apply knowledge of the concept of signal processing and signal conditioning for its industrial applications.
3. To analyze the requirements for a given industrial process and select the most appropriate Actuators, sensors, design circuit according to applications.
4. To understand the different logic gates, architecture of microprocessor and microcontroller for industrial applications.

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**Course Code**: MT-312  
**Course Title**: Strength of Materials Lab  
**Number of Credits**: 1 (L: 0; T: 0; P: 2)  
**Course Category**: MT

**Course Objective**: Demonstrating the basic principles in the area of strength and mechanics of materials and structural analysis to the undergraduate students through a series of experiments is the objective of the strength of materials lab. Measuring the
properties of the materials such as impact strength, tensile strength, compressive strength, hardness, ductility is conducted in the lab.

Major Equipments Strength of Materials Lab: - Universal testing machine, Torsion testing machine, Impact testing machine, Brinell hardness testing machine, Rockwell hardness testing machine, etc.

**List of Experiments:**
1. Tension test
2. Bending tests on simply supported beam and Cantilever beam.
3. Torsion test
4. Hardness tests (Brinnel’s and Rockwell)
5. Tests on closely coiled and open coiled springs
6. Compression test on wood or concrete
7. Impact test
8. Shear test

**Text/Reference Books:**

**EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Experiment Name</th>
<th>Experiment Link(s)</th>
</tr>
</thead>
</table>
| 1     | Tension test.                                       | 1. [http://sm-nitk.vlabs.ac.in/exp13/index.html](http://sm-nitk.vlabs.ac.in/exp13/index.html)  
2. [http://sm-nitk.vlabs.ac.in/exp14/index.html](http://sm-nitk.vlabs.ac.in/exp14/index.html) |
| 2     | Bending tests on simply supported beam and Cantilever beam. | 1. [https://mdmv-nitk.vlabs.ac.in/exp2/index.html](https://mdmv-nitk.vlabs.ac.in/exp2/index.html)  
2. [https://mdmv-nitk.vlabs.ac.in/exp3/index.html](https://mdmv-nitk.vlabs.ac.in/exp3/index.html)  
2. [http://sm-nitk.vlabs.ac.in/exp19/index.html](http://sm-nitk.vlabs.ac.in/exp19/index.html) |
| 4     | Hardness tests (Brinnel’s and Rockwell)             | 1. [http://eerc01-iiith.vlabs.ac.in/exp10/Introduction.html?domain=Civil%20Engineering&lab=Welcome%20to](http://eerc01-iiith.vlabs.ac.in/exp10/Introduction.html?domain=Civil%20Engineering&lab=Welcome%20to) |
## Course Outcomes:
Upon completion of the course student should be able:

1. To Analyze and design structural members subjected to tension, compression, torsion, bending and combined stresses using the fundamental concepts of stress, strain and elastic behavior of materials.
2. To Utilize appropriate materials in design considering engineering properties, sustainability, cost and weight.
3. To Perform engineering work in accordance with ethical and economic constraints related to the design of structures and machine parts.

### Course Code: MT-313
### Course Title: Electrical Machines Lab
Course Objective:
● Understand the concepts of magnetic circuits and their applications.
● Understand the operation of ac and dc machines and their characteristic curves.
● Analyze the differences in operation of different dc and ac machine configurations.

List of Experiments:
1. Performance characteristics of a D.C. Shunt motor.
2. Speed control of dc shunt motor by varying armature circuit and field circuit method.
3. Load test of D.C. shunt motor.
4. Perform an open circuit test and block rotor test on a 3 phase IM to draw equivalent circuit.
5. Perform load test on a universal motor and determine the performance with dc/ac supply voltage.
8. Obtain a circle diagram of the given three-phase induction motor by conducting no load and blocked motor test and to determine the maximum torque, maximum power output.

Text/Reference Books:

EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Experiment Name</th>
<th>Experiment Link(s)</th>
</tr>
</thead>
</table>
| 1     | To obtain a circle diagram of the given three-phase induction motor by conducting no load and blocked motor test and to determine the maximum torque, maximum power output. | 1. [http://em-coep.vlabs.ac.in/Exp3/Theory.html?domain=Electrical%20Engineering&lab=Welcome%20to%20Electrical%20Machines](http://em-coep.vlabs.ac.in/Exp3/Theory.html?domain=Electrical%20Engineering&lab=Welcome%20to%20Electrical%20Machines)  
**Course Outcomes:** Upon completion of the course student should be able:

1. To obtain performance characteristics of a D.C. Shunt motor.
2. To analyze speed control of dc shunt motor by varying armature circuit and field circuit method.
3. To perform an open circuit test and block rotor test on a 3 phase IM to draw equivalent circuit.
4. To perform load test on a universal motor and determine the performance with dc/ac supply voltage.
5. To Determine the performance characteristics of a three-phase induction motor by load test.
6. To obtain a circle diagram of the given three-phase induction motor by conducting no load and blocked motor test and to determine the maximum torque, maximum power output.

*****

<table>
<thead>
<tr>
<th>Course Code</th>
<th>MT-314</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Title</td>
<td>Embedded Systems Lab</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>1 (L: 0; T: 0; P: 2)</td>
</tr>
<tr>
<td>Course Category</td>
<td>MT</td>
</tr>
</tbody>
</table>

**Course Objective:** The student should be made to:

- Learn the working of ARM processor.
- Understand the Building Blocks of Embedded Systems.
- Learn the concept of memory map and memory interface.
- Know the characteristics of Real Time Systems.
- Write programs to interface memory, I/Os with processor.
- Study the interrupt performance.

**List of Experiments:**

1. Study of ARM evaluation system.
2. Interfacing ADC and DAC.
3. Interfacing LED and PWM.
4. Interfacing real time clock and serial port.
5. Interfacing keyboard and LCD.
6. Interfacing EPROM and interrupt.
7. Interrupt performance characteristics of ARM and FPGA.
8. Flashing of LEDs.
9. Interfacing stepper motor and temperature sensor.
10. Interfacing the wireless Modules with ARM.

**Text/Reference Books:**

EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Experiment Name</th>
<th>Experiment Link(s)</th>
</tr>
</thead>
</table>
| 1      | Interfacing ADC and DAC.   | 1. [http://vlabs.iitkgp.ernet.in/rtes/exp4/index.html](http://vlabs.iitkgp.ernet.in/rtes/exp4/index.html)  
| 2      | Interfacing keyboard and LCD. | [http://vlabs.iitkgp.ernet.in/rtes/exp9/index.html](http://vlabs.iitkgp.ernet.in/rtes/exp9/index.html) |
| 3      | Flashing of LEDs.          | [http://vlabs.iitkgp.ernet.in/rtes/exp11/index.html](http://vlabs.iitkgp.ernet.in/rtes/exp11/index.html) |

Course Outcomes: At the end of the course, a student will be able:
1. To Write programs in ARM for a specific Application.
2. To Interface memory and Write programs related to memory operations.
3. To Interface A/D and D/A convertors with ARM system.
4. To Write programme for interfacing keyboard, display, motor and sensor.
5. To Analyse the performance of interrupt.

Course Code : MT-315
Course Title : Mini Project or Internship
Number of Credits : 1
Course Category : MT

Mini Project or Internship of 3 to 4 Weeks shall be performed during summer break after semester II and will be assessed as part of Semester III.

During the summer vacations, after the 2nd Semester, students are required to be involved in Inter/ Intra Institution Activities viz; Training with higher Institutions; Soft skill training organized by Training and Placement Cell of the respective institution; contribution at incubation/ innovation /entrepreneurship cell of the Institution; participation in conferences/ workshops/ competitions etc.; Learning at Departmental Lab/ Tinkering Lab/ Institutional workshop; Working for consultancy/ research project within the institutes and Participation in all the activities of Institute’s Innovations Council for e.g: IPR workshop/ Leadership Talks/ Idea/ Design/ Innovation/ Business Completion/ Technical Expos etc.
After completion of Mini-project or Internship the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period or while working on mini-project. The student may contact Industrial Supervisor/ Faculty Mentor/TPO for assigning special topics and problems and should prepare the final report on the assigned topics.

Student’s Diary and Internship Report should be submitted by the students along with attendance record and an evolution sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training. It will be evaluated on the basis of the following criteria:

- Regularity in maintenance of the diary.
- Adequacy & quality of information recorded.
- Drawing, sketches and data recorded.
- Thought process and recording techniques used.
- Organization of the information.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>:  HSMC (H-102)</th>
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</thead>
<tbody>
<tr>
<td>Course Title</td>
<td>:  Universal Human Values 2: Understanding Harmony</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>:  3 (L: 2; T: 1; P: 0)</td>
</tr>
<tr>
<td>Course Category</td>
<td>:  MT</td>
</tr>
<tr>
<td>Pre-requisites</td>
<td>:  None. Universal Human Values 1 (Desirable)</td>
</tr>
</tbody>
</table>

**Human Values Courses:** During the Induction Program, students would get an initial exposure to human values through Universal Human Values – I. This exposure is to be augmented by this compulsory full semester foundation course.

**Objective:** The objective of the course is four fold:
1. Development of a holistic perspective based on self-exploration about themselves (human being), family, society and nature/existence.
2. Understanding (or developing clarity) of the harmony in the human being, family, society and nature/existence
4. Development of commitment and courage to act.

**Course topics:** The course has 28 lectures and 14 practice sessions in 5 modules:

**Module 1: Course Introduction - Need, Basic Guidelines, Content and Process for Value Education**
1. Purpose and motivation for the course, recapitulation from Universal Human Values-I.
3. Continuous Happiness and Prosperity - A look at basic Human Aspirations
4. Right understanding, Relationship and Physical Facility- the basic requirements for fulfilment of aspirations of every human being with their correct priority.
5. Understanding Happiness and Prosperity correctly- A critical appraisal of the current scenario
6. Method to fulfil the above human aspirations: understanding and living in harmony at various levels.

Include practice sessions to discuss natural acceptance in human being as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking-disliking.

Module 2: Understanding Harmony in the Human Being - Harmony in Myself
1. Understanding human being as a co-existence of the sentient ‘I’ and the material ‘Body’.
2. Understanding the needs of Self (‘I’) and ‘Body’ - happiness and physical facility.
3. Understanding the Body as an instrument of ‘I’ (I being the doer, seer and enjoyer).
4. Understanding the characteristics and activities of ‘I’ and harmony in ‘I’.
5. Understanding the harmony of I with the Body: Sanyam and Health; correct appraisal of Physical needs, meaning of Prosperity in detail.
6. Programs to ensure Sanyam and Health.

Include practice sessions to discuss the role others have played in making material goods available to me. Identifying from one’s own life.

Differentiate between prosperity and accumulation. Discuss program for ensuring health vs dealing with disease.

Module 3: Understanding Harmony in the Family and Society- Harmony in Human-Human Relationship
1. Understanding values in human-human relationship; meaning of Justice (nine universal values in relationships) and program for its fulfilment to ensure mutual happiness; Trust and Respect as the foundational values of relationship
2. Understanding the meaning of Trust; Difference between intention and competence
3. Understanding the meaning of Respect, Difference between respect and differentiation; the other salient values in relationship
4. Understanding the harmony in the society (society being an extension of family): Resolution, Prosperity, fearlessness (trust) and co-existence
as comprehensive Human Goals
5. Visualizing a universal harmonious order in society - Undivided Society, Universal Order - from family to world family.

Include practice sessions to reflect on relationships in family, hostel and institute as extended family, real life examples, teacher-student relationship, goal of education etc. Gratitude as a universal value in relationships. Discuss with scenarios. Elicit examples from students’ lives.

Module 4: Understanding Harmony in the Nature and Existence - Whole existence as Coexistence
1. Understanding the harmony in the Nature
2. Interconnectedness and mutual fulfilment among the four orders of nature - recyclability and self-regulation in nature.
3. Understanding Existence as Co-existence of mutually interacting units in all-pervasive space.
4. Holistic perception of harmony at all levels of existence.
5. Include practice sessions to discuss human being as cause of imbalance in nature (film “Home” can be used), pollution, depletion of resources and role of technology etc.

Module 5: Implications of the above Holistic Understanding of Harmony on Professional Ethics
1. Natural acceptance of human values
2. Definitiveness of Ethical Human Conduct
3. Basis for Humanistic Education, Humanistic Constitution and Humanistic Universal Order
5. Case studies of typical holistic technologies, management models and production systems
6. Strategy for transition from the present state to Universal Human Order:
   a. At the level of individual: as socially and ecologically responsible engineers, technologists and managers
   b. At the level of society: as mutually enriching institutions and organizations
7. Sum up.

Include practice Exercises and Case Studies will be taken up in Practice (tutorial) Sessions e.g. to discuss the conduct as an engineer or scientist etc.

Readings: Text Book

Reference Books
1. Jeevan Vidya: EkParichaya, A Nagaraj, Jeevan Vidya Prakashan,
Amarkantak, 1999.
3. The Story of Stuff (Book).
5. Small is Beautiful - E. F Schumacher.
6. Slow is Beautiful - Cecile Andrews
7. Economy of Permanence - J C Kumarappa
8. Bharat Mein Angreji Raj - Pandit Sunderlal
9. Rediscovering India - by Dharampal
10. Hind Swaraj or Indian Home Rule - by Mohandas K. Gandhi
12. Vivekananda - Romain Rolland (English)
13. Gandhi - Romain Rolland (English)

**Mode Of Conduct (L-T-P-C 2-1-0-3 or 2L:1T:0P 3 credits):** Lectures hours are to be used for interactive discussion, placing the proposals about the topics at hand and motivating students to reflect, explore and verify them.

Tutorial hours are to be used for practice sessions.

While analysing and discussing the topic, the faculty mentor’s role is in pointing to essential elements to help in sorting them out from the surface elements. In other words, help the students explore the important or critical elements.

In the discussions, particularly during practice sessions (tutorials), the mentor encourages the student to connect with one’s own self and do self-observation, self-reflection and self-exploration.

Scenarios may be used to initiate discussion. The student is encouraged to take up “ordinary” situations rather than “extra-ordinary” situations.

Such observations and their analyses are shared and discussed with other students and faculty mentor, in a group sitting.

Tutorials (experiments or practical) are important for the course. The difference is that the laboratory is everyday life, and practical are how you behave and work in real life. Depending on the nature of topics, worksheets, home assignment and/or activity are included. The practice sessions (tutorials) would also provide support to a student in performing actions commensurate to his/her beliefs. It is intended that this would lead to development of commitment, namely behaving and working based on basic human values.

It is recommended that this content be placed before the student as it is, in the form of a basic foundation course, without including anything else or excluding any part of this content. Additional content may be offered in separate, higher courses.

**This course is to be taught by faculty from every teaching department, including HSS faculty.**
Teacher preparation with a minimum exposure to at least one 8-day FDP on Universal Human Values is deemed essential.

**Assessment:**
This is a compulsory credit course. The assessment is to provide a fair state of development of the student, so participation in classroom discussions, self-assessment, peer assessment etc. will be used in evaluation.

Example:
Assessment by faculty mentor: 10 marks
Self-assessment: 10 marks
Assessment by peers: 10 marks
Socially relevant project/Group Activities/Assignments: 20 marks Semester End Examination: 50 marks
The overall pass percentage is 40%. In case the student fails, he/she must repeat the course.

**Outcome of the Course:** By the end of the course, students are expected to become more aware of themselves, and their surroundings (family, society, nature); they would become more responsible in life, and in handling problems with sustainable solutions, while keeping human relationships and human nature in mind.

They would have better critical ability. They would also become sensitive to their commitment towards what they have understood (human values, human relationship and human society). It is hoped that they would be able to apply what they have learnt to their own self in different day-to-day settings in real life, at least a beginning would be made in this direction.

This is only an introductory foundational input. It would be desirable to follow it up by
a) faculty-student or mentor-mentee programs throughout their time with the institution
b) Higher level courses on human values in every aspect of living. E.g. as a professional

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SEMESTER – IV
SEMESTER IV

<table>
<thead>
<tr>
<th>Course Code</th>
<th>MT-401</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>Fluid Mechanics</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>3 (L: 3; T: 0; P: 0)</td>
</tr>
<tr>
<td>Course Category</td>
<td>MT</td>
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</tbody>
</table>

**Course Objective:**
- To learn about the application of mass and momentum conservation laws for fluid flows
- To understand the importance of dimensional analysis
- To obtain the velocity and pressure variations in various types of simple flows
- To analyze the flow in water pumps and turbines.

**Course Content:**

**Module I:** Definition of fluid, Newton's law of viscosity, Modules and Dimensions-
Properties of fluids, mass density, specific volume, specific gravity, viscosity, compressibility and surface tension, Control volume- application of continuity equation
and momentum equation, Incompressible flow, Bernoulli’s equation and its applications.

**Module II:** Exact flow solutions in channels and ducts, Couette and Poisuielle flow,
laminar flow through circular conduits and circular annuli- concept of boundary layer –
measures of boundary layer thickness – Darcy Weisbach equation, friction factor,
Moody’s diagram.

**Module III:** Need for dimensional analysis – methods of dimension analysis – Similitude
– types of similitude Dimensionless parameters – application of dimensionless
parameters – Model analysis.

**Module IV:** Euler’s equation – theory of Rotodynamic machines – various efficiencies –
velocity components at entry and exit of the rotor, velocity triangles – Centrifugal pumps,
working principle, work done by the impeller, performance curves – Cavitation in
pumps- Reciprocating pump – working principle.

**Module V:** Classification of water turbines, heads and efficiencies, velocity triangles-
Axial, radial and mixed flow turbines- Pelton wheel, Francis turbine and Kaplan turbines,
working principles – draft tube- Specific speed, Module quantities, performance curves
for turbines – governing of turbines.

**Text/Reference Books:**
2. Fluid Mechanics and Machinery, C.S.P.Ojha, R. Berndtsson and P. N.
Alternative NPTEL/SWAYAM Course:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Fluid Mechanics</td>
<td>Prof. S.K. Som</td>
<td>IIT KARAGPUR</td>
</tr>
</tbody>
</table>

Course Outcomes: At the end of the course, a student will be able:
1. To analyze simple flow situations mathematically.
2. To evaluate the performance of pumps and turbines.

Course Code: MT-402
Course Title: Analog and Digital Electronics
Number of Credits: 3 (L: 3; T: 0; P: 0)
Course Category: MT

Course Objective: This course will enable students to:
- Recall and Recognize construction and characteristics of JFETs and MOSFETs and differentiate with BJT
- Demonstrate and Analyze Operational Amplifier circuits and their applications
- Describe, Illustrate and Analyze Combinational Logic circuits, Simplification of Algebraic Equations using Karnaugh Maps and Quine McClusky Techniques.
- Describe and Design Decoders, Encoders, Digital multiplexers, Adders and Subtractors, Binary comparators, Latches and Master-Slave Flip-Flops.
- Describe, Design and Analyze Synchronous and Asynchronous Sequential
- Explain and design registers and Counters, A/D and D/A converters.

Course Content:

**Module-I: Field Effect Transistors:** Junction Field Effect Transistors, MOSFETs, Differences between JFETs and MOSFETs, Biasing MOSFETs, FET Applications, CMOS Devices. Wave-Shaping Circuits: Integrated Circuit(IC) Multi vibrators. Introduction to Operational Amplifier: Ideal v/s practical Op Amp, Performance Parameters, Operational Amplifier Application Circuits: Peak Detector Circuit, Comparator, Active Filters, Non Linear Amplifier, Relaxation Oscillator, Current-To-Voltage Converter, Voltage-To Current Converter.


Module-IV: Flip- Flops: FLIP-FLOP Timing, JK Master-slave FLIP-FLOP, Switch Contact Bounce Circuits, Various Representation of FLIP-FLOPs, HDL Implementation of FLIP-FLOP.

Registers: Types of Registers, Serial In - Serial Out, Serial In - Parallel out, Parallel In - Serial Out, Parallel In - Parallel Out, Universal Shift Register, Applications of Shift Registers, Register implementation in HDL.

Module-V: Counters: Decade Counters, Preset table Counters, Counter Design as a Synthesis problem, A Digital Clock, Counter Design using HDL.


Text/Reference Books:

Course Outcomes: At the end of this course students will demonstrate the ability to
1. To understand the current voltage characteristics of semiconductor devices.
2. To analyze logic processes and implement logical operations using combinational logic circuits.
3. To understand of the fundamental concepts and techniques used in digital processing circuits.
4. To analyze, design and implement sequential logic circuits.
5. To apply the fundamental knowledge of analog and digital electronics to get different types of analog to digitalized signal and vice-versa converters in real world.

*****
Course Code : MT-403
Course Title : Computer Organization
Number of Credits : 3 (L: 3; T: 0; P: 0)
Course Category : MT

Course Objective: To expose the students to the following:
1. How Computer Systems work & the basic principles.
2. Instruction Level Architecture and Instruction Execution.
3. The current state of art in memory system design.
4. How I/O devices are accessed and its principles.
5. To provide the knowledge on Instruction Level Parallelism.
6. To impart the knowledge on micro programming.
7. Concepts of advanced pipelining techniques.

Course Content:


Data representation: signed number representation, fixed and floating-point representations, character representation. Computer arithmetic – integer addition and subtraction, ripple carry adder, carry look-ahead adder, etc. multiplication – shift-and add, Booth multiplier, carry save multiplier, etc. Division restoring and non-restoring techniques, floating point arithmetic.

Module II: Introduction to x86 architecture.
CPU control Module design: hardwired and micro-programmed design approaches, Case study – design of a simple hypothetical CPU.
Memory system design: semiconductor memory technologies, memory organization.
Peripheral devices and their characteristics: Input-output subsystems, I/O device interface, I/O transfers program controlled, interrupt driven and DMA, privileged and non-privileged instructions, software interrupts and exceptions. Programs and processes – role of interrupts in process state transitions, I/O device interfaces – SCII, U.

Module III: Pipelining: Basic concepts of pipelining, throughput and speedup, pipeline hazards.
Parallel Processors: Introduction to parallel processors, Concurrent access to memory and cache coherency.
Module IV: Memory organization: Memory interleaving, concept of hierarchical memory organization, cache memory, cache size vs. block size, mapping functions, replacement algorithms, write policies.

Text/Reference Books:

Alternative NPTEL/SWAYAM Course:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Computer Organization &amp; Architecture: A Pedagogical Aspect</td>
<td>Dr. Arnab Sarkar</td>
<td>IIT Gawahati</td>
</tr>
<tr>
<td>2.</td>
<td>Computer Architecture &amp; Organisation</td>
<td>Prof. Indranil Sengupta</td>
<td>IIT Kharagpur</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prof. Kamalika Datta</td>
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</tbody>
</table>

Course Outcomes: At the end of this course students will demonstrate the ability:
1. To design a single bus architecture of a computer and describe the function of the instruction execution cycle, RTL interpretation of instructions, addressing modes, instruction set.
2. To write assembly language program for specified microprocessor for computing 16-bit multiplication, division and I/O device interface (ADC, Control circuit, serial port communication).
3. To predict flowchart for Concurrent access to memory and cache coherency in Parallel Processors and describe the process.
4. To design a memory Module and analyze its operation by interfacing with the CPU.
5. To assess its performance, and apply design techniques to enhance performance using pipelining, parallelism and RISC methodology.

*****

Course Code : MT-404
Course Title : Signals And Systems
Number of Credits : 3 (L: 3; T: 0; P: 0)
Course Category : MT

Course Objective: The course will provide strong foundation on signals and systems which will be useful for creating foundation of communication and signal processing. The students will learn basic continuous time and discrete time signals and systems. Student
will understand application of various transforms for analysis of signals and systems both continuous time and discrete time. Students will also explore to power and energy signals and spectrum.

**Course Content:**

**Module I:** Basic definitions, Classification of signals and systems. Signal operations and properties. Basic continuous time signals, signal sampling and quantization, discretization of continuous time signals, discrete time signals. Basic system properties, Representation of digital signals. Case study of different signals from communication and biomedical field.

**Module II:** Impulse response characterization and convolution integral for CT-LTI system, signal responses to CT-LTI system, properties of convolution, LTI system response properties from impulse response. (*Review of Laplace transform with reference to CT signals and systems.)

**Module III:** Impulse response characterization and convolution sum, Causal signal response to DT-LTI systems. Properties of convolution summation, Impulse response of DT-LTI system. DT-LTI system properties from Impulse response. System analysis from difference equation model

**Module IV:** Representation of periodic functions, Fourier series, Frequency spectrum of a periodic signals, Fourier Transform, Relation between Laplace Transform and Fourier Transform and its properties. Introduction to DTFT and DFT

**Module V:** The z-Transform, Convergence of z-Transform, Basic z-Transform, Properties of z-Transform, Inverse z-Transform and Solving difference equation using z-Transform

**Text/Reference Books:**

1. Signals and Systems by Alan V. Oppenheim, Alan S. Wilsky and Nawab, Prentice Hall.
5. Linear Systems and Signals by B.P.Lathi, Oxford University Press.
8. Signal and Systems by Anand Kumar, 3rd Edition, PHI.

**Alternative NPTEL/SWAYAM Course:**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Signals &amp; Systems</td>
<td>Prof. k.S. Venkatesh</td>
<td>IIT Kanpur</td>
</tr>
<tr>
<td>2.</td>
<td>Signals &amp; Systems</td>
<td>Prof. V.M. Gadre</td>
<td>IIT Bombay</td>
</tr>
</tbody>
</table>
Course Outcomes: After learning the course the students should be able:
- To Understand about various types of signals, classify them, analyze them, and perform various operations on them.
- To Understand about various types of systems, classify them, analyze them and understand their response behavior.
- To illustrate of transforms in analysis of signals and system.
- To rate signals and systems for observing effects of applying various properties and operations to Create strong foundation of communication and signal processing to be studied in the subsequent semester.

Course Code: MT-405
Course Title: Industrial Automation
Number of Credits: 3 (L: 3; T: 0; P: 0)
Course Category: MT

Course Objective: This course focuses on understanding various components of state of art automation technologies encountered in modern manufacturing industries. This course introduces the practical methods of automatic control of machines, processes and systems. All major parts of a modern industrial control system will be described and their principles explained.

Course Content:
Module I: Factory Automation and Integration: Basic concepts, types of automation, automation strategies, automation technologies, applications around us and in manufacturing industries.

Module II: Design and Operation of Logic Control Circuits for Hydraulics and Pneumatics: Basic elements of hydraulics/pneumatics, fluid power control elements and standard graphical symbols for them, hydraulic & pneumatic cylinders, hydraulic & pneumatic valves for pressure, flow & direction control, Circuit design approach and real time examples; sequence operation of two/more than two cylinders as per the design requirement to automate the systems. Hydraulics/pneumatic safety and their applications to clamping, traversing and releasing operations.

Module III: Design and Operation of Electro-Pneumatic Logic Control Circuits: Electro-pneumatic systems, solenoid valves, different sensors, factory automation sensors, electrical sensors, process automation sensors and their interfaces as per application criteria. Circuit design approach using relay logic circuits and real time examples; sequence operation of two/more than two cylinders as per the design
requirement to automate the systems. Electro pneumatic & electro hydraulic systems using relay logic circuits.

**Module IV: Industrial Control Systems:** Programmable Logic Controllers (PLC) based control system, programming languages & instruction set, ladder logic, functional blocks, structured text, and applications. Human Machine Interface (HMI) & Supervisory Control and Data Acquisition System (SCADA); motion controller, applications of RFID technology and machine vision.

**Module V: Research Micro Projects:** Students in a group will carry out micro project on design and implementation of an automatic modular system which can be useful in contemporary automation industries. The methodologies will be followed as first design and simulation of automated systems using Festo Fluid, SIM, SIROS, PLC software and then implementation by using pneumatic controls, electro-pneumatic controls, PLC and motion controls.

**Text Books:**
7. Garry Dunning Programmable Logic Controller.
8. Programmable Logic Controllers by Frank Petruzella.

**Alternative NPTEL/SWAYAM Course:**

<table>
<thead>
<tr>
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<th>Instructor</th>
<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Industrial Automation &amp; Control</td>
<td>Prof. S. Mukhopadhyay</td>
<td>IIT Kharagpur</td>
</tr>
</tbody>
</table>

**Course Outcomes:**
1. To demonstrated the knowledge of various devices used for industrial automation and their application, which will help students in their projects and knowledge in industry.
2. To learn terms, history, functions and principles of fluid power components in this automation technologies course. Control tactics, hydraulic interpretation, component symbols, pneumatic drawings and pneumatic circuit design are also examined. Students explore actuators and fluid transmission devices as well as the causes and consequences of fluid contamination.
3. To explore the programming and implementation of programmable logic controllers. Topics include the theories and application of hardware selection, configuration,
math blocks and troubleshooting. Students run industry-related simulations for PLC hardware and networking, related mechanisms, external device and operating cycle.

4. To illustrate the circuits used for automatic process controls of industrial systems.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>AU-401</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>Environmental Science</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>0 (L: 2; T: 0; P: 0)</td>
</tr>
<tr>
<td>Course Category</td>
<td>AU</td>
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</tbody>
</table>

**Course Objective:** People working in industries or elsewhere essentially require the knowledge of environmental science so as to enable them to work and produce most efficient, economical and eco-friendly finished products.

- Solve various engineering problems applying ecosystem to produce eco-friendly products.
- Use relevant air and noise control method to solve domestic and industrial problems.
- Use relevant water and soil control method to solve domestic and industrial problems.
- To recognize relevant energy sources required for domestic and industrial applications.
- Solve local solid and e-waste problems.

**Course Content:**

**Module I: Ecosystem**

1. Structure of ecosystem, Biotic & Abiotic components.
2. Food chain and food web.
3. Aquatic (Lentic and Lotic) and terrestrial ecosystem.
5. Global warming - Causes, effects, process, Green House Effect, Ozone depletion.

**Module II: Air and Noise Pollution**

1. Definition of pollution and pollutant, Natural and manmade sources of air pollution (Refrigerants, I.C., Boiler).
3. Gaseous Pollution Control: Absorber, Catalytic Converter, Effects of air pollution due to Refrigerants, I.C., Boiler.
Module III: Water and Soil Pollution

Module IV: Renewable sources of Energy
4. New Energy Sources: Need of new sources. Different types new energy sources. Applications of (Hydrogen energy, Ocean energy resources, Tidal energy conversion.) Concept, origin and power plants of geothermal energy.

Module V: Solid Waste Management, ISO 14000 & Environmental Management
1. Solid waste generation- Sources and characteristics of: Municipal solid waste, E-waste, biomedical waste.
4. Concept of Carbon Credit, Carbon Footprint.
5. Environmental management in fabrication industry.

Text Books/References:
5. O.P. Gupta, Elements of Environmental Pollution Control, Khanna Publishing House, New Delhi.

Open source software and website address:
1. www.eco-prayer.org
2. www.teriin.org
3. www.cpcp.nic.in
4. www.cpcp.gov.in
5. www.indiaenvironmentportal.org.in
6. www.whatis.techtarget.com
7. www.sustainabledevelopment.un.org
8. www.conserve-energy-future.com

Teachers should use the following strategies to achieve the various outcomes of the course.

- Different methods of teaching and media to be used to attain classroom attention.
- Massive open online courses (MOOCs) may be used to teach various topics/sub topics.
- 15-20% of the topics which are relatively simpler of descriptive in nature should be given to the students for self-learning and assess the development of competency through classroom presentations.
- Micro-projects may be given to group of students for hand-on experiences.
- Encouraging students to visit to sites such as Railway station and research establishment around the institution.

Alternative NPTEL/SWAYAM Course:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL ID</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>127105018</td>
<td>Introduction to Environmental Engineering and Science - Fundamental and Sustainability Concepts</td>
<td>Prof. Brajesh Kumar Dubey</td>
<td>IIT KGP</td>
</tr>
</tbody>
</table>

Course Outcomes: At the end of the course student will be able:
1. To Understand the ecosystem and terminology and solve various engineering problems applying ecosystem knowledge to produce eco – friendly products.
2. To Understand the suitable air, extent of noise pollution, and control measures and acts.
3. To Understand the water and soil pollution, and control measures and acts.
4. To Understand different renewable energy resources and efficient process of harvesting.
5. To Understand Solid Waste Management, ISO 14000 & Environmental Management.

*****

<table>
<thead>
<tr>
<th>Course Code</th>
<th>MT-411</th>
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</thead>
<tbody>
<tr>
<td>Course Title</td>
<td>Fluid Mechanics Lab</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>2 (L: 0; T: 0; P: 4)</td>
</tr>
<tr>
<td>Course Category</td>
<td>MT</td>
</tr>
</tbody>
</table>

**Course Objective:**

- To teach basic principles of fluid mechanics.
- To teach and apply physical and mathematical methods used in analyzing engineering applications involving fluids.

**List of Experiments:**

1. Measurement of viscosity
2. Determination of co-efficient of friction of flow in a pipe
3. Determination of minor losses in flow through pipes
4. Application of momentum equation for determination of coefficient of impact of jets on flat and curved blades
5. Calibration of flow measuring devices:
   - a. Orifice plate meter
   - b. Nozzle meter
   - c. Venturimeter
   - d. V-notch
6. Study of Pressure Measuring Devices
8. Performance on hydraulic pumps: a) Single stage and multi stage centrifugal pumps b) Reciprocating pump.

**Text Books/References:**

3. Hydraulics and Fluid Mechanics, P M Modi and S M Seth, Standard Book House
## EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Experiment Name</th>
<th>Experiment Link(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Determination of minor losses in flow through pipes.</td>
<td><a href="https://mfts-iitg.vlabs.ac.in/PipeFlow.html">https://mfts-iitg.vlabs.ac.in/PipeFlow.html</a></td>
</tr>
</tbody>
</table>
2. [http://fmc-nitk.vlabs.ac.in/fluid-machinery-lab/exp/pelton-turbine/](http://fmc-nitk.vlabs.ac.in/fluid-machinery-lab/exp/pelton-turbine/)  
3. [http://fmc-nitk.vlabs.ac.in/fluid-machinery-lab/exp/francis-turbine/](http://fmc-nitk.vlabs.ac.in/fluid-machinery-lab/exp/francis-turbine/) |
| 6      | Performance on hydraulic pumps: a) Single stage and multi stage centrifugal pumps b) Reciprocating pump. | [http://fmc-nitk.vlabs.ac.in/fluid-machinery-lab/exp/centrifugal-pump/](http://fmc-nitk.vlabs.ac.in/fluid-machinery-lab/exp/centrifugal-pump/) |
| 7      | Venturimeter.                                                                    | [http://fm-nitk.vlabs.ac.in/exp5/index.html](http://fm-nitk.vlabs.ac.in/exp5/index.html) |

### Course Outcomes:
At the end of the course student will be able:

1. To Understanding of basic physics of fluids.
2. To calculate and design engineering applications involving fluid.
3. To analyze flow of systems in terms of mass, momentum, and energy balance.
4. To assess Having knowledge about current research topics about fluid mechanics.

*****
Course Code : MT-412
Course Title : Analog and Digital Electronics Lab
Number of Credits : 1 (L: 0; T: 0; P: 2)
Course Category : MT

**Course Objective:**
This course encompasses analog and digital electronic circuits from a circuit and monolithic (integrated circuit) implementation point of view. The objective of this course is to provide undergraduates with sufficient fundamental theoretical and practical knowledge to pursue advanced topics in analog and digital integrated circuits.

**List of Experiments:**
1. a. Design and construct a Schmitt trigger using Op-Amp for given UTP 1 and LTP values and demonstrate its working. b. Design and implement a Schmitt trigger using Op-Amp using a simulation package for two sets of UTP and LTP values and demonstrate its working.
2. a. Design and construct a rectangular waveform generator (Op-Amp 5 relaxation oscillator) for given frequency. b. Design and implement a rectangular waveform generator (Op-Amp relaxation oscillator) using a simulation package and observe the change in frequency when all resistor values are doubled.
3. Design and implement a stable multivibrator circuit using 555 timers for a given frequency and duty cycle.
5. a. Given any 4-variable logic expression, simplify using Entered 16 Variable Map and realize the simplified logic expression using 8:1 multiplexer IC. b. Write the Verilog /VHDL code for an 8:1 multiplexer. Simulate 18 and verify it's working.
7. Design and verify the Truth Table of 3-bit Parity Generator and 4-bit Parity Checker using basic logic gates with an even parity bit.


**Reference Books:**
**EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Experiment Name</th>
<th>Experiment Link(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Design and implement Half adder, Full Adder, Half Subtractor, Full Subtractor using basic gates.</td>
<td><a href="http://vlabs.iitkgp.ernet.in/dec/exp7/index.html">http://vlabs.iitkgp.ernet.in/dec/exp7/index.html</a></td>
</tr>
<tr>
<td>2</td>
<td>Design and implement code converter I) Binary to Gray II) Gray to Binary Code using basic gates.</td>
<td><a href="https://he-coep.vlabs.ac.in/Experiment2/Theory.html?domain=ElectronicsandCommunications&amp;lab=Hybrid%20Electronics%20Lab">https://he-coep.vlabs.ac.in/Experiment2/Theory.html?domain=ElectronicsandCommunications&amp;lab=Hybrid%20Electronics%20Lab</a></td>
</tr>
<tr>
<td>3</td>
<td>Realize a J-K Master/Slave Flip-Flop using NAND gates and verify its truth table.</td>
<td><a href="http://vlabs.iitkgp.ernet.in/dec/exp8/index.html">http://vlabs.iitkgp.ernet.in/dec/exp8/index.html</a></td>
</tr>
</tbody>
</table>

**Course Outcomes:** On the completion of this laboratory course, the students will be able:

1. To Use Various Electronic Devices like Cathode Ray Oscilloscope, Signal generators, Digital Trainer Kit, Multimeters and components like Resistors, Capacitors, Op amp and Integrated Circuit.
2. To Design and demonstrate various combinational logic circuits.
3. To Design and demonstrate various types of counters and Registers using Flipflops
4. To simulate package to design circuits.
5. To Understand the working and implementation of ALU.

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<table>
<thead>
<tr>
<th>Course Code</th>
<th>MT-413</th>
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</thead>
<tbody>
<tr>
<td>Course Title</td>
<td>Industrial Automation Lab</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>2 (L: 0; T: 0; P: 4)</td>
</tr>
<tr>
<td>Course Category</td>
<td>MT</td>
</tr>
</tbody>
</table>

**Course Objective:**

- This lab imparts skill and knowledge on Industrial automation with an exclusive training on hardware and software components to automate industrial and commercial applications.
- Candidates are trained on automation products like PLC, HMI and SCADA to control and monitor the plant and machine.
- Programme are to be developed to enhance the skill set of the participants on Hardware & Programming basics and servicing.
List of Experiments:
1. Study hardware and software used in PLC.
2. Implementation of logic gates in PLC.
3. Implementation of arithmetic instruction.
4. Implementation of on and off delay timers.
5. Study, understand and perform experiments on timers and counters.
6. Study and simulate analog function blocks.
7. Logic implementation for traffic control application.
8. Logic implementation for bottle filling application.
10. Indirect control of double acting cylinder.
11. Hydraulic pump/characteristic curve of variable displacement pump.

EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Experiment Name</th>
<th>Experiment Link(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Study and simulate analog and digital function blocks.</td>
<td><a href="http://ial-coep.vlabs.ac.in/List%20of%20experiments.html?domain=Electrical%20Engineering">http://ial-coep.vlabs.ac.in/List%20of%20experiments.html?domain=Electrical%20Engineering</a></td>
</tr>
</tbody>
</table>
Text Books:

Course Outcomes:
1. To demonstrate the knowledge of various devices used for industrial automation and their application, which will help students in their projects and knowledge in industry.
2. To explain history, functions and principles of fluid power components in this automation technologies course. Control tactics, hydraulic interpretation, component symbols, pneumatic drawings and pneumatic circuit design are also examined. Students explore actuators and fluid transmission devices as well as the causes and consequences of fluid contamination.
3. To explore the programming and implementation of programmable logic controllers. Topics include the theories and application of hardware selection, configuration, math blocks and troubleshooting. Students run industry-related simulations for PLC hardware and networking, related mechanisms, external device and operating cycle.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>MT-414</th>
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</thead>
<tbody>
<tr>
<td>Course Title</td>
<td>Signals and Systems Lab</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>1 (L: 0; T: 0; P: 2)</td>
</tr>
<tr>
<td>Course Category</td>
<td>MT</td>
</tr>
</tbody>
</table>
**Course Objective:**
1. To enable the student on how to approach solving Engineering problems using simulation tools.
2. To prepare the students to use and analyze MATLAB or other related softwares in their project works.
3. To provide a foundation in use of this software for real time applications.

**List of Experiments:**
1. Basic Operations on Matrices.
2. Generation of Various Signals and Sequences (Periodic and Aperiodic), such as Module Impulse, Module Step, Square, Saw tooth, Triangular, Sinusoidal, Ramp, Sinc.
3. Operations on Signals and Sequences such as Addition, Multiplication, Scaling, Shifting, Folding, Computation of Energy and Average Power.
4. Finding the Even and Odd parts of Signal/Sequence and Real and Imaginary parts of Signal.
5. Convolution between Signals and sequences.
6. Auto Correlation and Cross Correlation between Signals and Sequences.
8. Computation of Module sample, Module step and Sinusoidal responses of the given LTI system and verifying its physical realizability and stability properties.
10. Finding the Fourier Transform of a given signal and plotting its magnitude and phase spectrum.

**Text Books/References:** Institutes may design their own Lab Manual; MATLAB Math works software or any other related software may be used.

**EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Experiment Name</th>
<th>Experiment Link(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Finding the Even and Odd parts of Signal/Sequence and Real and Imaginary parts of Signal.</td>
<td><a href="http://ssl-iitg.vlabs.ac.in/Signals%20and%20their%20properties(objectives).html">http://ssl-iitg.vlabs.ac.in/Signals%20and%20their%20properties(objectives).html</a></td>
</tr>
<tr>
<td>2</td>
<td>Convolution between Signals and sequences.</td>
<td><a href="http://ssl-iitg.vlabs.ac.in/Signals%20and%20their%20properties%205(objectives).html">http://ssl-iitg.vlabs.ac.in/Signals%20and%20their%20properties%205(objectives).html</a></td>
</tr>
<tr>
<td>3</td>
<td>Auto Correlation and Cross Correlation between Signals and Sequences.</td>
<td><a href="http://ssl-iitg.vlabs.ac.in/Signals%20and%20their%20properties%205(objectives).html">http://ssl-iitg.vlabs.ac.in/Signals%20and%20their%20properties%205(objectives).html</a></td>
</tr>
<tr>
<td>4</td>
<td>Finding the Fourier Transform of a given signal and plotting its magnitude and phase spectrum.</td>
<td><a href="http://ssl-iitg.vlabs.ac.in/Signals_exp3(objectives).html">http://ssl-iitg.vlabs.ac.in/Signals_exp3(objectives).html</a></td>
</tr>
</tbody>
</table>
Course Outcomes: At the end of the course student will demonstrate:
1. Ability to express programming & simulation for engineering problems.
2. Ability to find importance of this software for Lab Experimentation.
3. Articulate importance of software’s in research by simulation work.
4. Ability to write basic mathematical, electrical, electronic problems in MATLAB.

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<table>
<thead>
<tr>
<th>Course Code</th>
<th>: MT-415</th>
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</thead>
<tbody>
<tr>
<td>Course Title</td>
<td>: Industrial Visit</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>: 1</td>
</tr>
<tr>
<td>Course Category</td>
<td>: MT</td>
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</tbody>
</table>

The objective of an industrial visit is to provide opportunity to students to get an insight regarding internal working of companies. Industrial visit helps to combine theoretical knowledge with practical knowledge. Industrial visits may be organized in any of the nearby industries interested to share their processes with students for their learning.

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SEMESTER – V
SEMESTER V

<table>
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<tr>
<th>Course Code</th>
<th>MT-501</th>
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</thead>
<tbody>
<tr>
<td>Course Title</td>
<td>Digital Signal Processing</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>3 (L: 2; T: 1; P: 0)</td>
</tr>
<tr>
<td>Course Category</td>
<td>MT</td>
</tr>
</tbody>
</table>

**Course Objective:**
1. To learn the basic concepts and properties of discrete time signals and system.
2. To learn the frequency domain characteristics of discrete time signals and systems.
3. To design and implement digital filter design techniques.

**Course Contents:**

**Module I: Discrete-time signals and systems**
Discrete time signals and systems: Sequences; representation of signals on orthogonal basis; Representation of discrete systems using difference equations, Sampling and reconstruction of signals - aliasing; Sampling theorem and Nyquist rate.

**Module II: Z-transform**
z-Transform, Region of Convergence, Analysis of Linear Shift Invariant systems using z-transform, Properties of z-transform for causal signals, Interpretation of stability in z-domain, Inverse z-transforms.

**Module III: Discrete Fourier Transform**

**Module IV: Design of Digital filters**

**Module V: Applications of Digital Signal Processing**

**Text Books/References:**

Alternative NPTEL/SWAYAM Course:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Digital Signal Processing</td>
<td>C.S Ramalingam</td>
<td>IIT Madras</td>
</tr>
<tr>
<td>2.</td>
<td>Digital Signal Processing</td>
<td>Prof. S.C Dutta</td>
<td>IIT Delhi</td>
</tr>
</tbody>
</table>

**Course Outcomes:** At the end of the course student will be able:

1. To Represent signals mathematically in continuous and discrete-time, and in the frequency domain.
2. To Analyze discrete-time systems using z-transform.
3. To Understand the Discrete-Fourier Transform (DFT) and the FFT algorithms.
4. To Design digital filters for various applications.
5. To Apply digital signal processing for the analysis of real-life signals.

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<table>
<thead>
<tr>
<th>Course Code</th>
<th>: MT-502</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Title</td>
<td>: Sensors &amp; Instrumentation</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>: 3 (L: 2; T: 1; P: 0)</td>
</tr>
<tr>
<td>Course Category</td>
<td>: MT</td>
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</tbody>
</table>

**Course Objective:** The course provides good knowledge of working of different types of sensors used in various application areas. The course also provides knowledge of interfacing of electronic circuits with different sensors for its applications in different fields.

**Course Contents:**

**Module I: Sensors Fundamentals and Characteristics:** Sensors, Signals and Systems; Sensor Classification; Modules of Measurements; Sensor Characteristics.

**Module II: Physical Principles of Sensing:** Electric Charges, Fields, and Potentials; Capacitance; Magnetism; Induction; Resistance; Piezoelectric Effect; Hall Effect; Temperature and Thermal Properties of Material; Heat Transfer; Light; Dynamic Models of Sensor Elements.

**Module III: Interface Electronic Circuits:** Input Characteristics of Interface Circuits, Amplifiers, Excitation Circuits, Analog to Digital Converters, Direct Digitization and Processing, Bridge Circuits, Data Transmission, Batteries for Low Power Sensors.
Module IV: Sensors in Different Application: Area Occupancy and Motion Detectors; Position, Displacement, and Level; Velocity and Acceleration; Force, Strain, and Tactile Sensors; Pressure Sensors, Temperature Sensors.


Text Books/References:
2. D. Patranabis, Sensors and Transducers, PHI Publication, New Delhi

Course Outcomes:
1. To Understand the concept of sensors and its characteristics.
2. To Understand the practical approach in design of technology based on different sensors
3. To Learn various sensor materials and technology used in designing sensors.
4. To demonstrate different sensors work
5. To Develop a sense for recognizing bad data and an intuition of how to resolve problems.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>MT-503</th>
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</thead>
<tbody>
<tr>
<td>Course Title</td>
<td>Control System Engineering</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>3 (L: 3; T: 0; P: 0)</td>
</tr>
<tr>
<td>Course Category</td>
<td>MT</td>
</tr>
</tbody>
</table>

Course Objective:
- To teach the fundamental concepts of control systems & mathematical modelling of system.
- To study the concept of time response and frequency response of the system.
- To teach the basics of stability analysis of the system.

Course Contents:


Text Books/References:

Alternative NPTEL/SWAYAM Course:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Control Systems</td>
<td>Prof. C.S Shankar Ram</td>
<td>IIT Madras</td>
</tr>
</tbody>
</table>

Course Outcomes: At the end of this course, students will demonstrate the ability:
1. To Understand the modelling of linear invariant systems using transfer function and state space representations.
2. To Understand the concept of stability and its assessment for linear time invariant systems.
3. To Design simple feedback controllers.

*****
**Course Objective:** The aim of the course is to understand the basic principles of management, and the four major functions of managers e.g. planning, organizing, leading and controlling and how managers actually operate. Students will be required to think critically and strategically about management theories and issues which will enable them to develop their decision-making and analytical skills. They will be involved in application exercises and case studies which will assist them to develop graduate attributes.

**Course Contents:**

**Module-I:** Introduction: Concept and scope of Industrial Management. Productivity: Definition, measurement, productivity index, types of production system, Industrial Ownership. Functions of Management, Taylor’s Scientific Management Theory, Fayol’s Principles of Management, Social responsibilities of Management,

**Module-II:** Introduction to Human resources management: Nature of HRM, functions and importance of HRM.

**Work Study:** Introduction, definition, objectives, steps in work study, Method study: definition, objectives, steps of method study, Work Measurement: purpose, types of study stop watch methods steps allowances standard time calculations work sampling,

**Module-III:** Production Planning and Control Inventory Control: Inventory, Cost, Models of inventory control: EOQ, ABC, VED. Quality Control: statistical quality control, Control charts for variables and attributes, Acceptance Sampling- Single sampling- Double sampling plans, Introduction to TQM.

**Module-IV:** Project Planning & Scheduling Introduction to PERT & CPM, planning and scheduling networks, time estimation, determination of critical path, CPM model, event slacks & floats, PERT model, expected time for activities, expected length of critical path, calculating the project length and variance, PERT & CPM cost accounting systems, lowest cost schedule, crashing of networks, linear programming formulation of event oriented networks, updating of networks, LOB technique.

**Module-V:** Modification & Extensions of Network Models Complexity of project scheduling with limited resources, resource leveling of project schedules, resource allocation in project scheduling - heuristic solution. Precedence networking- examples with algorithm, decision networks, probabilistic networks, computer aided project management essential requirements of PM software, software packages for CPM. Enterprise- wide PM, using spread sheets for financial projections.
Text Books/References:
2. Industrial Engineering and Management, P. Khanna, Dhanpat Rai publications Ltd.
3. Production & Operation Management, Paneer Selvam, PHI.

Course Outcomes:
Student is able:
1. To apply principles of management in his / her extra and co-curricular activity in college and in industrial in-plant training.
2. To apply work improvement techniques in an organization where he undergoes for in-plant training.
3. To compare & find out and reduce work content of the job.

Course Code: MT-505
Course Title: Kinematics and Theory of Machines
Number of Credits: 3 (L: 3; T: 0; P: 0)
Course Category: MT

Course Objective:
- To understand the kinematics and rigid body dynamics of kinematically driven machine components.
- To understand the motion of linked mechanisms in terms of the displacement, velocity and acceleration at any point in a rigid link.
- To be able to design some linkage mechanisms and cam systems to generate specified output motion.
- To understand the kinematics of gear trains.

Course Contents:

Module I: Classification of mechanisms- Basic kinematic concepts and definitions-
Degree of freedom, mobility- Grashof’s law, Kinematic inversions of four bar chain and slider crank chains- Limit positions- Mechanical advantage- Transmission angle-
Description of some common mechanisms- Quick return mechanism, straight line generators- Universal Joint- Rocker mechanisms.

Module II: Displacement, velocity and acceleration analysis of simple mechanisms,
graphical velocity analysis using instantaneous centres, velocity and acceleration analysis
using loop closure equations- kinematic analysis of simple mechanisms- slider crank mechanism dynamics.

**Module III:** Coincident points- Coriolis component of acceleration- introduction to linkage synthesis- three position graphical synthesis for motion and path generation.

**Module IV:** Classification of cams and followers- Terminology and definitions- Displacement diagrams- Uniform velocity, parabolic, simple harmonic and cycloidal motions- derivatives of follower motions- specified contour cams- circular and tangent cams- pressure angle and undercutting, sizing of cams, graphical and analytical disc cam profile synthesis for roller and flat face followers.

Involute and cycloidal gear profiles, gear parameters, fundamental law of gearing and conjugate action, spur gear contact ratio and interference/undercutting- helical, bevel, worm, rack & pinion gears, epicyclic and regular gear train kinematics.

**Module V:** Surface contacts- sliding and rolling friction- friction drives- bearings and lubrication- friction clutches- belt and rope drives- friction in brakes.

**Text Books:**

**Alternative NPTEL/SWAYAM Course:**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kinematics of Machines</td>
<td>Prof. Ashok K Mallik</td>
<td>IIT KANPUR</td>
</tr>
</tbody>
</table>

**Course Outcomes:** After completing this course, the students can design various types of linkage mechanisms for obtaining specific motion and analyze them for optimal functioning.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>: MT-506</th>
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</thead>
<tbody>
<tr>
<td>Course Title</td>
<td>: Entrepreneurship and Startups</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>: 3 (L: 3; T: 0; P: 0)</td>
</tr>
<tr>
<td>Course Category</td>
<td>: HS</td>
</tr>
</tbody>
</table>

**Course Objective:**
- Acquiring Entrepreneurial spirit and resourcefulness.
● Familiarization with various uses of human resource for earning dignified means of living.
● Understanding the concept and process of entrepreneurship - its contribution and role in the growth and development of individual and the nation.
● Acquiring entrepreneurial quality, competency, and motivation.
● Learning the process and skills of creation and management of entrepreneurial venture.

Course Content:

Module I: Introduction to Entrepreneurship and Start – Ups
• Definitions, Traits of an entrepreneur, Intrapreneurship, Motivation
• Types of Business Structures, Similarities/differences between entrepreneurs and managers.

Module II: Business Ideas and their implementation
• Discovering ideas and visualizing the business
• Activity map
• Business Plan

Module III: Idea to Start-up
• Market Analysis – Identifying the target market,
• Competition evaluation and Strategy Development,
• Marketing and accounting,
• Risk analysis

Module IV: Management
• Company’s Organization Structure,
• Recruitment and management of talent.
• Financial organization and management

Module V: Financing and Protection of Ideas
• Financing methods available for start-ups in India
• Communication of Ideas to potential investors – Investor Pitch
• Patenting and Licenses

Module VI: Exit strategies for entrepreneurs, bankruptcy, and succession and harvesting strategy.

Text Books/References:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Title of Book</th>
<th>Author</th>
<th>Publication</th>
</tr>
</thead>
</table>
The Innovator’s Dilemma: The Revolutionary Book That Will Change the Way You Do Business

Clayton M. Christensen

Websites:

Course Outcomes: Upon completion of the course, the student will be able:
1. To Understand the dynamic role of entrepreneurship and small businesses
2. To Organize and Managing a Small Business
3. To do Financial Planning and Control
4. To Forms of Ownership for Small Business
5. To develop Strategic Marketing Planning
6. To illustrate New Product or Service Development
7. To illustrate Business Plan Creation

Course Code : AU-501
Course Title : Indian Constitution
Number of Credits : 0 (L: 2; T: 0; P: 0)
Course Category : AU

Course Content

Module I: The Constitution - Introduction
- The History of the Making of the Indian Constitution
- Preamble and the Basic Structure, and its interpretation
- Fundamental Rights and Duties and their interpretation
- State Policy Principles

Module II - Union Government
- Structure of the Indian Union
- President – Role and Power
- Prime Minister and Council of Ministers
- Lok Sabha and Rajya Sabha

Module III – State Government
- Governor – Role and Power
- Chief Minister and Council of Ministers
- State Secretariat

Module IV – Local Administration
- District Administration
Module V – Election Commission

a. Role and Functioning
b. Chief Election Commissioner
c. State Election Commission

Text Books/Suggested Learning Resources:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Title of Book</th>
<th>Author</th>
<th>Publication</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>The Constitution of India</td>
<td>B.L. Fadia</td>
<td>Sahitya Bhawan; New edition (2017)</td>
</tr>
<tr>
<td>3</td>
<td>Introduction to the Constitution of India</td>
<td>DD Basu</td>
<td>Lexis Nexis; Twenty-Third 2018 edition</td>
</tr>
</tbody>
</table>

Suggested Software/Learning Websites:
1. [https://www.constitution.org/cons/india/const.html](https://www.constitution.org/cons/india/const.html)
3. [https://www.sci.gov.in/constitution](https://www.sci.gov.in/constitution)

Alternative NPTEL/SWAYAM Course:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL ID</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12910600</td>
<td>CONSTITUTION OF INDIA AND ENVIRONMENTAL GOVERNANCE: ADMINISTRATIVE AND ADJUDICATORY PROCESS</td>
<td>PROF. SAIRAM BHAT, PROF. M. K. RAMESH</td>
<td>NATIONAL LAW SCHOOL OF INDIA UNIVERSITY</td>
</tr>
</tbody>
</table>

Course Outcomes: Upon completion of this course, the students will be able:
1. To Understand the emergence and evolution of Indian Constitution.
2. To Understand the structure and composition of Indian Constitution.
3. To Understand and analyse federalism in the Indian context.
4. To Analyse Panchayati Raj institutions as a medium of decentralization.
5. To Understand and analyse the three organs of the state in the contemporary scenario.
6. To Understand and Evaluate the Indian Political scenario amidst the emerging challenges.
Course Objective: The objective of the course is practical implementation of the convolution, correlation, DFT, IDFT, Block convolution, Signal smoothing, filtering of long duration signals, and Spectral analysis of signals.

List of Experiments:
1. To study about DSP Processors and its architecture.
2. Introduction to MATLAB and IDE for processor development.
3. Introduction to Scilab Open Source Software.
4. Write a Program for the generation of basic signals such as Module impulse, Module step, ramp, exponential, sinusoidal and cosine.
5. To study matrix multiplication using code composer studio.
6. Evaluate 4 point DFT of and IDFT of \( x(n) = 1, 0 \leq n \leq 3; 0 \) elsewhere.
7. To implement the FFT algorithm.
8. Verify Blackman and Hamming windowing techniques.
9. Implement IIR Butterworth analog Low Pass for a 4 KHz cut off frequency.
12. To implement Tone Generation.
13. To implement floating point arithmetic.

Experiments that may be performed through virtual labs:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Experiment Name</th>
<th>Experiment Link(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Implement IIR Butterworth analog Low Pass for a 4 KHz cut off frequency.</td>
<td>[<a href="http://vlabs.iitkgp.ernet.in/dsp/exp">http://vlabs.iitkgp.ernet.in/dsp/exp</a> 10/index.html](<a href="http://vlabs.iitkgp.ernet.in/dsp/exp">http://vlabs.iitkgp.ernet.in/dsp/exp</a> 10/index.html)</td>
</tr>
</tbody>
</table>

Text Books/References:

Course Outcomes: After studying this course the students would be able:
1. To Understand the handling of discrete/digital signals using MATLAB & related softwares.
2. To Understand the basic operations of Signal processing.
3. To Analyze the spectral parameter of window functions.
4. To Design IIR, and FIR filters for band pass, band stop, low pass and high pass filters.
5. To develop the signal processing algorithm using MATLAB & VLAB.

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<table>
<thead>
<tr>
<th>Course Code</th>
<th>MT-512</th>
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</thead>
<tbody>
<tr>
<td>Course Title</td>
<td>Sensors &amp; Instrumentation Lab</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>1 (L: 0; T: 0; P: 2)</td>
</tr>
<tr>
<td>Course Category</td>
<td>MT</td>
</tr>
</tbody>
</table>

**Course Objective:** This introduces the students with the theory and methods for conducting experimental work in the laboratory and calibration of various instruments for measuring pressure, temperature, displacement, speed, vibration etc.

**List of Experiments:**
3. Study of the characteristics of Resistance Temperature Detector (RTD)
4. Study of the characteristics of a Thermistor
5. Study of the characteristics of a Thermocouple
6. Study of the characteristics of a Magnetic Proximity sensor for Speed Measurement
7. Study of the characteristics and operation of Magnetic Sensor.
8. Study of the operation and characteristics of optical sensors

**EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Experiment Name</th>
<th>Experiment Link(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Study of the characteristics of a Thermistor.</td>
<td><a href="http://vlab.amrita.edu/?sub=1&amp;brch=282&amp;sim=1511&amp;cnt=1">http://vlab.amrita.edu/?sub=1&amp;brch=282&amp;sim=1511&amp;cnt=1</a></td>
</tr>
</tbody>
</table>
Study of the characteristics of a Thermocouple.

Text Books/References:
2. D. Patranabis, Sensors and Transducers, PHI Publication, New Delhi

Course Outcomes:
1. To Understand the concept of sensors and its characteristics.
2. To Understand the practical approach in design of technology based on different sensors.
3. To Learn various sensor materials and technology used in designing sensors.
4. To describe different sensors working.
5. To Develop a sense for recognizing bad data and an intuition of how to resolve problems.

Course Code : MT-513
Course Title : Control System Engineering Lab
Number of Credits : 1 (L: 0; T: 0; P: 2)
Course Category : MT

Course Objective: To understand concepts of the mathematical modelling, feedback control and stability analysis in Time and Frequency domains.

List of Experiments:
1. Different Toolboxes in MATLAB, Introduction to Control Systems Toolbox or its equivalent open source freeware software like Scilab.
2. Determine transpose, inverse values of given matrix.
3. Plot the pole-zero configuration in s-plane for the given transfer function.
4. Determine the transfer function for a given closed loop system in block diagram representation.
5. Plot Module step response of given transfer function and find delay time, rise time, peak time and peak overshoot.
6. Determine the time response of the given system subjected to any arbitrary input.
7. Plot root locus of given transfer function, locate closed loop poles for different values of k. Also find out Wd and What for a given root.
8. Create the state space model of a linear continuous system.
9. Determine the State Space representation of the given transfer function.
10. Plot bode plot of given transfer function. Also determine the relative stability by measuring gain and phase margins.
11. Determine the steady state errors of a given transfer function.
12. Plot Nyquist plot for given transfer function and to discuss closed loop stability. Also determine the relative stability by measuring gain and phase margin.

Text Books/References:
3. Ogata, K., Modern Control Engineering, Prentice.

Course Outcomes:
After the successful completion of the course the students will be able:
1. To Develop the mathematical model of the physical systems.
2. To Analyze the response of the closed and open loop systems.
3. To Analyze the stability of the closed and open loop systems.
4. To Design the various kinds of compensator.
5. To Develop and analyze state space models.

Course Code : MT-514
Course Title : Kinematics and Theory of Machines Lab
Number of Credits : 1 (L: 0; T: 0; P: 2)
Course Category : MT

Course Objective:
1. To develop skills for designing and analyzing linkages, cams, gears and other mechanisms.
2. To develop skills for use of mathematics software and for writing computer programs to solve kinematics problems.
3. To provide a foundation for the study of machine design.
4. Development of individual and team skills involving pre- and post-processing and interpretation computer-aided design and analysis data.
5. Development of individual and team communications skills.

List of Experiments:
1. Study of simple linkage models/mechanisms.
2. Study of inversions of four bar linkage.
3. Study of inversions of single/double slider crank mechanisms.
4. Experiment on Gears tooth profile, interference etc.
5. Experiment on Gear trains.
6. Experiment on longitudinal vibration.
7. Experiment on transverse vibration.
8. Experiments on dead weight type governor.
9. Experiment on spring controlled governor.
10. Experiment on critical speed of shaft.
11. Experiment on gyroscope.
12. Experiment on Cam profile.

**Text Books/References:**
2. Recommended Software: Math CAD.

**EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Experiment Name</th>
<th>Experiment Link(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Study of simple linkage models/mechanisms.</td>
<td><a href="http://mm-nitk.vlabs.ac.in/exp25/index.html">http://mm-nitk.vlabs.ac.in/exp25/index.html</a></td>
</tr>
<tr>
<td>2</td>
<td>Study of inversions of four bar linkage.</td>
<td><a href="http://mm-nitk.vlabs.ac.in/exp4/index.html">http://mm-nitk.vlabs.ac.in/exp4/index.html</a></td>
</tr>
</tbody>
</table>
| 3      | Study of inversions of single/double slider crank mechanisms.                   | 1. [http://mm-nitk.vlabs.ac.in/exp14/index.html](http://mm-nitk.vlabs.ac.in/exp14/index.html)  
               2. [http://mm-nitk.vlabs.ac.in/exp13/index.html](http://mm-nitk.vlabs.ac.in/exp13/index.html) |

**Course Outcomes:**
After the successful completion of the course the students will be able:
1. To Distinguish kinematic and kinetic motion.
2. To Identify the basic relations between distance, time, velocity, and acceleration.
3. To Apply vector mechanics as a tool for solving kinematic problems.
4. To Create a schematic drawing of a real-world mechanism.

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<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Number of Credits</th>
<th>Course Category</th>
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</thead>
<tbody>
<tr>
<td>MT-515</td>
<td>Mini Project or Internship</td>
<td>1</td>
<td>MT</td>
</tr>
</tbody>
</table>

113
Mini Project or Internship of 3 to 4 Weeks shall be performed during summer break after semester IV and will be assessed as part of Semester V.

During the summer vacations, after the 4th Semester, students are required to be involved in Inter/Intra Institution Activities viz.; Training with higher Institutions; Soft skill training organized by Training and Placement Cell of the respective institution; contribution at incubation/innovation/entrepreneurship cell of the Institution; participation in conferences/workshops/competitions etc.; Learning at Departmental Lab/Tinkering Lab/Institutional workshop; Working for consultancy/research project within the institutes and Participation in all the activities of Institute’s Innovations Council for e.g.: IPR workshop/Leadership Talks/Idea/Design/Innovation/Business Completion/Technical Expos etc.

After completion of Mini-project or Internship the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period or while working on mini-project. The student may contact Industrial Supervisor/Faculty Mentor/TPO for assigning special topics and problems and should prepare the final report on the assigned topics.

Student’s Diary and Internship Report should be submitted by the students along with attendance record and an evolution sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training. It will be evaluated on the basis of the following criteria:

- Regularity in maintenance of the diary.
- Adequacy & quality of information recorded.
- Drawing, sketches and data recorded.
- Thought process and recording techniques used.
- Organization of the information.

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SEMESTER – VI
SEMESTER VI

<table>
<thead>
<tr>
<th>Course Code</th>
<th>MT-601</th>
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</thead>
<tbody>
<tr>
<td>Course Title</td>
<td>Design of Machine Elements</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>3 (L: 3; T: 0; P: 0)</td>
</tr>
<tr>
<td>Course Category</td>
<td>MT</td>
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</tbody>
</table>

**Course Objective:**
1. To develop an ability to apply knowledge of mathematics, science, and engineering.
2. To develop an ability to design a system, components to meet desired needs within realistic constraints.
3. To develop an ability to identify, formulate and solve engineering problems.
4. To develop an ability to use the technique, skills, & engineering tools.

**Course Content:**

**Module-I:** Design considerations - limits, fits and standardization, Review of failure theories for static and dynamic loading (including fatigue failure),

**Module-II:** Design of shafts under static and fatigue loadings, Analysis and design of sliding and rolling contact bearings,

**Module-III:** Design of transmission elements: spur, helical, bevel and worm gears; belt and chain drives,

**Module-IV:** Design of springs: helical compression, tension, torsional and leaf springs,

**Module-V:** Design of joints: threaded fasteners, pre-loaded bolts and welded joints, Analysis and applications of power screws and couplings, Analysis of clutches and brakes

**Text Books/References:**

**Alternative NPTEL/SWAYAM Course:**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Design of Machine Elements I</td>
<td>Prof. B. Maiti</td>
<td>IIT Kharagpur</td>
</tr>
</tbody>
</table>
**Course Outcomes:** After the completion of this course, students will get an overview of the design methodologies employed for the design of various machine components.

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<table>
<thead>
<tr>
<th>Course Code</th>
<th>MT-602</th>
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</thead>
<tbody>
<tr>
<td>Course Title</td>
<td>Computer Network &amp; Cyber Security</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>3 (L: 3; T: 0; P: 0)</td>
</tr>
<tr>
<td>Course Category</td>
<td>MT</td>
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</tbody>
</table>

**Course Objective:**

- To develop an understanding of modern network architectures from a design and performance perspective.
- To introduce the student to the major concepts involved in wide-area networks (WANs), local area networks (LANs) and Wireless LANs (WLANs).
- To provide an opportunity to do network programming.
- To provide WLAN measurement ideas.

**Course Content:**


**Module II:** Data Link Layer and Medium Access Sub Layer: Error Detection and Error Correction - Fundamentals, Block coding, Hamming Distance, CRC; Flow Control and Error control protocols - Stop and Wait, Go back – N ARQ, Selective Repeat ARQ, Sliding Window, Piggybacking, Random Access, Multiple access protocols -Pure ALOHA, Slotted ALOHA, CSMA/CD, CDMA/CA


**Module IV:** Application Layer: Domain Name Space (DNS), DDNS, TELNET, EMAIL, File Transfer Protocol (FTP), WWW, HTTP, SNMP, Bluetooth, Firewalls, Basic concepts of Cryptography. Cyber Security Concepts Essential Terminologies: CIA, Risks, Breaches,


**Text Books/References:**
5. TCP/IP Illustrated, Volume 1, W. Richard Stevens, Addison-Wesley, Moduleed States of America.

**Alternative NPTEL/SWAYAM Course:**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
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</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Computer Networks &amp; Internet Protocol</td>
<td>Prof. Sandip Chakraborty</td>
<td>IIT Kharagpur</td>
</tr>
</tbody>
</table>

**Course Outcomes:**
1. To Explain the functions of the different layers of the OSI Protocol.
2. To Draw the functional block diagram of wide-area networks (WANs), Local Area Networks (LANs) and Wireless LANs (WLANs) describe the function of each block.
3. To assess requirement (small scale) of wide-area networks (WANs), local area networks (LANs) and Wireless LANs (WLANs) design it based on the market available component.
4. To classify problem related TCP/IP protocol developed the network programming.
5. To Configure DNS, TELNET, EMAIL, File Transfer Protocol (FTP), WWW, HTTP, SNMP, Bluetooth, Firewalls using open source available software and tools.

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<th>Course Code</th>
<th>Course Title</th>
<th>Number of Credits</th>
<th>Course Category</th>
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</thead>
<tbody>
<tr>
<td>MT-603</td>
<td>Microprocessor &amp; Microcontroller</td>
<td>3 (L: 3; T: 0; P: 0)</td>
<td>MT</td>
</tr>
</tbody>
</table>
Course Objective: To introduce the basics of microprocessors and microcontrollers technology and related applications. Study of the architectural details and programming of 16 bit 8085 microprocessors and its interfacing with various peripheral ICs; Study of architecture and programming of 8085 processors.

Course Content:


Module II: Hardware Interfacing with 8085: Methods of data Transfer and Interrupts of 8085 microprocessors: Classification of interrupts, Programming using interrupts, Direct Memory Access, Serial and parallel data transfer, Interfacing of Memory Chips with 8085 Microprocessor, Interfacing of 8085 with 8155/8156 (RAM), 8355/8755 (ROM). Interfacing of Programmable Devices with 8085 Microprocessor, 8279 programmable Keyboard/Display interface, 8255A programmable Parallel interface, 8254 programmable Interval Timer, 8259A programmable Interrupt Controller, Assembly language programming.

Module III: 16-bit low power MCU: Introduction to microcontrollers and embedded systems, Von Neumann (Princeton) and Harvard architecture, RISC and CISC machine, Architecture, Programming Techniques, Addressing Modes, Programming System registers and configuration I/O ports pull up/down registers concepts, Low Power aspects of MSP430: low power modes, Active vs Standby current consumption.

Module IV: Configuring Peripherals in MSP430: External interrupts and software interrupt, interrupt programming, Watchdog timer, Clock Tree in MSP430, Timer/counter interrupt, Programming MSP430 timer, counter programming, Real Time Clock (RTC), PWM control, timing generation and measurements. Analog interfacing and data acquisition: ADC and Comparator in MSP430, data transfer using DMA.


Text Books:
1. Ramesh Gaonkar, “Microprocessor Architecture, Programming, and Applications with the 8085”, Penram International Publication (India) Pvt. Ltd.

References:

Course Outcomes: The student will be able:
1. To Acquire knowledge about microprocessors and its need.
2. To Write the programs using 8085 and 8086 microprocessors.
3. To illustrate Know the internal architecture and interfacing of different peripheral devices with 8085 and 8086 microprocessors.
4. To Design the system using 8085 processors.

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<table>
<thead>
<tr>
<th>Course Code</th>
<th>:  MT-604</th>
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</thead>
<tbody>
<tr>
<td>Course Title</td>
<td>:  Manufacturing Technologies</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>:  3 (L: 3; T: 0; P: 0)</td>
</tr>
<tr>
<td>Course Category</td>
<td>:  MT</td>
</tr>
</tbody>
</table>

Course Objective:
1. To provide knowledge on machines and related tools for manufacturing various components.
2. To understand the relationship between process and system in manufacturing domain.
3. To identify the techniques for the quality assurance of the products and the optimality of the process in terms of resources and time management.

MODULE I: Patterns and Pattern making, Introduction to Foundry - Steps involved in casting, advantages, limitations and applications of casting process. Pattern types, allowances for pattern, pattern materials, color coding and storing of patterns Moulding, Moulding methods and processes-materials, equipment, Moulding sand ingredients, essential requirements, sand preparation and control, testing, cores and core making. Design considerations in casting, gating and Riser - directional solidification in castings, Metallurgical aspects of Casting.
MODULE II: Casting Processes - Sand castings, pressure die casting, permanent mould casting, centrifugal casting, precision investment casting, shell Moulding, Co2 Moulding, continuous casting-squeeze casting, electro slag casting, Fettling and finishing, defects in Castings, Casting of non-ferrous materials Melting, Pouring and Testing, Melting furnaces- crucibles oil fired furnaces-electric furnaces-cupola, selection of furnace, calculation of cupola charges-Degasification, inoculation, pouring techniques casting defects and Inspection of castings.

MODULE III: Cutting tools and tool geometry 8 Types of cutting tools, tool materials-HSS (including heat treatment) ceramics, cements, CBN &PCD, tool geometry and nomenclature, selection of tool materials and tool life, tool wear and machinability

Mechanics of chip formation, types of chips and conditions conducive for the formation of each type Built-up edge, its effects Orthogonal Vs oblique cutting- merchant’s force circle diagram. Force and velocity relationship, shear plane angle. Energy consideration in Machining-Ernst Merchant theory of shear angle, relationship-original assumptions and modification made.

MODULE IV: Extrusion and Drawing Processes, Classification of extrusion processes-tool, equipment, and principle of these processes, influence on Friction-Extrusion force calculation-defects and analysis-rod/wire drawing-tool, equipment and principle of processes.


MODULE V: Basic Joining Processes Types of welding-gas welding, -arc welding, -shielded metal arc welding, GTAW, GMAW, SAW, ESW-Resistance welding (spot, seam, projection, percussion, flash types)-atomic hydrogen arc welding-thermit welding, Flame cutting - Use of Oxyacetylene, modern cutting processes, arc cutting.

Soldering, brazing and braze welding and their application., welding of special materials -Stainless steel, aluminium etc. weldability of cast iron, steel, stainless steel, aluminium alloys. Introduction to Electron beam and Laser welding.

Text Books/References:
Alternative NPTEL/SWAYAM Course:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Manufacturing Processes I</td>
<td>Dr. Pradeep Kumar</td>
<td>IIT ROORKEE</td>
</tr>
</tbody>
</table>

Course Outcomes: Upon completion of this course, students will be able to the tooling needed for manufacturing, the dimensional accuracy and tolerances of products, assembly of different components and the application of optimization methods in manufacturing.

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<table>
<thead>
<tr>
<th>Course Code</th>
<th>: MTPE-60X</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>: Professional Elective I</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>: 3 (L: 3; T: 0; P: 0)</td>
</tr>
<tr>
<td>Course Category</td>
<td>: MTPE</td>
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</tbody>
</table>

Any one course from following may be opted as “Professional Elective I”:
1. Optimization Technique (MTPE-601)
2. Operation Research (MTPE-602)
3. Total Quality Management (MTPE-603)

Refer Appendix I on Professional Electives.

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<table>
<thead>
<tr>
<th>Course Code</th>
<th>: MT-611</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>: Computer Aided Design Lab</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>: 2 (L: 0; T: 0; P: 4)</td>
</tr>
<tr>
<td>Course Category</td>
<td>: MT</td>
</tr>
</tbody>
</table>

Course Objective:
- To impart fundamental knowledge to students in the latest technological topics on Computer Aided Design, Computer Aided Manufacturing and Computer Aided Engineering Analysis and to prepare them for taking up further research in the areas.
● To create a congenial environment that promotes learning, growth and imparts ability to work with inter-disciplinary groups in professional, industry and research organizations.
● To broaden and deepen their capabilities in analytical and experimental research methods, analysis of data, and drawing relevant conclusions for scholarly writing and presentation.
● To provide guidance to students for their choices in research and professional career outlook and to encourage students to take up research.

List of Experiments:
2. Design of machine components or other system experiments: Writing and validation of computer programs.
3. Understanding and use of any 3-D Modeling Software / commands.
4. Experiment: Solid modeling of a machine component using CAD Software.
5. Writing a small program for FEM for 2 spring system and validation of program or using a FEM Package
6. Numerical differentiation or numerical integration experiment: Writing and validation of computer programs.

Text Books/References:

Course Outcomes: Upon completion of this course, students will be able:
1. To develop solutions in the areas of Design and simulation in Mechanical Engineering.
2. To develop Have abilities and capabilities in applying computer software and hardware to mechanical design and manufacturing fields.
3. To Review and document the knowledge developed by scholarly predecessors and critically assess the relevant technological issues.
4. To Formulate relevant research problems; conduct experimental and/or analytical study and analyzing results with modern mathematical / scientific methods and use of software tools.
5. To Design and validate technological solutions to defined problems and communicate clearly and effectively for the practical application of their work.
**Course Objective:** In this course, students will learn the fundamental principles of computer and network security by studying attacks on computer systems, network, and the Web. Students will learn how those attacks work and how to prevent and detect them. The course emphasizes "learning by doing", and requires students to conduct a series of lab exercises. Through these labs, students can enhance their understanding of the principles, and be able to apply those principles to solve real problems. After completion of the course, students should be able to possess the following skills:

- be able to explain security principles,
- be able to evaluate risks faced by computer systems,
- be able to explain how various attacks work,
- be able to describe and generalize various software vulnerabilities

**List of Experiments:**
1. Study of different wireless network components and features of any one of the Mobile Security Apps.
2. Study of the features of firewall in providing network security and to set Firewall Security in windows.
3. Steps to ensure Security of any one web browser (Mozilla Firefox/Google Chrome)
4. Study of different types of vulnerabilities for hacking websites / Web Applications.
5. Analysis the Security Vulnerabilities of E-commerce services.
6. Analysis the security vulnerabilities of E-Mail Application

**Text Books/References:**

**Course Outcomes:**
- To understand the basics of Computer Networks, Cyber Security and Various Protocols. He / She will be in a position to understand the World Wide Web concepts.
- To illustrate a network and flow of information further he/she can understand easily the concepts of network security, Mobile and ad hoc networks.

*****
Course Code : MT-613
Course Title : Microprocessor & Microcontroller Lab
Number of Credits : 2 (L: 0; T: 0; P: 4)
Course Category : MT

Course Objective:
● To expose students to the operation of a typical microprocessor (8085) trainer kit.
● To prepare the students to be able to solve different problems by developing different programs.
● To develop the quality of assessing and analyzing the obtained data.

List of Experiments:

8086 Programs using kits and MASM
1. Basic arithmetic and Logical operations
2. Move a data block without overlap
3. Code conversion, decimal arithmetic and Matrix operations.
4. Floating point operations, string manipulations, sorting and searching
5. Password checking, Print RAM size and system date
6. Counters and Time Delay

Peripherals and Interfacing Experiments using 8085 and 16 bit MCU.
1. Traffic light control.
2. Stepper motor control.
5. A/D and D/A interface and Waveform Generation.

Text Books/References:

Course Outcomes: At the end of the course, the students will be able
1. To Identify relevant information to supplement the Microprocessor and Microcontroller course.
2. To Set up programming strategies and select proper mnemonics and run their program on the training boards.
3. To Practice different types of programming keeping in mind technical issues and evaluate possible causes of discrepancy in practical experimental observations in comparison.
4. To Develop testing and experimental procedures on Microprocessor and Microcontroller analyze their operation under different cases.
**Course Objective:** To Study and practice the various operations that can be performed in lathe, shaper, drilling, milling machines etc. and to equip with the practical knowledge required in the core industries.

**List of Experiments:**
1. Design of pattern & pattern making: At least one wooden pattern with proper calculations.
2. Making a green sand mould
   - One mould each on pit Moulding & split pattern.
   - At least two for different type of components with core and without core to be made.
3. Sand testing experiments to determine:
   - Grain Fineness Number
   - Green Strength
   - Permeability Test
   - Moisture content test
4. Study, understanding and working of simple destructive & non-destructive testing procedures used for castings.
5. Measurement of forces for orthogonal turning operation by tool dynamometer.
7. Study of the extrusion and drawing process – visit to industry with report presentation.
8. Welding Lab:
   - Preparation of simple shapes of metal sheets by gas cutting.
   - Preparation of specimen & welding of: Angle joint / T joint Lap joint / Butt joint (use of both Arc & Gas welding).
   - Study, understanding and working of simple destructive & non-destructive testing procedures used for welding.
   - Study on influence of welding parameters in Arc & Gas welding with demonstration.
9. Study of the extrusion and drawing process – visit to industry with report presentation.
Text Books/References:

EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

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<th>S. No.</th>
<th>Experiment Name</th>
<th>Experiment Link(s)</th>
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</table>

Course Outcomes: Upon the completion of this course the students will be able
1. To Demonstrate the safety precautions exercised in the mechanical workshop.
2. To contrast workpiece as per given shape and size using Lathe.
3. To illustrate Join two metals using arc welding.
4. To demonstrate Use sheet metal fabrication tools and make a simple tray and funnel.
5. To design Use different moulding tools, patterns and prepare sand moulds.

*****

Course Code : MT-615
Course Title : Seminar
Number of Credits : 1
Course Category : MT

The objective of the seminar is to improve communication/presentation skills of students and develop his/her acquaintance with new and upcoming technologies including new and emerging processes. Faculty in-charge may select the appropriate topic for the student and fixup the time and duration of the presentation. Students are expected to improve their awareness of careers and their individual career goals through this activity.

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SEMESTER – VII
SEMESTER VII

<table>
<thead>
<tr>
<th>Course Code</th>
<th>MT-701</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>Robotics</td>
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<tr>
<td>Number of Credits</td>
<td>3 (L: 3; T: 0; P: 0)</td>
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<tr>
<td>Course Category</td>
<td>MT</td>
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</table>

Course Objective:
- To acquire the knowledge on advanced algebraic tools for the description of motion.
- To develop the ability to analyze and design the motion for articulated systems.
- To develop an ability to use software tools for analysis and design of robotic systems.

Course Contents:

Module I: Introduction:

Module II: Robot Programming:
Introduction, On-line programming: Manual input, Lead through-programming, Teach pendant programming, Off-line programming language, Simulation, Introduction to ROS Concept

Module-III: Kinematics of Robotic Manipulators:
Introduction to manipulator kinematics, Homogeneous transformations and robot kinematics, Denavit- Hartenberg (D-H) representation, Concept of forward and inverse kinematics.

Module-IV: Control of Robot Manipulator:
Open and closed loop control system, Control system concepts, Linear control schemes, PID control system, Types of motion control, drives and control, Planning of trajectories, Human Robot Collaboration

Module V: Control Components and Sensors:
Mechanical control by stops and cams, Solenoids, Relays; Internal Sensors, potentiometers, resolvers and encoders; External sensing: Simple touch sensing, strain sensing, tactile sensing, acoustic sensing, magnetic sensing, capacitive sensing, laser sensing & machine vision

Text Books/References:

Alternative NPTEL/SWAYAM Course:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Robotics</td>
<td>Prof. Dilip Kumar Pratihar</td>
<td>IIT Kharagpur</td>
</tr>
<tr>
<td>2.</td>
<td>Robotics</td>
<td>PROF. D.K. PRATIHAR</td>
<td>IIT Kharagpur</td>
</tr>
</tbody>
</table>

Course Outcomes:
1. To Understand the basic knowledge on robotics.
2. To demonstrate the different type of robot programing & distinguish between them
3. To Design various types of linkage mechanism for obtaining specific motion and analyze them for optimal functioning.
4. To inspect the knowledge related to control techniques related to robot systems.
5. To Understand the knowledge of different types of sensor used in robot systems.

Course Code : MT-702
Course Title : Mechatronics System
Number of Credits : 3 (L: 2; T: 1; P: 0)
Course Category : MT

Course Objective: This course aims at providing fundamental understanding about the elements of a mechatronics system, interfacing, and its practical applications.

Course Contents:


Module II: Sensors and transducers: classification, Development in Transducer technology, Opto-Electronics-Shaft encoders, CD Sensors, Vision System, etc;
Module III: Drives and Actuators: Hydraulic and Pneumatic drives, Electrical Actuators such as servo motor and Stepper motor, Drive circuits, open and closed loop control; Embedded Systems: Hardware Structure, Software Design and Communication, Programmable Logic Devices, Automatic Control and Real Time Control Systems;

Module IV: Replacement Programmable Logic Controllers: Basic Structure, Types and Working Principle, Concept of Scan Cycle and Scan Time, IO’s and its Types, Selection Criteria and Applications

Programming Techniques: Ladder diagram – Concept of Contacts and Coil, Latching/Holding Circuit, Memory Bits, Timers and Counter.

Module V: Micro mechatronic systems: Microsensors, Microactuators; Microfabrication techniques LIGA Process: Lithography, etching, Micro-joining etc. Application examples; Case studies Examples of Mechatronic Systems from Robotics Manufacturing, Machine Diagnostics, Road vehicles and Medical Technology.

Text Books/References:

Alternative NPTEL/SWAYAM Course:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
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<tbody>
<tr>
<td>1.</td>
<td>Mechatronics &amp; Manufacturing</td>
<td>Dr. Shrikrishna N. Joshi</td>
<td>IIT Guwahati</td>
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<tr>
<td></td>
<td>Automation</td>
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Course Outcomes: Upon completion of this course, students will get an overview of mechatronics applications and the use of micro-sensors and microprocessors.

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<tr>
<th>Course Code</th>
<th>: MT-703</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>Computer Aided Manufacturing</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>: 3 (L: 3; T: 0; P: 0)</td>
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<tr>
<td>Course Category</td>
<td>: MT</td>
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</tbody>
</table>

Course Objective:
1. To educate students by covering different aspects of computer Aided Manufacturing.
2. To create strong skills of writing CNC programs, PLC programs.
3. To educate students to understand different advances in manufacturing systems like: GT, CAPP and FMS.
4. To educate students by covering different integrated production management systems.

**Course Content:**

**Module I:** Fundamentals of Numerical Control, elements of NC machine tools, classification of NC machine tools, Advantages, suitability and limitations of NC machine tools, Application of NC system. Definition and designation of control axes, Constructional details of Numerical Control Machine Tools, MCU structure and functions, Methods of improving accuracy and productivity using NC.

**Module II:** Computer Numerical Control (CNC): Features of CNC, Elements of CNC machines, the machine control Module for CNC, Direct Numerical Control(DNC) and Adaptive Controls. System Devices: Drives, Feedback devices, counting devices, DAC and ADCs, Interpolator systems, Control loop circuit elements in PTP system, Contouring system, Incremental and absolute systems.

**Module III:** NC Part Programming- (a) Manual (word address format) programming Examples Drilling, Turning and Milling; canned cycles, Subroutine, and Macro. Computer Assisted Part programming (APT) Geometry, Motion and Additional statements, Macro- statement.

**Module IV:** Computer Integrated manufacturing system, Group Technology, Flexible Manufacturing System, Computer aided process Planning-Retrieval and Generative System. Manufacturing Execution System; Overview, Components and Functionality, Relationship between MES and ERP, Benefits of MES.

**Module V:** Smart Manufacturing; Introduction to additive manufacturing, IoT, Smart Sensing, Smart Machines, Data Visualization and Analysis, Augmented Reality, Automated material handling & Cobots. Overview of 3D printing Technology, Materials used in 3D printing, Cyber-security for manufacturing.

**Text Books/References:**

Course Outcomes: After learning the course:
1. To describe basic concepts of CAM application and understand CAM wheel.
2. To design CNC programs for manufacturing of different geometries on milling and lathe machines.
3. To illustrate logic diagrams for different applications of automation.
4. To classify different components using different techniques of group technology.
5. To develop process planning for different components.

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<tr>
<th>Course Code</th>
<th>MT-70X</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>Professional Elective II</td>
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<tr>
<td>Number of Credits</td>
<td>3 (L: 3; T: 0; P: 0)</td>
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<tr>
<td>Course Category</td>
<td>MT</td>
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</table>

Any one course from following options can be opted under ‘Professional Elective II’:
1. Product Development (MTPE-701)
2. Rapid Prototyping (MTPE-702)
3. Machine Learning (MTPE-703)

Refer Appendix I on Professional Electives.

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<table>
<thead>
<tr>
<th>Course Code</th>
<th>MT-711</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>Robotics Lab</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>2 (L: 0; T: 0; P: 4)</td>
</tr>
<tr>
<td>Course Category</td>
<td>MT</td>
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</table>

Course Objective:
1. To introduce different types of robotics and demonstrate them to identify different parts and components.
2. To write programming for simple operations.

List of Experiments:
1. Study the major equipment/Software/Components in Robotics Lab, e.g. Robotic Arm components, Arena etc.
2. Study components of a real robot and its DH parameters.
3. Integration of assorted sensors (IR, Potentiometer, strain gages etc.), micro controllers and ROS (Robot Operating System) in a robotic system.
Exercise on any Robotic Simulation Software
1. Determination of maximum and minimum position of links.
2. Study Forward kinematics and validation.
3. Study Inverse kinematics and validation.
4. Measure the knowledge of Robotic arm, material handling, Scorbase Software and Homing and Moving Robot
5. Recoding Robot positions (Absolute positions, Delete Positions, Save and load positions and Move the Robot to recorded positions.)
6. Verification of transformation (Position and orientation) with respect to gripper and world coordinate system.
7. Robot Programming and Simulation using linear and nonlinear paths.
8. Writing and running Robot programs – Activity material handling operation.
10. Make a model using software to simulate the processing in small manufacturing cell.
11. Study and Simulate path planning and navigation in ROS.
12. Study the implementation of PID Control in ROS.

Text Books/References:

EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Experiment Name</th>
<th>Experiment Link(s)</th>
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</thead>
</table>

Course Outcomes: Upon Completion of the course, the students will be able;
1. To assess kinematics & dynamic analysis of robot manipulators.
2. To understand the functionality and limitations of robot actuators.
3. To program a robot to perform a specified task in a target environment and solve problems in areas such as robot control and navigation.
4. To Understand how simulations of robots, where they can be useful and where they can break down.

*****
Course Code : MT-712
Course Title : Computer Aided Manufacturing Lab
Number of Credits : 1 (L: 0; T: 0; P: 2)
Course Category : MT

Course Objective:
1. Acquire fundamental understanding of the principles of CAD/CAM, including engineering drawing, geometric and surface and feature-based design.
2. Math behind geometry to understand CAD.
3. Applying CAD/CAM concept to product design and manufacturing.
4. Exposure to CAD/CAM software’s.
5. Exposure to machines at Imagineering lab.

List of Experiments:
1. Study of CNC VMC part programming fundamentals and writing part program.
2. Study and demonstration of CNC VMC.
3. Part Programming (in word address format) experiment for turning operation (including operations such as grooving and threading) and running on CNC machine.
4. Part Programming (in word address format or ATP) experiment for drilling operation (point to point) and running on CNC machine.
5. Part Programming (in word address format or ATP) experiment for milling operation (contouring) and running on CNC machine.
6. Experiment on difference between ordinary machine and NC machine, study or retrofitting.

Text Books/References:

Course Outcomes: The student will be able:
1. To Understand engineering design concepts.
2. To illustrate Product specification methods.
3. To Construct 3D part models.
4. To examine Geometric tolerance.
5. To Understand process planning.
6. To design Rapid Manufacturing.
The objective of Project Work-I is to enable the student to take up investigative study in the broad field of Mechatronics Engineering, either fully theoretical/practical or involving both. Theoretical and practical work to be assigned by the Department on an individual basis or two/three students in a group, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work. The assignment normally includes:

- Survey and study of published literature on the assigned topic;
- Working out a preliminary Approach to the Problem relating to the assigned topic;
- Conducting preliminary Analysis / Modeling / Simulation / Experiment / Design / Feasibility;
- Preparing a Written Report on the Study conducted for presentation to the Department;
- Final Seminar, as oral Presentation before a Departmental Committee.

Mini Project or Internship of 3 to 4 Weeks shall be performed during summer break after semester VI and this will be assessed as part of Semester VII.

During the summer vacations, after the 6th Semester, students are required to be involved in Inter/ Intra Institution Activities viz.; Training with higher Institutions; Soft skill training organized by Training and Placement Cell of the respective institution; contribution at incubation/ innovation /entrepreneurship cell of the Institution; participation in conferences/ workshops/ competitions etc.; Learning at Departmental Lab/ Tinkering Lab/ Institutional workshop; Working for consultancy/ research project within the institutes and Participation in all the activities of Institute’s Innovations Council for e.g.: IPR workshop/ Leadership Talks/ Idea/ Design/ Innovation/ Business Completion/ Technical Expos etc.
After completion of Mini-project or Internship the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period or while working on mini-project. The student may contact Industrial Supervisor/Faculty Mentor/TPO for assigning special topics and problems and should prepare the final report on the assigned topics.

Student’s Diary and Internship Report should be submitted by the students along with an attendance record and an evolution sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training. It will be evaluated on the basis of the following criteria:

- Regularity in maintenance of the diary.
- Adequacy & quality of information recorded.
- Drawing, sketches and data recorded.
- Thought process and recording techniques used.
- Organization of the information.

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SEMESTER – VIII
SEMESTER VIII

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<tr>
<th>Course Code</th>
<th>MTOE-80X</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>Open Elective I</td>
</tr>
<tr>
<td>Number of Credits</td>
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<tr>
<td>Course Category</td>
<td>MTOE</td>
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</table>

Any one course from following options can be opted under ‘Open Elective I’:
1. Virtual and Augmented Reality (MTOE-801)
2. Image Processing & Computer Vision (MTOE-802)
3. Wireless Network & Communication (MTOE-803)

For syllabus, Refer Appendix II on Open Electives.

<table>
<thead>
<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>Open Elective II</td>
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<tr>
<td>Number of Credits</td>
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<tr>
<td>Course Category</td>
<td>MTOE</td>
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</table>

Any one course from following options can be opted under ‘Open Elective II’:
1. Artificial Intelligence (MTOE-804)
2. Real Time System (MTOE-805)
3. Artificial Neural Network (MTOE-806)

For syllabus, Refer Appendix II on Open Electives.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>MT-811</th>
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<tr>
<td>Course Title</td>
<td>Project Work II</td>
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<tr>
<td>Number of Credits</td>
<td>10</td>
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<tr>
<td>Course Category</td>
<td>MT</td>
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</table>

The object of Project Work II & Dissertation is to enable the student to extend further the investigative study taken up under EC P1, either fully theoretical/practical or involving both theoretical and practical work, under the guidance of a Supervisor from the
Department alone or jointly with a Supervisor drawn from R&D laboratory/Industry. This is expected to provide a good training for the student(s) in R&D work and technical leadership. The assignment to normally include:

1. In depth study of the topic assigned in the light of the Report prepared under EC P1;
2. Review and finalization of the Approach to the Problem relating to the assigned topic;
3. Preparing an Action Plan for conducting the investigation, including team work;
4. Detailed Analysis/Modeling/Simulation/Design/Problem Solving/Experiment as needed;
5. Final development of product/process, testing, results, conclusions and future directions;
6. Preparing a paper for Conference presentation/Publication in Journals, if possible;
7. Preparing a Dissertation in the standard format for being evaluated by the Department;
8. Final Seminar Presentation before a Departmental Committee.

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Appendix – I

Professional Electives

Professional Elective I

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Subject Code</th>
<th>Subject</th>
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<tbody>
<tr>
<td>1</td>
<td>MTPE-601</td>
<td>Optimization Techniques</td>
</tr>
<tr>
<td>2</td>
<td>MTPE-602</td>
<td>Operation Research</td>
</tr>
<tr>
<td>3</td>
<td>MTPE-603</td>
<td>Total Quality Management</td>
</tr>
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Professional Elective II

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<tr>
<th>S. No.</th>
<th>Subject Code</th>
<th>Subject</th>
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<tbody>
<tr>
<td>1</td>
<td>MTPE-701</td>
<td>Product Development</td>
</tr>
<tr>
<td>2</td>
<td>MTPE-702</td>
<td>Rapid Prototyping</td>
</tr>
<tr>
<td>3</td>
<td>MTPE-703</td>
<td>Machine Learning</td>
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</table>
Course Objective: The main objective of the course is to formulate mathematical models and to understand solution methods for real life optimal decision problems. The emphasis will be on basic study of linear programming problem, Integer programming problem, Transportation problem, two person zero sum games with economic applications and project management techniques using PERT and CPM.

Course Content:

Module I: Scope of Operations Research: Introduction to linear and non-linear programming formulation of different models.

Module II: Linear Programming: Geometry of linear programming, Graphical method, Linear programming (LP) in standard form, Solution of LP by simplex method, Exceptional cases in LP, Duality theory, Dual simplex method, Sensitivity analysis.

Integer Programming: Branch and bound technique.

Module III: Transportation and Assignment Problem: Initial basic feasible solutions of balanced and unbalanced transportation/assignment problems, optimal solutions.

Module IV: Project Management: Construction of networks, Network computations, Floats (free floats and total floats), Critical path method (CPM), Crashing.

Module V: Game Theory: Two persons zero-sum game, Game with mixed strategies, Graphical method and solution by linear programming.

Text/References Books:
5. Swarup, K., Gupta, P. K., Mammohan, Operations Research, Sultan Chand & Sons,

**Course Outcomes:** Upon Completion of this course the students will be able:
1. To Formulate and solve linear programming problems.
2. To solve the transportation and assignment problems

<table>
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<tr>
<th>Course Code</th>
<th>MTPE-602</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>Operations Research</td>
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<tr>
<td>Number of Credits</td>
<td>3 (L: 3, T: 0, P: 0)</td>
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<tr>
<td>Course Category</td>
<td>MTPE</td>
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**Course Objective:** This course aims at familiarizing the students with quantitative tools and techniques, which are frequently applied to business decision-making & to provide a formal quantitative approach to problem solving and an intuition about situations where such an approach is appropriate.

**Course Content:**

**MODULE I:** Introduction to Operations research- Scope, applications of operations research, phases and models of operations research, advantages and limitations of operations research. Linear programming problem (LPP)- formulation of linear programming problem (LPP), graphical method of solution, simplex method, artificial variable technique- Big M method and two phase method, duality in LPP, sensitivity analysis.

**MODULE II:** Transportation Problem (TP)-Mathematical formulation of TP, methods to obtain initial basic feasible solution, TP without degeneracy and TP with degeneracy. Assignment Problem (AP) - Mathematical formulation of AP, comparison with TP, variations of AP, Traveling salesman problem. Sequencing Problem- Assumptions in sequencing problem, processing of n jobs through two machines, processing of n jobs through three machines, and processing of n jobs through m machines.

**MODULE III:** Replacement models- Introduction, replacement of items that deteriorates-replacement of items whose maintenance and repair cost increases with time, ignoring money value and - replacement of items whose maintenance and repair cost increases with time, considering money value, replacement of items that fail suddenly- group replacement.
Queuing model- Kendall’s notation for representing queuing models, single channel Poisson arrivals with exponential service times, infinite population.

**MODULE IV: Games theory**- Minimax (Maximin) criterion for optimality, characteristics of games, dominance principles, 2X2 game arithmetic and algebraic method, 2Xn and mX2 game-graphical method and method of subgames, 3X3 game- method of matrices, iteration method and applications of games theory.

**MODULE V: Inventory models**- Need and types of inventory, inventory associated costs, Economic order quantity, Classical EOQ inventory model with uniform demand rate and infinite replenishment. EOQ model with multiple price breaks. Simulation- Monte Carlo simulation, advantages and limitations of simulation, applications of simulations.

**MODULE VI: Network analysis**- Network construction, identification of critical path, various types of floats and their computations, Programme Evaluation and Review Technique (PERT) time calculations, crashing of network, resource scheduling, network updating.

**Text Books:**

**References:**

**Alternative NPTEL/SWAYAM Course:**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
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</table>

**Course Outcomes:** After completion of this course, the students will be able
1. To Illustrate the need to optimally utilize the resources in various types of industries.
2. To Apply and analyze mathematical optimization techniques to various applications.
3. To Demonstrate cost effective strategies in various applications in industry.
Course Code: MTPE-603
Course Title: Total Quality Management
Number of Credits: 3 (L: 3, T: 0, P: 0)
Course Category: MTPE

Course Objective: To learn about
1. Total customer satisfaction
2. Totality of functions
3. Total range of products and services
4. Addressing all aspects of dimensions of quality
5. Addressing the quality aspect in everything – products, services, processes, people, resources and interactions.
6. Satisfying all customers – internal as well as external
7. Addressing the total organizational issue of retaining customers and
8. Improving profits, as well as generating new business for the future.
9. Involving everyone in the organization in the attainment of the said objective.
10. Demanding total commitment from all in the organization towards the achievement of the objective

Course Content:

MODULE I: Introduction to Quality Management

MODULE II: Principles and Philosophies of Quality Management

MODULE III: Statistical Process Control and Process Capability
Meaning and significance of statistical process control (SPC) – construction of control charts for variables and attributed.
Process capability – meaning, significance and measurement – Six sigma concepts of process capability.
MODULE IV: Tools and Techniques for Quality Management
Quality functions development (QFD) – Benefits, Voice of customer, information organization, House of quality (HOQ), building a HOQ, QFD process. Failure mode effect analysis (FMEA) – requirements of reliability, failure rate, FMEA stages, design, process and documentation. Seven old (statistical) tools. Seven new management tools. Bench marking and POKA YOKE.

MODULE V: Quality Systems Organizing and Implementation

Text Books:

Course Outcomes: After completion of this course, the students will be able
1. To Evaluate the principles of quality management and to explain how these principles can be applied within quality management systems.
2. To Identify the key aspects of the quality improvement cycle and to select and use appropriate tools and techniques for controlling, improving and measuring quality.
3. To Critically appraise the organizational, communication and teamwork requirements for effective quality management.
4. To Critically analyse the strategic issues in quality management, including current issues and developments, and to devise and evaluate quality implementation plans.

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Professional Elective II

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Subject Code</th>
<th>Subject</th>
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<tbody>
<tr>
<td>1</td>
<td>MTPE-701</td>
<td>Product Development</td>
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<tr>
<td>2</td>
<td>MTPE-702</td>
<td>Rapid Prototyping</td>
</tr>
<tr>
<td>3</td>
<td>MTPE-703</td>
<td>Machine Learning</td>
</tr>
</tbody>
</table>

Course Code: MTPE-701
Course Title: Product Development
Number of Credits: 3 (L: 3, T: 0, P: 0)
Course Category: MTPE

Course Objective: This course aims at introducing the students to the basic concepts of engineering design and product development with focus on the front end processes. At the end of this course the student is expected to demonstrate an understanding of the overview of all the product development processes and knowledge of concept generation and selection tools.

Course Content:

MODULE I: Need for developing products – the importance of engineering design – types of design – the design process – relevance of product lifecycle issues in design – designing to codes and standards – societal considerations in engineering design – generic product development process – various phases of product development – planning for products – establishing markets – market segments – relevance of market research.


Text Books/References:

Course Outcomes: After completion of this course, the students will be able
1. To analyze the product design and development processes in manufacturing industry.
2. To understand the components and their functions of product design and development processes and their relationships from concept to customer over whole product lifecycle.
3. To evaluate the methodologies for product design, development and management.
4. To illustrate product development to satisfy customer needs.
5. To Carry out cost and benefit analysis through various cost models.
6. To outline design protection and Intellectual Property.

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<tr>
<th>Course Code</th>
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<tr>
<td>Course Title</td>
<td>Rapid Prototyping</td>
</tr>
<tr>
<td>Number of Credits</td>
<td>3 (L: 3, T: 0, P: 0)</td>
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<td>Course Category</td>
<td>MTPE</td>
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Course Objective: Generating a good understanding of RP history, its development and applications. To expose the students to different types of Rapid prototyping processes, materials used in RP systems and reverse engineering.

Course Content:

MODULE I: Introduction
Other translators – medical applications of RP – On demand manufacturing – Direct material deposition – Shape Deposition Manufacturing.

**MODULE II: Liquid Based and Solid Based Rapid Prototyping Systems**
Classification – Liquid based system – Stereo Lithography Apparatus (SLA), details of SL process, products, Advantages, Limitations, Applications and Uses. Solid based system – Fused Deposition Modelling, principle, process, products, advantages, applications and uses – Laminated Object Manufacturing

**MODULE III: Powder Based Rapid Prototyping Systems**

**Text Books:**

**References:**

**Alternative NPTEL/SWAYAM Course:**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>NPTEL Course Name</th>
<th>Instructor</th>
<th>Host Institute</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Rapid Manufacturing</td>
<td>Prof. Janakranjan Ramkumar</td>
<td>IIT Kanpur</td>
</tr>
</tbody>
</table>

**Course Outcomes:** At the end of course, student will have knowledge on different types of Rapid Prototyping systems and its applications in various fields.
Course Code : MTPE-703
Course Title : Machine Learning
Number of Credits : 3 (L: 3, T: 0, P: 0)
Course Category : MTPE

Course Objective:
1. To introduce students to the basic concepts and techniques of Machine Learning.
2. To have a thorough understanding of the Supervised and Unsupervised learning techniques.
3. To study the various probability based learning techniques
4. To understand graphical models of machine learning algorithms

Course Contents:

MODULE I: Introduction

MODULE II: Linear Models

MODULE III: Tree and Probabilistic Models

MODULE IV: Dimensionality Reduction and Evolutionary Models

**MODULE V: Graphical Models**

**Text Books:**

**References:**

**Course Outcomes:** Upon completion of the course, the students will be able:
1. To Distinguish between, supervised, unsupervised and semi-supervised learning
2. To Apply the apt machine learning strategy for any given problem
3. To classify supervised, unsupervised or semi-supervised learning algorithms for any given problem.
4. To Design systems that uses the appropriate graph models of machine learning.
5. To Modify existing machine learning algorithms to improve classification efficiency.

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Appendix – II

Open Electives

Open Elective I

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<tr>
<th>S. No.</th>
<th>Subject Code</th>
<th>Subject</th>
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<tbody>
<tr>
<td>1</td>
<td>MTOE-801</td>
<td>Virtual and Augmented Reality</td>
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<tr>
<td>2</td>
<td>MTOE-802</td>
<td>Image Processing and Computer Vision</td>
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<tr>
<td>3</td>
<td>MTOE-803</td>
<td>Wireless Network &amp; Communication</td>
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Open Elective II

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<tr>
<td>1</td>
<td>MTOE-804</td>
<td>Artificial Intelligence</td>
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<tr>
<td>2</td>
<td>MTOE-805</td>
<td>Real Time System</td>
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<tr>
<td>3</td>
<td>MTOE-806</td>
<td>Artificial Neural Network</td>
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Open Elective I

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<th>S. No.</th>
<th>Subject Code</th>
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<tr>
<td>1</td>
<td>MTOE-801</td>
<td>Virtual and Augmented Reality</td>
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<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>Virtual and Augmented Reality</td>
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<tr>
<td>Number of Credits</td>
<td>3 (L: 3, T: 0, P: 0)</td>
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<tr>
<td>Course Category</td>
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**Course Objective:** To understand the basic concepts of Augmented and Virtual Reality. The student must be able to apply the various concepts of Augmented and Virtual Reality in other application areas.

**Course Content:**

**Introduction of Virtual Reality:** Fundamental concept and components of Virtual Reality, primary features and present development on Virtual Reality.

**Multiple Models 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.

**Visual Computation in Virtual Reality:** Fundamentals of computer graphics, software and hardware technology on stereoscopic display, advanced techniques in CG: Management of large scale environments & real time rendering.

**Environment Modelling in Virtual Reality:** Geometric Modelling, Behavior Simulation, Physically Based Simulation.

**Interactive Techniques in Virtual Reality:** Body Track, Hand Gesture, 3D Menus, Object Grasp.

**Introduction of Augmented Reality (AR):** System structure of Augmented Reality, key technology in AR.

**Development Tools and Frameworks in Virtual Reality:** Frameworks of software development tools in VR, X3D Standard, Vega, MultiGen, Virtools etc.

**Mixed Reality:** Augmented reality methods, visualization techniques for augmented reality, wireless displays in educational augmented reality applications, mobile projection.
interfaces, marker-less tracking for augmented reality, enhancing interactivity in AR environments, evaluating AR systems.

**Application of VR in Digital Entertainment:** VR technology in film & TV production, VR technology in physical exercises and games, demonstration of digital entertainment by VR.

**Laboratory Work:** To implement various techniques studied during the course.

**Text Books:**

**References:**

**Course Outcomes:** After the completion of the course, the student will be able:
1. To Analyze the components of AR and VR systems, its current and upcoming trends, types, platforms, and devices.
2. To Assess technologies in the context of AR and VR systems design.
3. To Implement various techniques and algorithms used to solve complex computing problems in AR and VR systems.
4. To Develop interactive augmented reality applications for PC and Mobile based devices using a variety of input devices.
5. To Demonstrate the knowledge of the research literature in augmented reality for both compositing and interactive applications.

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<tr>
<th>Course Code</th>
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<tbody>
<tr>
<td>Course Title</td>
<td>Image Processing and Computer Vision</td>
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<tr>
<td>Number of Credits</td>
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<tr>
<td>Course Category</td>
<td>MTOE</td>
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**Course Objective:**
1. To review image processing techniques for computer vision.
2. To understand shape and region analysis.
3. To understand Hough Transform and its applications to detect lines, circles, ellipses.
4. To understand three-dimensional image analysis techniques.
5. To understand motion analysis.
6. To study some applications of computer vision algorithms.

Course Content:

**MODULE I: IMAGE PROCESSING FOUNDATIONS**

**MODULE II: SHAPES AND REGIONS**

**MODULE III: HOUGH TRANSFORM**

**MODULE IV: 3D VISION AND MOTION**

**MODULE V: APPLICATIONS**
Text Books/References:

Course Outcomes: Upon completion of the course, the students will be able:
1. To Implement fundamental image processing techniques required for computer vision.
2. To design shape analysis.
3. To Implement boundary tracking techniques.
4. To Apply chain codes and other region descriptors.
5. To Apply Hough Transform for line, circle, and ellipse detections.
6. To Apply 3D vision techniques.
7. To Implement motion related techniques.
8. To Develop applications using computer vision techniques.

Course Code : MTOE-803
Course Title : Wireless Network and Communication
Number of Credits : 3 (L: 3, T: 0, P: 0)
Course Category : MTOE

Course Objective:
- To study about Wireless networks, protocol stack and standards.
- To study about fundamentals of 3G Services, its protocols and applications.
- To study about evolution of 4G Networks, its architecture and applications.

Course Content:


Text Books:

Reference Books:

Course Outcomes: Upon completion of the course, the students will be able
- To explain 3G/4G and WiMAX networks and its architecture.
- To Design and implement wireless network environment for any application using latest wireless protocols and standards.
- To Implement different type of applications for smart phones and mobile devices with latest network strategies.
Open Elective II

<table>
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<tr>
<th>S. No.</th>
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<tbody>
<tr>
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<td>MTOE-805</td>
<td>Real Time System</td>
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<tr>
<td>3</td>
<td>MTOE-806</td>
<td>Artificial Neural Network</td>
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</tbody>
</table>

**Course Code**: MTOE-804
**Course Title**: Artificial Intelligence
**Number of Credits**: 3 (L: 3, T: 0, P: 0)
**Course Category**: MTOE

**Course Objective**: The student should be made to:
- Study the concepts of Artificial Intelligence.
- Learn the methods of solving problems using Artificial Intelligence.
- Introduce the concepts of Expert Systems and machine learning.

**Course Content**:

**MODULE I: Introduction to AI and Production Systems**
Introduction to AI-Problem formulation, Problem Definition -Production systems, Control strategies, Search strategies. Problem characteristics, Production system characteristics - Specialized productions system- Problem solving methods – Problem graphs, Matching, Indexing and Heuristic functions -Hill Climbing-Depth first and Breath first, Constraints satisfaction – Related algorithms, Measure of performance and analysis of search algorithms.

**MODULE II: Representation of Knowledge**
Game playing – Knowledge representation, Knowledge representation using Predicate logic, Introduction to predicate calculus, Resolution, Use of predicate calculus, Knowledge representation using other Logic-Structured representation of knowledge.

**MODULE III: Knowledge Inference**
Knowledge representation -Production based system, Frame based system. Inference – Backward chaining, forward chaining, Rule value approach, Fuzzy reasoning – Certainty factors, Bayesian Theory-Bayesian Network-Dempster – Shafer theory.

**MODULE IV: Planning and Machine Learning**
MODULE V: Expert Systems

Text Books:

References:
5. http://nptel.ac.in

Course Outcomes: At the end of the course, the student should be able:
● To Identify problems that are amenable to solution by AI methods.
● To identify AI methods to solve a given problem.
● To illustrate problem in the language/framework of different AI methods.
● To Implement basic AI algorithms.
● To Design and carry out an empirical evaluation of different algorithms on a problem formalization, and state the conclusions that the evaluation supports.

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<td>Course Title</td>
<td>Real Time System</td>
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<tr>
<td>Number of Credits</td>
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<tr>
<td>Course Category</td>
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Course Objective: To study the basic of tasks and scheduling
● To understand programming languages and databases.
● To analyze real time communication.
● To analyze evaluation techniques and reliability models for Hardware Redundancy.
● To understand clock synchronization.
Course Content:


**MODULE II - Uni and Multi-Processor Scheduling:** Uniprocessor scheduling of IRIS tasks, Task assignment, Utilization balancing – Next fit- Bin packing- Myopic off-line - Focused addressing and bidding- Buddy strategy- Fault Tolerant Scheduling. -Aperiodic scheduling - Spring algorithm, Horn algorithm- Bratley. - Sporadic scheduling.

**MODULE III - Real Time Communication:** Introduction - VTCSMA – PB CSMA- Deterministic collision resolution protocol- DCR for multi packet messages- dynamic planning based- Communication with periodic and aperiodic messages.

**MODULE IV - Real Time Databases:** Basic Definition, Real time Vs General purpose databases, Main Memory Databases, Transaction priorities, Transaction Aborts, Concurrency control issues, Disk Scheduling Algorithms, Two-phase Approach to improve Predictability, Maintaining Serialization Consistency, Databases for Hard Real Time System.

**MODULE V - Real-Time Modelling and Case Studies:** Petri nets and applications in real-time modelling, Air traffic controller system – Distributed air defence system.

**Text Books:**

**References:**

**Alternative NPTEL/SWAYAM Course:**

<table>
<thead>
<tr>
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<th>Instructor</th>
<th>Host Institute</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Real Time Systems</td>
<td>Prof. Rajib Mall</td>
<td>IIT Kharagpur</td>
</tr>
</tbody>
</table>

**Course Outcomes:**
1. To understand advanced concepts in theory of computer science;  
2. To understand advanced concepts in applications of computer science;
3. To apply knowledge of advanced computer science to formulate the problems in computing and solve them;
4. To learn emerging concepts in theory and applications of computer science;
5. To design and conduct experiments as well as to analyze and interpret data;

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<tr>
<td>Course Title</td>
<td>Artificial Neural Network</td>
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<td>Number of Credits</td>
<td>3 (L: 3, T: 0, P: 0)</td>
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<tr>
<td>Course Category</td>
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Course Objective:
1. To understand the biological neural network and to model equivalent neuron models.
2. To understand the architecture, learning algorithms and issues of various feed forward and feedback neural networks.

Course Content:

MODULE – I
Introduction: A Neural Network, Human Brain, Models of a Neuron, Neural Networks viewed as Directed Graphs, Network Architectures, Knowledge Representation, Artificial Intelligence and Neural Networks Learning Process: Error Correction Learning, Memory Based Learning, Hebbian Learning, Competitive, Boltzmann Learning, Credit Assignment Problem, Memory, Adaption, Statistical Nature of the Learning Process

MODULE – II

MODULE – III
MODULE – IV
Introduction to Deep Learning, Deep Feed Forward network, regularizations, training deep models, dropouts, Convolutional Neural Network, Recurrent Neural Network, Deep Belief Network

Text Books:

References:
1. Artificial Neural Networks – B. Yegnanarayana Prentice Hall of India P Ltd 2005
2. Neural Networks in Computer Intelligence, Li Min Fu TMH 2003

Course Outcomes:
1. To Create different neural networks of various architectures both feed forward and feed backward.
2. To Perform the training of neural networks using various learning rules.
3. To Perform the testing of neural networks and do the analysis of these networks for various pattern recognition applications.

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Appendix – III

A Guide to Induction Program
Appendix – III: A Guide to Induction Program

1. Introduction

(Induction Program was discussed and approved for all colleges by AICTE in March 2017. It was discussed and accepted by the Council of IITs for all IITs in August 2016. It was originally proposed by a Committee of IIT Directors and accepted at the meeting of all IIT Directors in March 2016. This guide has been prepared based on the Report of the Committee of IIT Directors and the experience gained through its pilot implementation in July 2016 as accepted by the Council of IITs. Purpose of this document is to help institutions in understanding the spirit of the accepted Induction Program and implementing it.)

Engineering colleges were established to train graduates well in the branch/department of admission, have a holistic outlook, and have a desire to work for national needs and beyond.

The graduating student must have knowledge and skills in the area of his study. However, he must also have broad understanding of society and relationships. Character needs to be nurtured as an essential quality by which he would understand and fulfill his responsibility as an engineer, a citizen and a human being. Besides the above, several meta-skills and underlying values are needed.

There is a mad rush for engineering today, without the student determining for himself his interests and his goals. This is a major factor in the current state of demotivation towards studies that exists among UG students.

The success of gaining admission into a desired institution but failure in getting the desired branch, with peer pressure generating its own problems, leads to a peer environment that is demotivating and corrosive. Start of hostel life without close parental supervision at the same time, further worsens it with also a poor daily routine.

To come out of this situation, a multi-pronged approach is needed. One will have to work closely with the newly joined students in making them feel comfortable, allow them to explore their academic interests and activities, reduce competition and make them work for excellence, promote bonding within them, build relations between teachers and students, give a broader view of life, and build character.

\[1\] A Committee of IIT Directors was setup in the 152nd Meeting of IIT Directors on 6th September 2015 at IIT Patna, on how to motivate undergraduate students at IITs towards studies, and to develop verbal ability. The Committee submitted its report on 19th January 2016. It was considered at the 153rd Meeting of all IIT Directors at IIT Mandi on 26 March 2016, and the accepted report came out on 31 March 2016. The Induction Program was an important recommendation, and its pilot was implemented by three IITs, namely, IIT(BHU), IIT Mandi and IIT Patna in July 2016. At the 50th meeting of the Council of IITs on 23 August 2016, recommendation on the Induction Program and the report of its pilot implementation were discussed and the program was accepted for all IITs.
2. Induction Program
When new students enter an institution, they come with diverse thoughts, backgrounds and preparations. It is important to help them adjust to the new environment and inculcate in them the ethos of the institution with a sense of larger purpose. Precious little is done by most of the institutions, except for an orientation program lasting a couple of days.

We propose a 3-week long induction program for the UG students entering the institution, right at the start. Normal classes start only after the induction program is over. Its purpose is to make the students feel comfortable in their new environment, open them up, set a healthy daily routine, create bonding in the batch as well as between faculty and students, develop awareness, sensitivity and understanding of the self, people around them, society at large, and nature.2

The time during the Induction Program is also used to rectify some critical lacunas, for example, English background, for those students who have deficiency in it.

The following are the activities under the induction program in which the student would be fully engaged throughout the day for the entire duration of the program.

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2Induction Program as described here borrows from three programs running earlier at different institutions: (1) Foundation Program running at IIT Gandhinagar since July 2011, (2) Human Values course running at IIIT Hyderabad since July 2005, and (3) Counselling Service or mentorship running at several IITs for many decades. Contribution of each one is described next.

IIT Gandhinagar was the first IIT to recognize and implement a special 5-week Foundation Program for the incoming 1st year UG students. It took a bold step that the normal classes would start only after the five week period. It involved activities such as games, art, etc., and also science and other creative workshops and lectures by resource persons from outside.

IIIT Hyderabad was the first one to implement a compulsory course on Human Values. Under it, classes were held by faculty through discussions in small groups of students, rather than in lecture mode. Moreover, faculty from all departments got involved in conducting the group discussions under the course. The content is non-sectarian, and the mode is dialogical rather than sermonising or lecturing. Faculty were trained beforehand, to conduct these discussions and to guide students on issues of life.

Counselling at some of the IITs involves setting up mentor-mentee network under which 1st year students would be divided into small groups, each assigned a senior student as a student guide, and a faculty member as a mentor. Thus, a new student gets connected to a faculty member as well as a senior student, to whom he/she could go to in case of any difficulty whether psychological, financial, academic, or otherwise. The Induction Program defined here amalgamates all the three into an integrated whole, which leads to its high effectiveness in terms of building physical activity, creativity, bonding, and character. It develops sensitivity towards self and one’s relationships, builds awareness about others and society beyond the individual, and also in bonding with their own batch-mates and a senior student besides a faculty member.

Scaling up the above amalgamation to an intake batch of 1000 plus students was done at IIT(BHU), Varanasi starting from July 2016.
2.1. Physical Activity
This would involve a daily routine of physical activity with games and sports. It would start with all students coming to the field at 6 am for light physical exercise or yoga. There would also be games in the evening or at other suitable times according to the local climate. These would help develop team work. Each student should pick one game and learn it for three weeks. There could also be gardening or other suitably designed activity where labour yields fruits from nature.

2.2. Creative Arts
Every student would choose one skill related to the arts whether visual arts or performing arts. Examples are painting, sculpture, pottery, music, dance etc. The student would pursue it every day for the duration of the program. These would allow for creative expression. It would develop a sense of aesthetics and also enhance creativity which would, hopefully, flow into engineering design later.

2.3. Universal Human Values
It gets the student to explore oneself and allows one to experience the joy of learning, stand up to peer pressure, take decisions with courage, be aware of relationships with colleagues and supporting staff in the hostel and department, be sensitive to others, etc. Need for character building has been underlined earlier. A Module in Universal Human Values provides the base.

Methodology of teaching this content is extremely important. It must not be through do’s and don’ts, but get students to explore and think by engaging them in a dialogue. It is best taught through group discussions and real life activities rather than lecturing. The role of group discussions, however, with clarity of thought of the teachers cannot be over emphasized. It is essential for giving exposure, guiding thoughts, and realizing values. The teachers must come from all the departments rather than only one department like HSS or from outside of the Institute. Experiments in this direction at IIT(BHU) are noteworthy and one can learn from them.3

Discussions would be conducted in small groups of about 20 students with a faculty mentor each. It is to open thinking towards the self. Universal Human Values discussions could even continue for rest of the semester as a normal course, and not stop with the induction program.

Besides drawing the attention of the student to larger issues of life, it would build relationships between teachers and students which last for their entire 4-year stay and possibly beyond.

3The Universal Human Values Course is a result of a long series of experiments at educational institutes starting from IIT-Delhi and IIT Kanpur in the 1980s and 1990s as an elective course, NIT Raipur in late 1990s as a compulsory one-week off campus program. The courses at IIT(BHU) which started from July 2014, are taken and developed from two compulsory courses at IIIT Hyderabad first introduced in July 2005.
2.4. Literary
Literary activity would encompass reading, writing and possibly, debating, enacting a play etc.

2.5. Proficiency Modules
This period can be used to overcome some critical lacunas that students might have, for example, English, computer familiarity etc. These should run like crash courses, so that when normal courses start after the induction program, the student has overcome the lacunas substantially. We hope that problems arising due to lack of English skills, wherein students start lagging behind or failing in several subjects, for no fault of theirs, would, hopefully, become a thing of the past.

2.6. Lectures by Eminent People
This period can be utilized for lectures by eminent people, say, once a week. It would give the students exposure to people who are socially active or in public life.

2.7. Visits to Local Area
A couple of visits to the landmarks of the city, or a hospital or orphanage could be organized. This would familiarize them with the area as well as expose them to the underprivileged.

2.8. Familiarization to Dept./Branch & Innovations
The students should be told about different method of study compared to coaching that is needed at IITs. They should be told about what getting into a branch or department means what role it plays in society, through its technology. They should also be shown the laboratories, workshops & other facilities.

3. Schedule
The activities during the Induction Program would have an Initial Phase, a Regular Phase and a Closing Phase. The Initial and Closing Phases would be two days each.

3.1. Initial Phase

<table>
<thead>
<tr>
<th>Day</th>
<th>Time</th>
<th>Activity</th>
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<tbody>
<tr>
<td>Day 0</td>
<td>Whole Day</td>
<td>Students Arrive – Hostel Allotment (Preferably do pre-allotment)</td>
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<tr>
<td>Day 1</td>
<td>09:00 AM – 03:00 PM</td>
<td>Academic Registration</td>
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<td>04:30 PM – 06:00 PM</td>
<td>Orientation</td>
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<tr>
<td>Day 2</td>
<td>09:00 AM – 10:00 AM</td>
<td>Diagnostic test (for English etc.)</td>
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<td>10:00 AM – 12:25 PM</td>
<td>Visit to respective depts.</td>
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<td>03:00 PM – 03:30 PM</td>
<td>Interaction with parents</td>
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<td></td>
<td>03:30 PM – 05:00 PM</td>
<td>Mentor-Mentee Groups - Introduction within group. (Same as Universal Human Values Group)</td>
</tr>
</tbody>
</table>
3.2. Regular Phase
After two days is the start of the Regular Phase of Induction. With this phase there would be regular program to be followed every day.

3.2.1. Daily Schedule
Some of the activities are on a daily basis, while some others are at specified periods within the Induction Program. We first show a typical daily timetable.

### DAY 3 Onwards

<table>
<thead>
<tr>
<th>Session</th>
<th>Time</th>
<th>Activity</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>06:00 AM</td>
<td>Wake up Call</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>06:30 AM – 07:10 AM</td>
<td>Physical Activity (Mild Exercise / Yoga)</td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>07:15 AM – 08:55 AM</td>
<td>Bath, Breakfast etc.</td>
<td></td>
</tr>
<tr>
<td>II</td>
<td>09:10 AM – 10:55 AM</td>
<td>Creative Arts / Universal Human Values</td>
<td>Half the groups do creative arts</td>
</tr>
<tr>
<td>III</td>
<td>11:00 AM – 12:55 PM</td>
<td>Creative Arts / Universal Human Values</td>
<td>Complementary Alternate Groups</td>
</tr>
<tr>
<td></td>
<td>01:00 PM – 02:25 PM</td>
<td>Lunch</td>
<td></td>
</tr>
<tr>
<td>IV</td>
<td>02:30 PM – 03:55 PM</td>
<td>Afternoon Session</td>
<td>See below</td>
</tr>
<tr>
<td>V</td>
<td>04:00 PM – 05:00 PM</td>
<td>Afternoon Session</td>
<td>See below</td>
</tr>
<tr>
<td>V</td>
<td>05:00 PM – 05:25 PM</td>
<td>Break / Light Tea</td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>05:30 PM – 06:45 PM</td>
<td>Games / Special Lectures</td>
<td></td>
</tr>
<tr>
<td>VI</td>
<td>06:50 PM – 08:25 PM</td>
<td>Rest and Dinner</td>
<td></td>
</tr>
<tr>
<td>VII</td>
<td>08:30 PM – 09:25 PM</td>
<td>Informal Interactions (In hostels)</td>
<td></td>
</tr>
</tbody>
</table>

Sundays are off. Saturdays have the same schedule as above or have outings.

3.2.2. Afternoon Activities (Non-Daily)
The following five activities are scheduled at different times of the Induction Program, and are not held daily for everyone:

1. Familiarization to Dept./Branch & Innovations
2. Visits to Local Area
3. Lectures by Eminent People
4. Literary
5. Proficiency Modules

Here is the approximate activity schedule for the afternoons (may be changed to suit local needs):

<table>
<thead>
<tr>
<th>Session</th>
<th>Activity</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>IV</td>
<td>Familiarization with Dept./Branch &amp; Innovations</td>
<td>For 3 Days (Day 3 to Day 5)</td>
</tr>
<tr>
<td>IV, V and VI</td>
<td>Visit to Local Area</td>
<td>For 3 Days – interspersed (e.g. Saturdays)</td>
</tr>
</tbody>
</table>
### 3.3. Closing Phase

<table>
<thead>
<tr>
<th>Day</th>
<th>Time</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Last But One Day</td>
<td>08:30 AM – 12:00 PM</td>
<td>Discussions and finalization of presentation within each group</td>
</tr>
<tr>
<td></td>
<td>02:00 AM - 05:00 PM</td>
<td>Presentation by each group in front of 4 other groups besides their own (about 100 students)</td>
</tr>
<tr>
<td>Last Day</td>
<td>Whole Day</td>
<td>Examinations (if any). May be extended to last 2 days, in case needed.</td>
</tr>
</tbody>
</table>

### 3.4. Follow Up after Closure

A question comes up as to what would be the follow up program after the formal 3-week Induction Program is over? The groups which are formed should function as mentor-mentee network. A student should feel free to approach his faculty mentor or the student guide, when facing any kind of problem, whether academic or financial or psychological etc. (For every 10 undergraduate first year students, there would be a senior student as a student guide, and for every 20 students, there would be a faculty mentor.) Such a group should remain for the entire 4-5-year duration of the stay of the student. Therefore, it would be good to have groups with the students as well as teachers from the same department/discipline.\(^4\)

Here we list some important suggestions which have come up and which have been experimented with:

#### 3.4.1. Follow Up after Closure – Same Semester

It is suggested that the groups meet with their faculty mentors once a month, within the semester after the 3-week Induction Program is over. This should be a scheduled meeting shown in the timetable. (The groups are of course free to meet together on their own more often, for the student groups to be invited to their faculty mentor’s home for dinner or tea, nature walk, etc.)

#### 3.4.2. Follow Up – Subsequent Semesters

It is extremely important that continuity be maintained in subsequent semesters. It is suggested that at the start of the subsequent semesters (up to fourth semester), three days be set aside for three full days of activities related to follow up to Induction Program. The students be shown inspiring films, do collective art work, and group discussions be conducted. Subsequently, the groups should meet at least once a month.
4. Summary
Engineering institutions were set up to generate well trained manpower in engineering with a feeling of responsibility towards oneself, one’s family, and society. The incoming undergraduate students are driven by their parents and society to join engineering without understanding their own interests and talents. As a result, most students fail to link up with the goals of their own institution.

The graduating student must have values as a human being, and knowledge and meta-skills related to his/her profession as an engineer and as a citizen. Most students who get demotivated to study engineering or their branch, also lose interest in learning.

The Induction Program is designed to make the newly joined students feel comfortable, sensitize them towards exploring their academic interests and activities, reducing competition and making them work for excellence, promote bonding within them, build relations between teachers and students, give a broader view of life, and building of character.

The Universal Human Values component, which acts as an anchor, develops awareness and sensitivity, feeling of equality, compassion and oneness, draw attention to society and nature, and character to follow through. It also makes them reflect on their relationship with their families and extended family in the college (with hostel staff and others). It also connects students with each other and with teachers so that they can share any difficulty they might be facing and seek help.

References:
31 March 2016, IIT Directors’ Secretariat, IIT Delhi.

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