Model Curriculum for UG Degree Course in Robotics and Artificial Intelligence Engineering (Engineering & Technology) 2023

ALL INDIA COUNCIL FOR TECHNICAL EDUCATION
Nelson Mandela Marg, Vasant Kunj, New Delhi 110070
www.aicte-india.org
Model Curriculum for
UG Degree Course
in
Robotics and Artificial Intelligence Engineering
(Engineering & Technology)
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 Robotics and Artificial Intelligence 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 165 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 Dr. Bharat Kumar B Ahuja, Dr Shantipal S Ohol, Dr Arockia Selvakumar Arockia Doss, Dr. Rajesh Kumar, Dr. Sukhdeep Singh Dhami, Dr Hargovind Bansal and other committee members. 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 160 credits.

(Prof. T. G. Sitharam)
Chairman
All India Council for Technical Education
PREFACE

Taking cognizance 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 Robotics and Artificial Intelligence 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 Robotics and Artificial Intelligence Engineering 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.
- Introduction of Design Thinking and Universal Human Value course.

I gratefully acknowledge the time and efforts of the members of the working group Dr. Bharat Kumar B Ahuja, Dr Shantipal S Ohol, Dr. Arockia Selvakumar Arockia Doss, Dr. Rajesh Kumar, Dr. Sukhdeep Singh Dhami, Dr Hargovind Bansal and other committee members.

Special thanks to Prof. Prof. T. G. Sitharam, Chairman; Dr. Abhay Jere, 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. Naveen Arora, Assistant Director (P&AP); Dr. Anil Sharma, Assistant Director (P&AP), Mr. Rakesh Kumar Pandit, Young Professional (P&AP); Ms. Nishtha Sehgal, IT Consultant and other office staff of AICTE.

(Dr. Ramesh Unnikrishnan)
Advisor – II (P&AP)
## Committee for Model Curriculum

<table>
<thead>
<tr>
<th>S.No</th>
<th>Name</th>
<th>Designation &amp; Organization</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dr Bharat Kumar B Ahuja (Chairman)</td>
<td>Professor &amp; Director, Department of Production Engineering &amp; Industrial Management, College of Engineering, Pune</td>
</tr>
<tr>
<td>2</td>
<td>Dr Shantipal S Ohol</td>
<td>Associate Professor in Mechanical Engineering, College of Engineering, Pune</td>
</tr>
<tr>
<td>3</td>
<td>Dr. Arockia Selvakumar Arockia Doss</td>
<td>Senior Associate Professor, School Of Mechanical And Building Sciences, VIT University, Chennai, India</td>
</tr>
<tr>
<td>4</td>
<td>Dr. Rajesh Kumar</td>
<td>Professor, Dept. of Electrical Engineering, MNIT Jaipur</td>
</tr>
<tr>
<td>5</td>
<td>Dr. Sukhdeep Singh Dhami</td>
<td>Professor, Dept. of Mechanical Engineering, NITTTR Chandigarh</td>
</tr>
<tr>
<td>6</td>
<td>Dr Hargovind Bansal</td>
<td>Senior Lead Engineer, Qualcomm India Pvt Limited</td>
</tr>
</tbody>
</table>
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<th>To</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>General Course Structure &amp; Theme</td>
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<td>10</td>
</tr>
<tr>
<td>2</td>
<td>Semester Wise Structure</td>
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<td>3</td>
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<td>43</td>
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<td>4</td>
<td>Semester II</td>
<td>44</td>
<td>69</td>
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<td>Semester III</td>
<td>70</td>
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<td>Semester V</td>
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<td>Semester VI</td>
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<td>Semester VII</td>
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<td>11</td>
<td>Appendix 1- <strong>A Guide to Induction Program</strong></td>
<td>208</td>
<td>217</td>
</tr>
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</table>
GENERAL COURSE STRUCTURE
& CREDIT DISTRIBUTION
A. Definition of Credit:

<table>
<thead>
<tr>
<th>Category</th>
<th>Credit Breakup for R&amp;AI</th>
</tr>
</thead>
<tbody>
<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>
</tbody>
</table>

B. Range of Credits: In the light of the fact that a typical Model Four-year Under Graduate degree program in Engineering has about 160 credits, the total number of credits proposed for the four-year B. Tech/B.E. in Robotics and Artificial Intelligence Engineering (Engineering & Technology) is kept as 160.

C. Structure of UG Program in Robotics and Artificial Intelligence: The structure of UG program in Robotics and Artificial Intelligence Engineering 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>Credit Breakup for R&amp;AI</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Humanities and Social Sciences including Management courses</td>
<td>11*</td>
</tr>
<tr>
<td>2</td>
<td>Basic Science courses</td>
<td>26*</td>
</tr>
<tr>
<td>3</td>
<td>Engineering Science courses including workshop, drawing, basics of</td>
<td>21*</td>
</tr>
<tr>
<td></td>
<td>electrical/mechanical/computer etc.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Professional core courses</td>
<td>62*</td>
</tr>
<tr>
<td>5</td>
<td>Professional Elective courses relevant to chosen specialization/branch</td>
<td>4*</td>
</tr>
<tr>
<td>6</td>
<td>Open subjects – Electives from other technical and/or emerging subjects</td>
<td>4*</td>
</tr>
<tr>
<td>7</td>
<td>Project work, seminar and internship in industry or elsewhere</td>
<td>14*</td>
</tr>
<tr>
<td>8</td>
<td>Laboratory Courses</td>
<td>18*</td>
</tr>
<tr>
<td>9</td>
<td>Mandatory Courses (non-credit)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[Environmental Sciences, Induction Program, Indian Constitution,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Essence of Indian Knowledge Tradition]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td>160*</td>
</tr>
</tbody>
</table>

*Minor variation is allowed as per need of the respective disciplines.

**Professional Elective Courses (PEC):** Total 2 to be taken, one from each Elective Course Type, based on individual interest and project.

**Open Elective Courses (OEC):** Total 2 to be taken, one from each Elective Course Type, based on individual interest and project.

**TOTAL = 160 credits**
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>Lectures</td>
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<tr>
<td>T</td>
<td>Tutorials</td>
</tr>
<tr>
<td>P</td>
<td>Practicals</td>
</tr>
<tr>
<td>C</td>
<td>Credits</td>
</tr>
<tr>
<td>BSC</td>
<td>Basic Science Courses</td>
</tr>
<tr>
<td>ESC</td>
<td>Engineering Science Courses</td>
</tr>
<tr>
<td>HSMC</td>
<td>Humanities and Social Sciences including Management courses</td>
</tr>
<tr>
<td>PCC</td>
<td>Professional Core Courses</td>
</tr>
<tr>
<td>PEC</td>
<td>Professional Elective Courses</td>
</tr>
<tr>
<td>OEC</td>
<td>Open Elective Courses</td>
</tr>
<tr>
<td>LC</td>
<td>Laboratory Courses</td>
</tr>
<tr>
<td>MC</td>
<td>Mandatory Courses</td>
</tr>
</tbody>
</table>

- **Course level coding scheme**: Three-digit number (odd numbers are for the odd semester courses and even numbers are for even semester courses) used as suffix with the Course Code for identifying the level of the course. Digit at hundred’s place signifies the year in which course is offered. e.g.
  - 101, 102 ... etc. for first year.
  - 201, 202 .... Etc. for second year.
  - 301, 302 ... for third year.

- **Category-wise Courses**

**HUMANITIES & SOCIAL SCIENCES COURSES [HS] & MANAGEMENT COURSES**

(i) Number of Humanities & Social Science Courses: 6
(ii) Credits: 11

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Category</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Semester</th>
<th>Hours per week</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>HSMC</td>
<td>HSMC-101</td>
<td>English for Technical Writing</td>
<td>I</td>
<td>2 0 2</td>
<td>3</td>
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<tr>
<td>2</td>
<td>HSMC</td>
<td>HSMC-102</td>
<td>Universal Human Values – 2: Understanding Harmony And Ethical Human Conduct</td>
<td>II</td>
<td>3 0 0</td>
<td>3</td>
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<tr>
<td>3</td>
<td>HSMC</td>
<td>HSMC-103</td>
<td>Design Thinking</td>
<td>I</td>
<td>0 0 2</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>HSMC</td>
<td>HSMC-401</td>
<td>Innovation and Creativity</td>
<td>IV</td>
<td>1 0 0</td>
<td>1</td>
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<tr>
<td>5</td>
<td>HSMC</td>
<td>HSMC-601</td>
<td>Entrepreneurship</td>
<td>VI</td>
<td>1 0 0</td>
<td>1</td>
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<tr>
<td>6</td>
<td>HSMC</td>
<td>HSMC-701</td>
<td>Intellectual Property Rights</td>
<td>VII</td>
<td>2 0 0</td>
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**Total Credits**

<table>
<thead>
<tr>
<th></th>
<th>L</th>
<th>T</th>
<th>P</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>9</td>
<td>0</td>
<td>4</td>
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******
### BASIC SCIENCE COURSES [BSC] (Total 7)

<table>
<thead>
<tr>
<th>S.No</th>
<th>Category</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Semester</th>
<th>Hours per week</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>BSC-101</td>
<td>Physics- I</td>
<td>I</td>
<td>3 1 2</td>
<td>5</td>
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<tr>
<td>2</td>
<td>BSC</td>
<td>BSC-102</td>
<td>Maths-I (Linear Algebra and Univariate calculus)</td>
<td>I</td>
<td>3 1 0</td>
<td>4</td>
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<tr>
<td>3</td>
<td>BSC</td>
<td>BSC-103</td>
<td>Chemistry-I</td>
<td>II</td>
<td>3 1 0</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>BSC</td>
<td>BSC-104</td>
<td>Maths–II (Ordinary Differential Equations and Multivariate Calculus)</td>
<td>II</td>
<td>3 1 0</td>
<td>4</td>
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<tr>
<td>5</td>
<td>BSC</td>
<td>BSC-301</td>
<td>Vector Calculus and Partial Differential Equations</td>
<td>III</td>
<td>2 1 0</td>
<td>3</td>
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<tr>
<td>6</td>
<td>BSC</td>
<td>BSC-401</td>
<td>Probability &amp; Statistics</td>
<td>IV</td>
<td>2 1 0</td>
<td>3</td>
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<tr>
<td>7</td>
<td>BSC</td>
<td>BSC-402</td>
<td>Biology for Engineers &amp; Biomimetics</td>
<td>IV</td>
<td>2 1 0</td>
<td>3</td>
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<td></td>
<td>Total Credits</td>
<td></td>
<td>18 7 2</td>
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### ENGINEERING SCIENCE COURSES [ESC] (Total 7)

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<th>Category</th>
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<th>Hours per week</th>
<th>Credits</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>ESC</td>
<td>ESC-101</td>
<td>Basic Electrical Engineering</td>
<td>I</td>
<td>2 1 2</td>
<td>4</td>
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<tr>
<td>2</td>
<td>ESC</td>
<td>ESC-102</td>
<td>Engineering Graphics and Design</td>
<td>I</td>
<td>1 0 4</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>ESC</td>
<td>ESC-103</td>
<td>Programming for Problem Solving</td>
<td>II</td>
<td>3 0 4</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>ESC</td>
<td>ESC-104</td>
<td>Workshop: Manufacturing Practice</td>
<td>II</td>
<td>0 0 3</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>ESC</td>
<td>ESC-105</td>
<td>Workshop: Electronics and Computer</td>
<td>II</td>
<td>0 0 4</td>
<td>2</td>
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<tr>
<td>6</td>
<td>ESC</td>
<td>ESC-301</td>
<td>Fundamentals of Mechanical Engineering</td>
<td>III</td>
<td>2 0 0</td>
<td>2</td>
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<tr>
<td>7</td>
<td>ESC</td>
<td>ESC-302</td>
<td>Electrical Machines &amp; Drives</td>
<td>III</td>
<td>2 0 2</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Total Credits</td>
<td></td>
<td>11 1 18</td>
<td>21</td>
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## PROFESSIONAL CORE COURSES [PCC] (Total 26)

<table>
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<th>Category</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Hours per week</th>
<th>Credits</th>
</tr>
</thead>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>L</td>
<td>T</td>
</tr>
<tr>
<td>1</td>
<td>PCC</td>
<td>PCC RAI-301</td>
<td>Analog &amp; Digital Electronics</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>PCC</td>
<td>PCC RAI-302</td>
<td>Fundamentals of Materials Science &amp; Smart Materials</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>PCC</td>
<td>PCC RAI-303</td>
<td>Fundamentals of Robotics &amp; AI</td>
<td>3</td>
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<tr>
<td>4</td>
<td>PCC</td>
<td>PCC RAI-304</td>
<td>Wireless Networks</td>
<td>1</td>
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<tr>
<td>5</td>
<td>PCC</td>
<td>PCC RAI-401</td>
<td>Machine Learning</td>
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<td>6</td>
<td>PCC</td>
<td>PCC RAI-402</td>
<td>Sensors and Actuators for Robotics</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>PCC</td>
<td>PCC RAI-403</td>
<td>Microcontrollers and its Applications</td>
<td>2</td>
<td>0</td>
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<tr>
<td>8</td>
<td>PCC</td>
<td>PCC RAI-404</td>
<td>Signals and Systems</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>PCC</td>
<td>PCC RAI-405</td>
<td>Robot Safety and Maintenance</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>PCC</td>
<td>PCC RAI-501</td>
<td>Data Structures, Files and Algorithms</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>11</td>
<td>PCC</td>
<td>PCC RAI-502</td>
<td>Theory of Machines &amp; Machine Design</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>PCC</td>
<td>PCC RAI-503</td>
<td>Industrial Electronics and Power Convertors</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>13</td>
<td>PCC</td>
<td>PCC RAI-504</td>
<td>Advances in Robotics and Artificial Intelligence</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td>PCC</td>
<td>PCC RAI-505</td>
<td>Control Systems</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>PCC</td>
<td>PCC RAI-506</td>
<td>Hydraulic &amp; Pneumatic Drives for Robots</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>16</td>
<td>PCC</td>
<td>PCC RAI-601</td>
<td>Kinematics of Robotics</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>17</td>
<td>PCC</td>
<td>PCC RAI-602</td>
<td>Embedded Systems Design</td>
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<tr>
<td>18</td>
<td>PCC</td>
<td>PCC RAI-603</td>
<td>Data Science</td>
<td>2</td>
<td>1</td>
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<tr>
<td>19</td>
<td>PCC</td>
<td>PCC RAI-604</td>
<td>Dynamics and Trajectory Planning</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>20</td>
<td>PCC</td>
<td>PCC RAI-605</td>
<td>Robot Operating Systems</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>21</td>
<td>PCC</td>
<td>PCC RAI-606</td>
<td>Knowledge Engineering and Expert System</td>
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**Total Credits**: 55 3 8 62

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# PROFESSIONAL ELECTIVE COURSES [PEC]
(Total 2 to be taken, one from each Elective Course Type)

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<th>Hours per week</th>
<th>Credits</th>
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Total Credits 4 0 0 4

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ENGINEERING PROJECT (4 Stages)

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LABORATORY COURSES [LC] (Total 18)

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<td>Microcontrollers &amp; its Applications Laboratory</td>
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<td>LC RAI-403</td>
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### AUDIT COURSES [AU] (Total 4)

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<th>Credits</th>
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<td>2</td>
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<td>Intellectual Property Rights (Audit Course)</td>
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<tr>
<td>3</td>
<td>LLC</td>
<td>LLC RAI-701</td>
<td>Liberal Learning Course (Audit Course)</td>
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<tr>
<td>4</td>
<td>LCC</td>
<td>LLC RAI-801</td>
<td>Liberal Learning Course (Audit Course)</td>
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**Total credits:** 5 L 0 T 0 P 0

**TOTAL = 160 credits** | BSC = 18%, ESC = 13%, PCC = 39%, PEC+HSMC+OEC = 11%, PROJ = 9% || LC = 11%

******
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>
</tr>
</thead>
</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 for the students of each branch.
   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 Courses:
      (The weightage of Internal assessment is 40% and for End Semester Exam is 60%)
      The student has to obtain at least 40% marks individually both in internal assessment and end semester exams to pass.

   b. For Practical Courses:
      (The weightage of Internal assessment is 60% and for End Semester Exam is 40%)
      The student has to obtain at least 40% marks individually both in internal assessment and end semester exams to pass.

   c. For Summer 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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<tr>
<th>Range of Marks</th>
<th>Assigned Grade</th>
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<td>91-100</td>
<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>
</tr>
<tr>
<td>51-60</td>
<td>CC/C+</td>
</tr>
<tr>
<td>46-50</td>
<td>CD/C</td>
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<tr>
<td>40-45</td>
<td>DD/D</td>
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<tr>
<td>&lt; 40</td>
<td>FF/F (Fail due to less marks)</td>
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<tr>
<td>-</td>
<td>FR (Fail due to shortage of attendance and therefore, to repeat the course)</td>
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Semester wise Structure and Curriculum for UG Course in Robotics and Artificial Intelligence Engineering (Engineering & Technology)
### AICTE Model Curriculum for UG Degree Course in Robotics & Artificial Intelligence Engineering

#### SEMESTER- I

<table>
<thead>
<tr>
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#### SEMESTER- II

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<td>ESC-103</td>
<td>Programming for Problem Solving</td>
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<td>ESC-104</td>
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<td>BSC</td>
<td>BSC-402</td>
<td>Biology for Engineers &amp; Biomimetics</td>
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<td>Machine Learning</td>
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### SEMESTER-V

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<tr>
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<td>Data Structures, Files and Algorithms</td>
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<td>Theory of Machines &amp; Mechanism Laboratory</td>
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**Total Credits** | 14 | 2 | 12 | 22 |

### SEMESTER-VI

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**Total Credits** | 16 | 1 | 10 | 22 |
### AICTE Model Curriculum for UG Degree Course in Robotics & Artificial Intelligence Engineering

#### Sr. No. | Course Code | Course Specialization / Track | Elective Course -I
--- | --- | --- | ---
1 | PEC RAI-601 | Robotics | Mobile and Micro Robotics
2 | PEC RAI-602 | AI | Data Analytics
3 | PEC RAI-603 | Mechatronics | Intelligent Manufacturing
4 | PEC RAI-604 | Control Systems | Microcontrollers Architecture and Programming

#### SEMESTER-VII

<table>
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<tr>
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<td>Smart Manufacturing</td>
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**Total Credits**: 13 0 12 18

#### Sr. No. | Course Code | Course Specialization/Track | Elective Course -II
--- | --- | --- | ---
1 | OEC RAI-701 | Robotics | Autonomous Robotics and Telecheries
2 | OEC RAI-702 | AI | Deep Learning
3 | OEC RAI-703 | Mechatronics | Mechatronics System Design
4 | OEC RAI-704 | Control Systems | Control of Robotic Systems

---
### SEMESTER-VIII

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| Total credits | 7 1 18 16 |

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<td>Robotics</td>
<td>Advanced Robotics Programming</td>
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<td>PEC RAI-803</td>
<td>Mechatronics</td>
<td>Micro Electro Mechanical Systems</td>
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### Sr. No. | Course Code | Course Specialization/Track | Elective Course IV |
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<td>Robotics</td>
<td>Biomedical Robotics</td>
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<td>AI</td>
<td>Augmented Reality and Virtual Reality</td>
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<td>Mechatronics</td>
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<td>OEC RAI-804</td>
<td>Control Systems</td>
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➢ Total = 160 Credits
SEMESTER – I
SEMESTER I

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<td>Physics-I</td>
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Course Objective:

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

1. Introduction to Electromagnetic Theory
   Pre-requisites (if any): Mathematics course with vector calculus

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 center of a dielectric sphere, charge in front of a dielectric slab, dielectric slab and dielectric sphere in uniform electric field.

Module III: Magneto statics

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: Magneto statics 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; displace 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/Practicals:

Choice of experiments from the following:

1. Experiments on electromagnetic induction and electromagnetic braking;
2. LC circuit and LCR circuit;
3. Resonance phenomena in LCR circuits;
4. Magnetic field from Helmholtz coil;

Text Books/Suggested References:

2. A.B. Bhattachary and Atanu Nag, Engineering Physics
3. David Griffiths, Introduction to Electrodynamics
4. Halliday and Resnick, Physics
5. W. Saslow, Electricity, magnetism and light

Alternative NPTEL/SWAYAM Course:

<table>
<thead>
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<th>Instructor</th>
<th>Host Institute</th>
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<td>INTRODUCTION TO ELECTROMAGNETIC THEORY</td>
<td>PROF. MANOJ HARBOLA</td>
<td>IIT KANPUR</td>
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EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

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<th>Experiment Name</th>
<th>Experiment Link(s)</th>
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2. 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; \( F = - \nabla V \), 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
Suggested list of experiments from the following:

1. Coupled oscillators;
2. Experiments on an air-track;
3. Experiment on moment of inertia measurement,
4. Experiments with gyroscope;
5. Resonance phenomena in mechanical oscillators.

TEXTBOOKS/REFERENCES:

3. Introduction to Mechanics — MK Verma
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>
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<td>ENGINEERING MECHANICS</td>
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<td>IIT KANPUR</td>
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EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

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<th>Experiment Link(s)</th>
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3. 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, field ionization 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. A.B. Bhattachary and Atanu Nag, Engineering Physics
2. Eisberg and Resnick, Introduction to Quantum Physics
3. D. J. Griffiths, Quantum mechanics
4. Richard Robinett, Quantum Mechanics
5. Daniel McQuarrie, Quantum Chemistry

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 ELECTROMAGNETIC THEORY</td>
<td>PROF. HARBOLOA</td>
<td>MANOJ IIT KANPUR</td>
</tr>
<tr>
<td>2</td>
<td>QUANTUM MECHANICS I</td>
<td>PROF. P. RAMADEVI</td>
<td>IIT BOMBAY</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>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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4. 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: mono-chromaticity, 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:
2. A.B. Bhattacharya and Atanu Nag, Engineering Physics
3. Ian G. Main, Oscillations and waves in physics
4. H.J. Pain, The physics of vibrations and waves
5. E. Hecht, Optics
6. A. Ghatak, Optics
7. O. Svelto, Principles of Lasers

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>WAVES AND OSCILLATIONS</td>
<td>PROF. M. S. SANTHANAM</td>
<td>IISER PUNE</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>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>
</tr>
</tbody>
</table>

*****
Course Content:

Module I: Matrices and linear equations:

Module II: Eigenvalues and Eigenvectors:
Linear mappings, representation by matrices, rank-nullity theorem, Eigenvalues, Eigen vectors and their basic properties, diagonalization.

Module III: Calculus Theorems:
Review of limits, continuity and differentiability, Mean value theorems, Taylor's theorem, local extrema, increasing and decreasing functions, concavity, points of inflection.

Module IV: Calculus Theorems:
Integrals as limits of Riemann sums, fundamental theorem of calculus, surface area, integrals by special techniques: reduction formulae, arc length, solids of revolution, improper integrals, tests for convergence, Gamma and Beta functions.

Suggested Text Books:

(i) AICTE’s Prescribed Textbook: Mathematics-I (Calculus & Linear Algebra), Khanna Book Publishing Co.
(v) Advanced Engineering Mathematics (10th edition) by Erwin Kreyszig, Wiley eastern Ltd.

Suggested Reference Books:

Course Outcomes:
After completion of this course, the students will be able to:

- Understand and apply basic concepts. (To measure this outcome, questions may be of the type- explain, describe, illustrate, evaluate, give examples, compute etc.)
- Apply core concepts to new situations. (To measure this outcome, some questions will be based on self-study topics and also comprehension of unseen passages.)
- Give reasoning. (To measure this outcome, questions may be of the type- true/false with justification, theoretical fill in the blanks, theoretical problems, prove implications or corollaries of theorems, etc.)
- Analyse the problem and apply the appropriate concept. (To measure this outcome, questions will be based on applications of core concepts.)

*****
**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, Geothermal, Hydroelectric, Thermal-steam, diesel, gas, nuclear power plants; Concept of cogeneration, and distributed generation;

**TEXT/REFERENCES BOOKS:**

2. Ritu Sahdev (2022), Basic Electrical Engineering, Khanna Book Publishing.

**Alternative NPTEL/SWAYAM Course:**

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

******
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: Customisation & 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:

7. (Corresponding set of) CAD Software Theory and User Manuals.

Alternative NPTEL/SWAYAM Course:

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</thead>
<tbody>
<tr>
<td>1</td>
<td>PROF. RAJARAM LAKKARAJU</td>
<td>IIT KHARAGPUR</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.

************
Detailed Content:

Module 1: An Insight to Learning:


Module 2: Basics of Design Thinking:


Module 3: Process of Product Design:


Module 4: Celebrating the Difference Understanding:

Individual differences & Uniqueness Group Discussion and Activities to encourage the understanding, acceptance and appreciation of Individual differences.

Module 5: Design Thinking & Customer Centricity:

Practical Examples of Customer Challenges, Use of Design Thinking to Enhance Customer Experience, Parameters of Product experience, Alignment of Customer Expectations with Product Design.

Module 6: Feedback, Re-Design & Re-Create:

Feedback loop, Focus on User Experience, Address “ergonomic challenges, User focused design, rapid prototyping & testing, final product, Final Presentation – “Solving Practical Engineering Problem through Innovative Product Design & Creative Solution”.

Text/Reference Books:

1. E Balaguruswamy (2022), Developing Thinking Skills (The way to Success), Khanna Book Publishing Company.
Suggested Text Books:


Suggested Reference Books:


Course Outcomes:
At the end of this course, the students will be able to:

- Compare and classify the various learning styles and memory techniques and Apply them in their engineering education.
- Develop new ways of creative thinking and Learn the innovation cycle of Design Thinking process for developing innovative products.
- Propose real-time innovative engineering product designs and Choose appropriate frameworks, strategies, techniques during prototype development.
- Perceive individual differences and its impact on everyday decisions and further Create a better customer experience.
- Analyze emotional experience and Inspect emotional expressions to better understand users while designing innovative products.

*****
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:

1. Effective Communication Skills, Kulbhushan Kumar, Khanna Book Publishing. 2022

Alternative NPTEL/SWAYAM Course:

<table>
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</tr>
</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>IIT MADRAS</td>
</tr>
</tbody>
</table>

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

*****
AICTE Model Curriculum for UG Degree Course in Robotics & Artificial Intelligence Engineering

<table>
<thead>
<tr>
<th>AU-101</th>
<th>IDEA Lab Workshop</th>
<th>2L:0T:4P</th>
<th>0 Credit</th>
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</thead>
</table>

**Course Objectives:**

1. To learn all the skills associated with the tools and inventory associated with the IDEA Lab.
2. Learn useful mechanical and electronic fabrication processes.
3. Learn necessary skills to build useful and standalone system/project with enclosures.
4. Learn necessary skills to create print and electronic documentation for the system/project

**Course Contents:**

<table>
<thead>
<tr>
<th>Unit #</th>
<th>Topics</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>Electronic component familiarization, Understanding electronic system design flow. Schematic design and PCB layout and Gerber creation using EagleCAD. Documentation using Doxygen, Google Docs, Overleaf. Version control tools - GIT and GitHub. Basic 2D and 3D designing using CAD tools such as FreeCAD, Sketchup, Prusa Slicer, FlatCAM, Inkspace, OpenBSP and VeriCUT.</td>
<td>Introduction to basic hand tools - Tape measure, combination square, Vernier caliper, hammers, fasteners, wrenches, pliers, saws, tube cutter, chisels, vice and clamps, tapping and threading. Adhesives</td>
</tr>
</tbody>
</table>

| 2.     | Familiarization and use of basic measurement instruments - DSO including various triggering modes, DSO probes, DMM, LCR bridge, Signal and function generator. Logic analyzer and MSO. Bench power supply (with 4-wire output) Circuit prototyping using (a) breadboard, (b) Zero PCB (c) ‘Manhattan’ style and (d) custom PCB. Single, double and multilayer PCBs. Single and double-sided PCB prototype fabrication in the lab. Soldering using soldering iron/station. Soldering using a temperature controlled reflow oven. Automated circuit assembly and soldering using pick and place machines. | Mechanical cutting processes - 3-axis CNC routing, basic turning, milling, drilling and grinding operations, Laser cutting, Laser engraving etc. Basic welding and brazing and other joining techniques for assembly. Concept of Lab aboard a Box. |
Electronic circuit building blocks including common sensors, Arduino and Raspberry Pi programming and use. Digital Input and output. Measuring time and events. PWM. Serial communication. Analog input. Interrupts programming. Power Supply design (Linear and Switching types), Wireless power supply, USB PD, Solar panels, Battery types and charging

3D printing and prototyping technology – 3D printing using FDM, SLS and SLA. Basics of 3D scanning, point cloud data generation for reverse engineering. Prototyping using subtractive cutting processes. 2D and 3D Structures for prototype building using Laser cutter and CNC routers. Basics of IPR and patents; Accessing and utilizing patent information in IDEA Lab

- Discussion and implementation of a mini project.
- Documentation of the mini project (Report and video).

<table>
<thead>
<tr>
<th>S. No.</th>
<th>List of Lab activities and experiments</th>
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<tbody>
<tr>
<td>1.</td>
<td>Schematic and PCB layout design of a suitable circuit, fabrication and testing of the circuit.</td>
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<tr>
<td>2.</td>
<td>Machining of 3D geometry on soft material such as soft wood or modelling wax.</td>
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<td>3.</td>
<td>3D scanning of computer mouse geometry surface. 3D printing of scanned geometry using FDM or SLA printer.</td>
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<tr>
<td>4.</td>
<td>2D profile cutting of press fit box/casing in acrylic (3 or 6 mm thickness)/cardboard, MDF (2 mm) board using laser cutter &amp; engraver.</td>
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<tr>
<td>5.</td>
<td>2D profile cutting on plywood /MDF (6-12 mm) for press fit designs.</td>
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<tr>
<td>6.</td>
<td>Familiarity and use of welding equipment.</td>
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<td>7.</td>
<td>Familiarity and use of normal and wood lathe.</td>
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<tr>
<td>8.</td>
<td>Embedded programming using Arduino and/or Raspberry Pi.</td>
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<tr>
<td>9.</td>
<td>Design and implementation of a capstone project involving embedded hardware, software and machined or 3D printed enclosure.</td>
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<th>S. No.</th>
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<tbody>
<tr>
<td>Number</td>
<td>Book Title</td>
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<tr>
<td>4.</td>
<td>3D Printing &amp; Design</td>
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<tr>
<td>5.</td>
<td>The Big Book of Maker Skills: Tools &amp; Techniques for Building Great Tech Projects</td>
</tr>
<tr>
<td>8.</td>
<td>The Art of Electronics</td>
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<td></td>
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<tr>
<td>13.</td>
<td>Make Your Own PCBs with EAGLE: From Schematic Designs to Finished Boards</td>
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<td>14.</td>
<td>Pro GIT.</td>
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<td>Author(s)</td>
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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

Schrodinger 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 multicenter 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


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.
8. Potentiometry - determination of redox potentials and EMFs.
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:**

3. University chemistry, by B. H. Mahan
5. Fundamentals of Molecular Spectroscopy, by C. N. Banwell
6. Engineering Chemistry (NPTEL Web-book), by B. L. Tembe, Kamaluddin and M. S. Krishnan
7. 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>7</td>
<td>Potentiometry - determination of redox potentials and EMFs.</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/bio-chemistry/Estimation_of_Saponification_Value_of_Fats_or_Oils/">http://biotech01.vlabs.ac.in/bio-chemistry/Estimation_of_Saponification_Value_of_Fats_or_Oils/</a></td>
</tr>
</tbody>
</table>
9 Lattice structures and packing of spheres.  

**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 nanometer 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.

*****
BSC-104 | Maths–II (Ordinary Differential Equations and Multivariate Calculus) | 3L:1T:0P | 4 Credits

Detailed Content:

Module 1:
Review of first order differential equations, Reduction of order, linear differential equations, homogeneous higher order linear differential equations, non-homogeneous higher order linear differential equations with constant coefficients and reducible to differential equations with constant coefficients (method of undetermined coefficients and method of variation of parameters), systems of differential equations, applications to orthogonal trajectories, mass spring systems and electrical circuits.

Module 2:
Functions of several variables, level curves and level surfaces, partial and directional derivatives, differentiability, chain rule, local extreme values and saddle points, constrained optimization.

Module 3:
Double integrals in Cartesian and polar coordinates, iterated integrals, change of variables, triple integrals in Cartesian, spherical and cylindrical coordinates, and substitutions in multiple integrals, Applications to Area, Volume, Moments and Center of Mass.

Suggested Text Books:

(iii) Advanced Engineering Mathematics (10th edition) by Erwin Kreyszig, Wiley Eastern

Suggested Reference Books:


Course Outcomes:

After completion of this course, the students will be able to:
● Understand basic concepts (To measure this outcome, questions may be of the type- explain, describe, illustrate, evaluate, give examples, compute etc.).

● Illustrate any example.

● Analyze the problem and apply the appropriate concept (To measure this outcome, questions will be based on applications of core concepts).

● Know and recall core knowledge of the syllabus (To measure this outcome, questions may be of the type- define, identify, state, match, list, name etc.).

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<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
<th>Description</th>
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<tbody>
<tr>
<td>ESC-103</td>
<td>5</td>
<td>Programming for Problem Solving</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 understated 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:

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<th>Host Institute</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>INTRODUCTION TO PROGRAMMING IN C</td>
<td>PROF. SATYADEV NANDAKUMAR</td>
<td>IIT KANPUR</td>
</tr>
<tr>
<td>2</td>
<td>PROBLEM SOLVING THROUGH PROGRAMMING IN C</td>
<td>PROF. ANUPAM BASU</td>
<td>IIT Kharagpur</td>
</tr>
</tbody>
</table>

EXPERIMENTS THAT MAY BE PERFORMED THROUGH VIRTUAL LABS:

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</tr>
</thead>
</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.

### Table:

<table>
<thead>
<tr>
<th>No.</th>
<th>Topic</th>
<th>Description</th>
<th>Link</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1D Array manipulation.</td>
<td></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></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 Content:

- Manufacturing Methods- casting, forming, machining, joining, advanced manufacturing methods (3 lectures).
- CNC machining, Additive manufacturing (1 lecture).
- Fitting operations & power tools (1 lecture).
- Electrical & Electronics (1 lecture).
- Carpentry (1 lecture).
- Plastic molding, glass cutting (1 lecture).
- Metal casting (1 lecture).
- Welding (arc welding & gas welding), brazing (1 lecture).

Suggested Text Books:


Suggested Reference Books:


Course Outcomes:

After completion of this course, the students will be able to:

- Acquire knowledge of the different manufacturing processes which are commonly employed in the industry, to fabricate components using different materials.
- Understand the difference between traditional manufacturing and advanced manufacturing processes.
### 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, Dhyan Chand 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.
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.

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Detailed Content:

The following content should be covered in the Workshop practice:

Electronics:


Computer:

What is Computer, Basic Applications of Computer; Components of Computer System, Central Processing Unit (CPU), VDU, Keyboard and Mouse, Other input/output Devices, Computer Memory, Concepts of Hardware and Software; Concept of Computing, Data and Information; Applications of IECT; Connecting keyboard, mouse, monitor and printer to CPU and checking power supply. What is an Operating System; Basics of Popular Operating Systems; The User Interface, Using Mouse; Using right Button of the Mouse and Moving Icons on the screen, Use of Common Icons, Status Bar, Using Menu and Menu-selection, running an Application, Viewing of File, Folders and Directories, Creating and Renaming of files and folders, Opening and closing of different Windows; Using help; Creating Shortcuts, Basics of O.S Setup; Common utilities.

Suggested Text Books:


Course Outcomes:

After the completion of this course, the students will be able to:

- Identify different electronic components.
- Understand the working principle of different electronic devices.
- Understand the use and working of each component in computer system.
- Differentiate the use of operating system in programming languages.
HSMC-102 | Universal Human Values-II: Understanding Harmony And Ethical Human Conduct | 3L:0T:0P | 3 Credits

**Pre-requisites:** None. Universal Human Values 1 (Desirable)

**1-COURSES ON HUMAN VALUES**

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.

**Objectives of UHV-II Course**

This introductory course input is intended:

1. To help the students appreciate the essential complementarily between 'VALUES' and 'SKILLS' to ensure sustained happiness and prosperity which are the core aspirations of all human beings.
2. To facilitate the development of a Holistic perspective among students towards life and profession as well as towards happiness and prosperity based on a correct understanding of the Human reality and the rest of existence. Such a holistic perspective forms the basis of Universal Human Values and movement towards value-based living in a natural way.
3. To highlight plausible implications of such a Holistic understanding in terms of ethical human conduct, trustful and mutually fulfilling human behavior and mutually enriching interaction with Nature.

Thus, this course is intended to provide a much-needed orientational input in value education to the young enquiring minds.

**Salient Features of the Course**

The salient features of this course are:

1. It presents a universal approach to value education by developing the right understanding of reality (i.e. a worldview of the reality “as it is”) through the process of self-exploration.
2. The whole course is presented in the form of a dialogue whereby a set of proposals about various aspects of the reality are presented and the students are encouraged to self-explore the proposals by verifying them on the basis of their natural acceptance within oneself and validate experientially in living.
3. The prime focus throughout the course is toward affecting a qualitative transformation in the life of the student rather than just a transfer of information.
4. While introducing the holistic worldview and its implications, a critical appraisal of the prevailing notions is also made to enable the students discern the difference on their own right.
Course Methodology

1. The methodology of this course is explorational and thus universally adaptable. It involves a systematic and rational study of the human being vis-à-vis the rest of existence.
2. The course is in the form of 28 lectures (discussions) and 14 practice sessions.
3. It is free from any dogma or value prescriptions.
4. It is a process of self-investigation and self-exploration, and not of giving sermons. Whatever is found as truth or reality is stated as a proposal and the students are facilitated to verify it in their own right, based on their Natural Acceptance and subsequent Experiential Validation – the whole existence is the lab and every activity is a source of reflection.
5. This process of self-exploration takes the form of a dialogue between the teacher and the students to begin with, and then to continue within the student in every activity, leading to continuous self-evolution.
6. This self-exploration also enables them to critically evaluate their pre-conditionings and present beliefs.

2-COURSE TOPICS

The course has 28 lectures and 14 tutorials in 5 modules. The lectures and tutorials are of 01-hour duration. Tutorial sessions are to be used to explore and practice what has been proposed during the lecture sessions.

The Teacher’s Manual provides the outline for lectures as well as practice sessions. The teacher is expected to present the issues to be discussed as propositions and encourage the students to have a dialogue.

The syllabus for the lectures and practice sessions is given below:

Module 1 – Introduction to Value Education (6 lectures and 3 tutorials for practice session)

Lecture 1: Right Understanding, Relationship and Physical Facility (Holistic Development and the Role of Education)
Lecture 2: Understanding Value Education
Material 1: Practice Session PS1 Sharing about Oneself
Lecture 3: Self-exploration as the Process for Value Education
Lecture 4: Continuous Happiness and Prosperity – the Basic Human Aspirations
Material 2: Practice Session PS2 Exploring Human Consciousness
Lecture 5: Happiness and Prosperity – Current Scenario
Lecture 6: Method to Fulfill the Basic Human Aspirations
Material 3: Practice Session PS3 Exploring Natural Acceptance

Expected outcome:

The students start exploring themselves: get comfortable with each other and with the teacher; they start appreciating the need and relevance for the course.

The students start finding that technical education without study of human values can generate more problems than solutions. They also start feeling that lack of understanding of human values is the
root cause of most of the present-day problems; and a sustained solution could emerge only through understanding of value-based living. Any solution brought out through fear, temptation of dogma will not be sustainable.

The students are able to see that verification on the basic of natural acceptance and experiential validation through living is the only way to verify right or wrong, and referring to any external source like text or instrument or any other person cannot enable them to verify with authenticity; it will only develop assumptions.

The students are able to see that their practice in living is not in harmony with their natural acceptance most of the time, and all they need to do is to refer to their natural acceptance to overcome this disharmony.

The students are able to see that lack of right understanding leading to lack of relationship is the major cause of problems in their family and not the lack of physical facility in most of the cases, while they have given higher priority to earning of physical facility in their life giving less value to or even ignoring relationships and not being aware that right understanding is the most important requirement for any human being.

Module 2 – Harmony in the Human Being (6 lectures and 3 tutorials for practice session)

- **Lecture 7:** Understanding Human being as the Co-existence of the Self and the Body
- **Lecture 8:** Distinguishing between the Needs of the Self and the Body
- **Tutorial 4: Practice Session PS4** Exploring the difference of Needs of Self and Body
- **Lecture 9:** The Body as an Instrument of the Self
- **Lecture 10:** Understanding Harmony in the Self
- **Tutorial 5: Practice Session PS5** Exploring Sources of Imagination in the Self
- **Lecture 11:** Harmony of the Self with the Body
- **Lecture 12:** Programme to ensure self-regulation and Health
- **Tutorial 6: Practice Session PS6** Exploring Harmony of Self with the Body

**Expected outcome:**

The students are able to see that they can enlist their desires and the desires are not vague. Also they are able to relate their desires to ‘I’ and ‘Body’ distinctly. If any desire appears related to both, they are able to see that the feeling is related to I while the physical facility is related to the body. They are also able to see that ‘I’ and Body are two realities, and most of their desires are related to ‘I’ and not body, while their efforts are mostly centered on the fulfilment of the needs of the body assuming that it will meet the needs of ‘I’ too.

The students are able to see that all physical facility they are required for a limited time in a limited quantity. Also, they are able to see that in case of feelings, they want continuity of the naturally acceptable feelings and they do not want feelings which are not naturally acceptable even for a single moment.

The students are able to see that activities like understanding, desire, though and selection are the activities of ‘I’ only the activities like breathing, palpitation of different parts of the body are fully the activities of the body with the acceptance of ‘I’ while the activities they do with their sense organs like hearing through ears, seeing through eyes, sensing through touch, tasting through tongue and
smelling through nose or the activities they do with their work organs like hands, legs etc. are such activities that require the participation of both ‘I’ and body.

The students become aware of their activities of ‘I’ and start finding their focus of attention at different moments. Also they are able to see that most of their desires are coming from outside (through preconditioning or sensation) and are not based on their natural acceptance.

The students are able to list down activities related to proper upkeep of the body and practice them in their daily routine. They are also able to appreciate the plants wildly growing in and around the campus which can be beneficial in curing different diseases.

Module 3 – Harmony in the Family and Society (6 lectures and 3 tutorials for practice session)

- **Lecture 13:** Harmony in the Family – the Basic Unit of Human Interaction
- **Lecture 14:** 'Trust' – the Foundational Value in Relationship
- **Tutorial 7:** Practice Session PS7 Exploring the Feeling of Trust
- **Lecture 15:** 'Respect' – as the Right Evaluation
- **Tutorial 8:** Practice Session PS8 Exploring the Feeling of Respect
- **Lecture 16:** Other Feelings, Justice in Human-to-Human Relationship
- **Lecture 17:** Understanding Harmony in the Society
- **Lecture 18:** Vision for the Universal Human Order
- **Tutorial 9:** Practice Session PS9 Exploring Systems to fulfil Human Goal

**Expected outcome:**

The students are able to note that the natural acceptance (intention) is always for living in harmony, only competence is lacking! We generally evaluate ourselves on the basis of our intention and others on the basis of their competence! We seldom look at our competence and others’ intention as a result we conclude that I am a good person and other is a bad person.

The students are able to see that respect is right evaluation, and only right evaluation leads to fulfilment in relationship. Many present problems in the society are an outcome of differentiation (lack of understanding of respect), like gender biasness, generation gap, caste conflicts, class struggle, dominations through power play, communal violence, clash of isms and so on so forth. All these problems can be solved by realizing that the other is like me as he has the same natural acceptance, potential and program to ensure a happy and prosperous life for them and for others through he may have different body, physical facility or beliefs.

The students are able to use their creativity for education children. The students are able to see that they can play a role in providing value education for children. They are able to put in simple words the issues that are essential to understand for children and comprehensible to them. The students are able to develop an outline of holistic model for social science and compare it with the existing model.

Module 4 – Harmony in the Nature/Existence (4 lectures and 2 tutorials for practice session)

- **Lecture 19:** Understanding Harmony in the Nature
Lecture 20: Interconnectedness, self-regulation and Mutual Fulfilment among the Four Orders of Nature
Tutorial 10: Practice Session PS10 Exploring the Four Orders of Nature
Lecture 21: Realizing Existence as Co-existence at All Levels
Lecture 22: The Holistic Perception of Harmony in Existence
Tutorial 11: Practice Session PS11 Exploring Co-existence in Existence

Expected outcome:

The students are able to differentiate between the characteristics and activities of different orders and study the mutual fulfilment among them. They are also able to see that human beings are not fulfilling to other orders today and need to take appropriate steps to ensure right participation (in terms of nurturing, protection and right utilization) in the nature.

The students feel confident that they can understand the whole existence; nothing is a mystery in this existence. They are also able to see the interconnectedness in the nature, and point out how different courses of study relate to the different units and levels. Also, they are able to make out how these courses can be made appropriate and holistic.

Module 5 – Implications of the Holistic Understanding – a Look at Professional Ethics (6 lectures and 3 tutorials for practice session)

Lecture 23: Natural Acceptance of Human Values
Lecture 24: Definitiveness of (Ethical) Human Conduct
Tutorial 12: Practice Session PS12 Exploring Ethical Human Conduct
Lecture 25: A Basis for Humanistic Education, Humanistic Constitution and Universal Human Order
Lecture 26: Competence in Professional Ethics
Tutorial 13: Practice Session PS13 Exploring Humanistic Models in Education
Lecture 27: Holistic Technologies, Production Systems and Management Models-Typical Case Studies
Lecture 28: Strategies for Transition towards Value-based Life and Profession
Tutorial 14: Practice Session PS14 Exploring Steps of Transition towards Universal Human Order

Expected outcome:

The students are able to present sustainable solutions to the problems in society and nature. They are also able to see that these solutions are practicable and draw roadmaps to achieve them.

The students are able to grasp the right utilization of their knowledge in their streams of Technology/Engineering/Management/any other area of study to ensure mutual fulfilment. E.g. mutually enriching production system with rest of nature.
The students are able to sincerely evaluate the course and share with their friends. They are also able to suggest measures to make the course more effective and relevant. They are also able to make use of their understanding in the course for the happy and prosperous family and society.

**Guidelines and Content for Practice Sessions (Tutorials)**

In order to connect the content of the proposals with practice (living), 14 practice sessions have been designed. The full set of practice sessions is available in the Teacher’s Manual as well as the website.

**Practice Sessions for Module 1 – Introduction to Value Education**

PS1  Sharing about Oneself  
PS2  Exploring Human Consciousness  
PS3  Exploring Natural Acceptance

**Practice Sessions for Module 2 – Harmony in the Human Being**

PS4  Exploring the difference of Needs of Self and Body  
PS5  Exploring Sources of Imagination in the Self  
PS6  Exploring Harmony of Self with the Body

**Practice Sessions for Module 3 – Harmony in the Family and Society**

PS7  Exploring the Feeling of Trust  
PS8  Exploring the Feeling of Respect  
PS9  Exploring Systems to fulfil Human Goal

**Practice Sessions for Module 4 – Harmony in the Nature (Existence)**

PS10  Exploring the Four Orders of Nature  
PS11  Exploring Co-existence in Existence

**Practice Sessions for Module 5 – Implications of the Holistic Understanding – a Look at Professional Ethics**

PS12  Exploring Ethical Human Conduct  
PS13  Exploring Humanistic Models in Education  
PS14  Exploring Steps of Transition towards Universal Human Order
As an example, PS7 is a practice session in module 3 regarding trust. It is explained below:

**PS7:** Form small groups in the class and in that group initiate dialogue and ask the eight questions related to trust. The eight questions are:

1a. Do I want to make myself happy?  
1b. Am I able to make myself always happy?

2a. Do I want to make the other happy?  
2b. Am I able to make the other always happy?

3a. Does the other want to make him happy?  
3b. Is the other able to make him always happy?

4a. Does the other want to make me happy?  
4b. Is the other able to make me always happy?

**Intention (Natural Acceptance)**  
**Competence**

What is the answer?  
What is the answer?

Let each student answer the questions for himself/herself and everyone else. Discuss the difference between intention and competence. Observe whether you evaluate your intention and competence as well as the others’ intention and competence.

**Expected outcome of PS7:** The students are able to see that the first four questions are related to our Natural Acceptance i.e. intention and the next four to our Competence. They are able to note that the intention is always correct, only competence is lacking! We generally evaluate ourselves on the basis of our intention and others on the basis of their competence! We seldom look at our competence and others’ intention, as a result we conclude that I am a good person and other is a bad person.

**3-READINGS:**

**3-1-Text Book and Teachers Manual**

a. The Textbook


b. The Teacher’s Manual


3-2-Reference Books

3. The Story of Stuff (Book).
4. The Story of My Experiments with Truth - by Mohandas Karamchand Gandhi
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)

4-MODE OF CONDUCT (L-T-P-C 2-1-0-3)

Lecture 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.
Teacher preparation with a minimum exposure to at least one 8-day Faculty Development Program on Universal Human Values is deemed essential.

5-SUGGESTED 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.

6-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.

Therefore, the course and further follow up is expected to positively impact common graduate attributes like:

1. Holistic vision of life
2. Socially responsible behaviour
3. Environmentally responsible work
4. Ethical human conduct
5. Having Competence and Capabilities for Maintaining Health and Hygiene
6. Appreciation and aspiration for excellence (merit) and gratitude for all

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.

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SEMESTER – III
SEMESTER III

| BSC-301 | Vector Calculus and Partial Differential Equations | 2L:1T:0P | 3 Credits |

Detailed Content:

Module 1:

Vector differentiation, gradient, divergence and curl, line and surface integrals, path independence, statements and illustrations of theorems of Green, Stokes and Gauss, arc length parameterization, applications.

Module 2:

Partial differential equations with separation of variables, boundary value problems: vibrations of a string, heat equation, potential equation, vibrations of circular membranes.

Module 3:

Laplace Transforms, its properties, Unit step function, Dirac delta functions, Convolution Theorem, periodic functions, solving differential equations using Laplace transform.

Suggested Text Books:


Suggested Reference Books:


Course Outcomes:

After the completion of this course, the students will be able to:
Know and recall core knowledge of the syllabus (To measure this outcome, questions may be of the type- define, identify, state, match, list, name etc.).

Apply Partial differential concept to wherever necessary in Engineering Problems.

Apply and Perform Laplace Transformation.

Apply core concepts to new situations. (To measure this outcome, some questions will be based on self-study topics and also comprehension of unseen passages).

Understand basic concepts (To measure this outcome, questions may be of the type- explain, describe, illustrate, evaluate, give examples, compute etc.).

Analyze the problem and apply the appropriate concept (To measure this outcome, questions will be based on applications of core concepts).

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ESC-301 Fundamentals of Mechanical Engineering 2L:0T:0P 2 Credits

Pre-requisites (if any) Basic mathematics.

Detailed Content:

Module 1: Introduction to Thermodynamics:

Module 2: Elementary Ideas of Energy Conversion Devices:
Boilers, Steam and Gas Turbines, SI and CI Engines, Refrigeration and Air Conditioning.

Module 3: Fluid Mechanics and Machinery:

Module 4: Mechanics of Material:

Module 5: Power Transmission Devices:
Power Transmission Elements, Shaft and Axle, Rope, Belt and Chain Drives, Gear Drives, Dynamometers.

Module 6: Manufacturing Processes:
Types of Manufacturing Processes, Machining Operations, Turning, Drilling, Milling and Grinding, Forming and Forging Operations, Joining Processes, Soldering, Brazing and Welding.

Suggested Text Books:


Suggested Reference Books:


Course Outcomes:

After the completion of this course, the students will be able to:

- Understanding of the fundamentals essential for designing robot structure.
- Understanding of the fundamentals for selecting robot material according to its working environment.
- Knowledge of various mechanical elements used in mechanisms.
- Knowledge of various manufacturing processes.
- Knowledge of basic thermodynamic and Fluid mechanics concepts.

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ESC-302  Electrical Machines & Drives  2L:0T:2P  3 Credits

Detailed Content:

Module 1: Introduction to D.C. Motors:
Principles of working, Significance of back EMF, Torque Equation, Types, Characteristics and Selection of DC Motors, Starting of DC Motors, Speed Control, Losses and Efficiency, Condition for Maximum Efficiency, Braking of DC Motors, Effect of saturation and armature reaction on losses; Applications, Permanent Magnet DC Motors, Type and Routine tests.

Module 2: Introduction to Three Phase Induction (Asynchronous) Motor:
Types of induction motor, flux and MMF waves, development of circuit model, power across air gap, torque and power output, starting methods, speed control, induction generator, induction machine dynamics, high efficiency induction motors, Single phase IM, Modeling of induction machine.

Module 3: Introduction to Synchronous Machines:
Construction, types, armature reaction, circuit model of synchronous machine, determination of synchronous reactance, phasor diagram, power angle characteristics, parallel operation of synchronous generators, synchronizing to infinite bus bars, two axis theory, synchronous motor operation, dynamics, modeling of synchronous machine, PM synchronous machines.

Module 4: Electric Drives, Dynamics and Control:
Definition, Advantages of electrical drives, Components of Electric drive system, Selection Factors, speed control and drive classifications, Motor-Load Dynamics, Speed Torque conventions and multi quadrant operation, Equivalent values of drive parameters. Load Torque Components, Nature and classification of Load Torques, Constant Torque and Constant Power operation of a Drive, Steady state stability, Load epilation and selection motors.

Module 5: Introduction to DC Motor Drives:
DC motors and their performance starting, transient analysis, speed control, ward Leonard drives, Controlled rectifier fed drives, full controlled 3 phase rectifier control of dc separately excited motor], multi-quadrant operation, Chopper controlled drives Closed loop speed control of DC motor.

Module 6: Induction and Synchronous Motor Drives:
Induction motor analysis, starting and speed control methods- voltage and frequency control, current control, closed loop control of induction motor drives, rotor resistance control, Slip power recovery – Static Kramer and Scherbius Drive, Single phase induction motor starting, braking and speed control. Synchronous motor operation with fixed frequency, variable speed drives, PMAC and BLDC motor drives, Stepper motor drives, switched reluctance motor drives.

Suggested Text Books:


Course outcomes:

At the end of this course, the students will demonstrate the ability to:

- Analyze DC drive, Induction and Synchronous Motors Drives.
- Evaluate the steady state behavior and basic operating characteristics of A.C Machine.
- Understand the basics of electric drives and fundamentals of drive dynamics.
- Demonstrate analytical skills to assess machine performance in steady state.

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Course Content:

Module 1: Physics of Bipolar Junction Transistors:


Module 2: Fundamentals of Op-Amp:

Op-Amp Parameters Circuits with resistive feedback: Concept of feedback & their types, Inverting & non-inverting configurations, current to voltage converters, voltage to current converters, summing amplifier, difference amplifier, instrumentation amplifier.

Module 3: Non-linear circuits:

Schmitt trigger, Voltage comparators, comparator applications, precision rectifiers, analog switches, peak detectors, sample & hold circuits, Integrators & differentiators, Clippers and Clampers Feedback & Oscillator Circuit: Effect of positive and negative feedback, Analysis of practical feedback amplifiers, Sinusoidal Oscillators (RC, LC and Crystal), Multi-vibrators using 555 timers.

Module 4: Logic Simplification and Combinational Logic Design:

Review of Boolean Algebra and De Morgan’s Theorem, SOP & POS forms, Canonical forms, Karnaugh maps up to 6 variables, Binary codes, Code Conversion. MSI devices like Multiplexers, Encoder, Decoder, Comparators, Half and Full Adders, Subtractors, BCD Adder, Barrel shifter and ALU.

Module 5: Sequential Logic Design:

Building blocks like S-R, JK and D latch, Master-Slave JK FF, Edge triggered FF, Ripple and Synchronous counters, Shift registers, Finite state machines, Design of synchronous FSM.

Module 6: Logic Families and Semiconductor Memories:

TTL NAND gate, Specifications, Noise margin, Propagation delay, fan-in, fan-out, Tristate TTL, ECL, CMOS families and their interfacing, Memory elements, Concept of PLDs like PAL, PLA, CPLDs, FPGA etc. Logic implementation using Programmable Devices (ROM, PLA).

Suggested Text Books:

Suggested Reference Books:


Course Outcomes:

At the end of the course, the students will demonstrate the ability to:

- Design and Analyze Analog sub-circuits using BJT and FET.
- Design & analyze modular combinational circuits with MSI devices like MUX/DEMUX, Decoder, Encoder, etc.
- Design the linear and non-linear applications of Op-Amp.
- Design & analyze synchronous sequential logic circuits with FFs and combinatorial circuits.
- Design & analyze modular combinational circuits with MSI devices like MUX/DEMUX, Decoder, Encoder, etc.
Course Content:

➢ **Material Science:**

**Module 1: Introduction to engineering materials & their properties:**

Crystalline versus non crystalline solids, Unit cell, Crystal systems, Bravais lattice, Fundamental reasons behind classification of lattice, Miller indices for directions & planes, Close-packed planes & directions, packing efficiency, Interstitial voids, Role of X-ray diffraction in determining crystal structures. Deformation of metals, understanding of some material-properties independent of interatomic bonding forces/energies, Stiffness versus modulus, Theoretical/ideal strength versus actual strength of metals, Crystal defects, Role of dislocations in deformation, Strengthening Mechanisms, Role of Cottrell atmosphere.

**Module 2: Phase Diagrams:**


**Module 3: Heat Treatment:**

Definition, Purpose & classification of heat treatment processes for various types of steels, Bainite & Martensite formation, Introduction & applications of various case hardening & surface hardening treatments, Precipitation Hardening, Heat treatment defects.

➢ **Smart materials:**

**Module 4: Concept of Smart Materials:**


**Module 5: Structural material:**

self-healing materials, heat and cold resistant materials, radiation resistant materials, corrosion-resistant materials and anti-corrosive coatings, lubricants, frictional materials, materials for operation at abnormal temperatures. Materials for biological and biomedical systems materials for implants, targeted drug delivery and tissue growth, antimicrobial materials, filters for water cleaning, biodegradable packages, active and bio-selective packages.
Module 6: Mechanics of smart materials:

Object and subject of smart materials mechanics, structural and functional analysis smart materials in terms of mechanics, the materials with negative characteristics as source of smart effects in structures: Auxetics, statements and solutions of some smart materials based mechanics problems – e.g. self-healing of cracks, self-reinforcing of multimodular materials, porous materials-auxetic materials reversible transformations, self- assembling porous materials etc. Smart materials and energy problem: Global energy problem, energy consumption for production of materials, technical and economical efficiency of smart materials and technical systems.

Suggested Text Books:


Suggested Reference Books:


Course Outcomes:

At the end of the course, the students will be able to:

- Analyze the properties of smart materials and structures in the broader external conditions for the utilization in selected technologies.
- Understand the basic properties that characterize the behavior of materials and classify the materials with their types of loadings/environment that materials should withstand.
- Acquire the knowledge of various smart materials, their fabrication and their multidisciplinary applications.
- Know the concept of “Smart” materials and systems.
Detailed Content:

**Module 1: Introduction:**


**Module 2: Sensors, Drives and Grippers:**


**Module 3: Kinematics of Manipulators:**


Robot Applications: Material transfer and machine loading/unloading, processing operations assembly and inspection. Programming and Languages: Methods of robot programming, Introduction to various languages such as RAIL and VAL II …etc., Features of each type and development of languages for recent robot systems.

**Module 4: Introduction to Artificial Intelligence:**

Overview: foundations, scope, problems, and approaches of AI. Intelligent agents: reactive, deliberative, goal-driven, utility-driven, and learning agents, Artificial Intelligence programming techniques.

**Module 5: Problem-solving through Search:**

forward and backward, state-space, blind, heuristic, problem reduction, alpha-beta pruning, minimax, constraint propagation, neural, stochastic, and evolutionary search algorithms, sample applications.

**Module 6: Knowledge Representation and Reasoning:**

Ontologies, foundations of knowledge representation and reasoning, representing and reasoning about objects, relations, events, actions, time, and space; predicate logic, situation calculus, description logics, reasoning with defaults, reasoning about knowledge, sample applications. Planning: planning as search, partial order planning, construction and use of planning graphs. Representing and Reasoning with Uncertain Applications of AI (vision/robotics etc.).
Suggested Text Books:

Suggested Reference Books:

Course Outcomes:

At the end of the course, the students will be able to:
- Differentiate types of robots and robot grippers.
- Apply basic principles of AI in solutions that require problem solving, inference, perception, knowledge representation and learning.
- Understand AI, its current scope and limitations, and societal implications.
- Analyze forces in links and joints of a robot.
- Demonstrate awareness and a fundamental understanding of AI techniques in intelligent agents, artificial neural networks.
- Model forward and inverse kinematics of robot manipulator.

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Course Content:

Module 1: Wireless Networks:
Wireless network topologies, infrastructure and ad-hoc networks, different generations of wireless networks; The cellular concept and design fundamentals, coverage and user capacity.

Module 2: Wireless Fading Channels:
Large scale path loss modeling and shadow fading, indoor and outdoor propagation models; Multipath and Doppler, types of small-scale fading, simulation techniques.

Module 3: Multiple Access Techniques:
Performance in fading and multipath channels. Fixed assignment and random access; Capacity and performance of FDMA, TDMA, DS/CDMA and FH/CDMA; WCDMA and OFDMA; Access techniques for WLAN, Bluetooth and mobile data networks.

Module 4: Ad Hoc Wireless Sensor Networks:
Overview, Communication Coverage, Sensing Coverage, Localization, Routing.

Module 5: Wireless Local Area Networks:
Introduction, WLAN Topologies, WLAN Technologies, IEEE 802.11 WLAN, Other WLAN Standards- HIPERLAN.

Module 6: Quality-of-Service (QoS) in Wireless Networks:
QoS issues in Wireless Networks, a case study of broadband service regulations for maintaining QoS by telecom regulatory bodies such as TRAI.

Suggested Text Books:

Suggested Reference Books:


Course Outcomes:

At the end of the course, the students will demonstrate the ability to:

- Explain concepts and issues involved in the design of wireless networks.
- Understand cellular (mobile) communication systems.
- Analyze mechanisms to improve Quality of service in Networking.
- Elaborate the concept of multiple access in Communication Networking.
- State key features and operating principles of Wi-Fi (Bluetooth) and WLAN.

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Course Content:
- Hardness testing (Study of Hardness conversion number).
- Rockwell/Vickers hardness test.
- Brinell and Poldi hardness Test.
- Impact Test for Steel, Aluminum, Brass and Copper (Charpy/Izod).
- Non Destructive testing - Dye Penetrant Test/ Magnetic Particle test/ Ultrasonic Test.
- Specimen Preparation procedure for microscopic examination & Demonstration of Optical Metallurgical microscope.
- Observation and Drawing of Microstructure of Steels, Cast Iron of various compositions, Non Ferrous Metals of various compositions.
- Testing of materials used in robotics technology (Hardness, Strength etc.).
- Aluminium casting and Aluminum alloys.
- Carbon Fiber plates, tubes and channels.
- FRP sheets and Channels.

Suggested Text Books:

Suggested Reference Books:
Course Outcomes:
At the end of the course, the students will be able to:

- Determine mechanical properties using destructive and nondestructive testing of materials.
- Study of different parameters of the system viz., phases, variables, components, grains, grain boundary, and degree of freedom. etc.
- Understand the use of non-conventional materials such as CNT, FRP, Al alloys etc.
- Select appropriate materials for Robotic applications.

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Detailed Content:

- Input and Output Characteristics of BJT in CE configuration.
- Transfer and Drain Characteristics of MOSFET.
- Design and simulate LC and RC oscillators.
- Build and test LC or RC oscillator.
- Design different types of multivibrators using IC 555.
- Simplification and implementation of a Boolean function using k-map technique e.g. code converter.
- Use of Multiplexers, Encoders, Demultiplexer and decoders for implementing logic.
- Design and implementation of ripple and synchronous counters using JK and D FF and additional gates.
- Design of MOD counter using ICs like 7490/93 (ripple) and 74192/193(synchronous).

Suggested Text Books:


Suggested Reference Books:


Course Outcomes:

At the end of the course, the students will demonstrate the ability to:

- Analyze and design various applications of Op-Amp.
- Identify and characterize basic devices such as BJT and FET from their package information.
by referring to manufacturers' data sheets.

- Design, simulate, build and debug complex sequential circuits based on an abstract functional specification.
- Design, simulate, build and debug complex combinational circuits based on an abstract functional specification.
Detailed Content:

- Robot Programming using Flex Pendant- Lead through programming including Coordinate systems of Robot.
- Wrist Mechanism-Interpolation-Interlock commands.
- VAL language commands motion control, hand control, program control, pick and place applications.
- Palletizing applications using VAL.
- Object detection and Sorting.
- Robot welding application using VAL program.
- RAPID Language and AML.
- Programming using Robot studio software.

Suggested Text Books:


Suggested Reference Books:


Course Outcomes:

At the end of this course, the students will be able to:

- Use fundamental and technical knowledge of robot Programming.
- Learn Robot Programming using teach Pendant for various applications.
- Use RAPID Language and AML.
- Program a Robot for Industrial applications.
- Program using Robot studio software.
SEMESTER – IV
Detailed Content:

Module 1: Descriptive statistics:
Measures of location and variation. Visualization of data: Frequency tables, bar diagrams, histograms, heat maps, other visualization tools. Review on introduction to combinatorics and probability theory.

Module 2: Some of the basic probability distributions:
Binomial, Poisson, Exponential, and Normal. Central limit theorem.

Module 3: Introduction to ‘R’:
Introductory R language fundamentals and basic syntax, major R data structures, Using R to perform data analysis, creating visualizations using R.

Module 4: Basic statistical inference and hypothesis testing:
Estimation, basic tests such as t-test, z-test, F-test, χ² test; Non parametric tests: Sign test, Wilcoxon signed rank test.

Module 5: Regression methods:
Simple linear regression and multiple regression.

Module 6: Engineering applications of statistics:
Engineering applications of statistics (Branch Specific (any 2)): Discussion on reliability and quality control. Introduction to random processes, stochastic processes, Markov chains. Machine learning and data science.

Suggested Text Books:


Suggested Reference Books:


Course Outcomes:

At the end of this course, the students will be able to:

- Make use of concepts of random variables and associated probability distributions to solve problems, illustrate the central limit theorem.
- Demonstrate a number of methods of summarizing and visualizing data sets, evaluating probabilities of events.
- Evaluate for basic statistical inference (t-test, z-test, F-test, $\chi^2$–test, confidence interval, non-parametric tests).
- Explain basic principles of regression analysis and perform the same.
- Demonstrate use of R software for all the above.

*****
Course Content:

Module 1: Biomolecules and biopolymers:
Structure and function, organic and inorganic molecules; unique properties of water, vitamins and minerals, carbohydrates, lipids, amino acids and proteins, nucleic acids (DNA and RNA), cell as a basic unit of life, prokaryotic and eukaryotic cells, microbes, plant and animal cells; cell organelles, structure and function; cell membrane, Levels of organization: cells, tissues, organs, systems & organisms.

Module 2: Transport Phenomena in Biological Systems:

Module 3: Engineering perspectives of biological sciences:
Biology and engineering, crosstalk – At cell level: Hybridoma, technology, At tissue level: Plant Tissue Culture, Animal Tissue Culture; Tissue Engineering: Principles, methods and applications, Nano biotechnology.

Module 4: Introduction to Biomimetics:
Introduction to Biomimetics and Biomimicry, Biomimetic Principles, steps in biomimetic method, Biomimetic Material and working principle.

Module 5: Biomimetic sensors:

Module 6: Biomimetic actuators:
EAP (Electroactive polymers), Artificial Muscles, Biomimetic applications of electrochemical actuators, materials used for actuators, Hydrogel actuators and Sensors for biomedical soft robots, 3D printing Magnetic actuators, Biomimetic Actuation device and System, Control of Biomimetic System, Non Muscular Biomimetic Actuator based on electrodynamic swelling.

Suggested Text Books:
Suggested Reference Books:


Course Outcomes:

At the end of this course, the students will be able to:

- Understand basic biological principles and organizational structure of living systems at molecular level.
- Know Energy transformations and information processing in biological systems.
- Appreciate biological processes with an engineering perspective.
- Know about Different Biomimetic sensors.
- Impart knowledge about the common corridors of biology and engineering and biologically inspired technologies.
- Comprehend basic biological principles and organizational structure of living systems at cellular level.

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Detailed Content:

Module 1: Introduction to Machine Learning:

Module 2: Supervised Learning:
Linear and Nonlinear examples, Multi-Class & Multi-Label classification, Linear Regression, Multilinear Regression, Naïve Bayes Classifier, Decision Trees, ID3, CART, Error bounds.

Module 3: Classifiers:

Module 4: Unsupervised Learning:
Clustering basics (Partitioned, Hierarchical and Density based), K-Means clustering, K-Mode clustering, Self-organizing maps, Expectation maximization, Principal Component Analysis.

Module 5: Evaluation Metrics and ensemble learning:
ROC Curves, Evaluation Metrics, Significance tests, Error correction in Perceptrons - Bagging and Boosting (Random forests, Adaboost, XG boost inclusive).

Module 6: Machine learning process in practice:
Data collection, Preprocessing (Missing values, Normalization, adopting to chosen algorithm etc.,), Outlier Analysis (Z-Score), Model selection & evaluation, Optimization of tuning parameters, Setting the environment, Visualization of results.

Suggested Text Books:

Suggested Reference Books:
Course Outcomes:
At the end of this course, the students will demonstrate the ability to:

- Understand, visualize, analyze and preprocess the data from a real-time source.
- Apply appropriate algorithms to the data.
- Analyze the results of the algorithm and convert to appropriate information required for the real-time application.
- Evaluate the performance of various algorithms that could be applied to the data and to suggest the most relevant algorithm according to the environment.

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Module 1: Anatomy of Robotic system:
links and joints in robots, types of joints, end effectors, concept of degrees of Freedom and its calculations.

Module 2: Sensors:

Module 3: Vision Sensors:

Module 4: Advanced Sensor Technology:
Smart sensors, MEMS based sensors, Innovations in sensor technology Actuators and its selection while designing a robot system. Types of transmission systems.

Module 5: Electric Actuators:
Direct current motor, Permanent magnet stepper motor, Servo Control DC motors, Linear and latching linear actuators, Rotary actuators, Piezoelectric actuators, Actuator parameters and characteristics, Stepper motors, Specifications and characteristics of Stepper Motors Servo Motors.

Module 6: Pneumatic & Hydraulic actuators:
Hydraulic and pneumatic power actuation devices:
Hydraulic Actuators, selection of linear actuating cylinders, Hydraulic Motors, Pneumatic actuators, design considerations and selection, pneumatic cylinders, pneumatic drive system, Linear & rotary actuators. Advanced actuators – Piezoelectric actuators, elastomer actuators, soft actuators, shape memory alloy based actuators, under actuated robotic hand.

Suggested Text Books:


Suggested Reference Books:

Course Outcomes:

At the end of this course, the students will be able to:

- Analyze sensory systems in robotics.
- Select the sensor for robotic application and design the systems.
- Analyze actuators and configuring the parameters of Actuators.
Course Content:

Module 1: Fundamentals of Microprocessors:
Fundamentals of Microprocessor architecture, 8-bit Microprocessor and Microcontroller architecture, comparison of 8-bit microcontrollers, 16-bit and 32-bit microcontrollers, definition of embedded system and its characteristics, role of microcontrollers in embedded systems, overview of the 8051 family, introduction to ARM7, Intel I (i3, i5, i7) series processors.

Module 2: The 8051 Architecture:
Internal Block Diagram, CPU, ALU, address, data and control bus, working registers, SFRs, Clock and RESET circuits, Stack and Stack Pointer, Program Counter, I/O ports, RAM- ROM organization, Memory Structures, Data and Program Memory, Timing diagrams and Machine Cycles.

Module 3: Instruction Set:
Addressing modes: Instruction syntax, Data types, Subroutines Immediate addressing, Register addressing, Direct addressing, Indirect addressing, Relative addressing, Indexed addressing, bit inherent addressing, bit direct addressing, 8051 Instruction set, Instruction timings, Data transfer instructions, Arithmetic instructions, Logical instructions, Branch instructions, Subroutine instructions, Bit manipulation instruction, Interrupts.

Module 4: Programming:
Assembly language programs, C language programs, Assemblers and compilers, Programming and debugging tools.

Module 5: I/O and External Communication Interface:
Memory and I/O expansion buses, control signals, memory wait states. Interfacing of peripheral devices such as General Purpose I/O, timers, counters, memory devices, Synchronous and Asynchronous Communication, serial communication, RS232, SPI, I2C. Introduction and interfacing to protocols like Blue-tooth and Zig-bee.

Module 6: Applications:
LED, LCD and keyboard interfacing, Stepper motor interfacing, DC Motor interfacing, sensor interfacing, Analog-to-Digital Convertors, Digital-to-Analog Convertors, Sensors with Signal conditioning Interface.

Suggested Text Books:


Suggested Reference Books:

Course Outcomes:

At the end of this course, the students will demonstrate the ability to:

- Comprehend and analyze architectures of microprocessors, microcontroller and ARM7 processor.
- Comprehend the memory organization of 8051 microcontrollers.
- Showcase the skill, knowledge and ability of programming using instruction set.
- Comprehend and use peripheral serial communication and the concepts of interrupts in 8051 microcontrollers.
- Interface 8051 microcontroller with the input and output devices such as LEDs, LCDs, 7-segment display and keypad.
- Design 8051 microcontroller based system with analog-to-digital converters and digital-to-analog converters within realistic constraints like user specification, availability of components etc.
Course Content:

Module 1: Introduction to Signals and Systems:
Signals and systems as seen in everyday life, and in various branches of engineering and science. Signal properties: periodicity, absolute integrability, determinism and stochastic character. Some special signals of importance: the unit step, the unit impulse, the sinusoid, the complex exponential, some special time-limited signals; continuous and discrete time signals, continuous and discrete amplitude signals. Classification of systems - Static and dynamic, Linear and nonlinear, Time-variant and time-invariant, Causal and non-causal, Stable and unstable, Impulse response and step response of systems. System properties: linearity: additivity and homogeneity, shift-invariance, causality, stability, realizability.

Module 2: Behavior of continuous and discrete-time LTI systems:

Module 3: System Analysis of Fourier Transforms:

Module 4: System Analysis of Laplace Transform:
Relation between Laplace and Fourier transforms, Review of the Laplace Transform for continuous time signals and systems, system functions, poles and zeros of system functions and signals, Laplace domain analysis, Inverse Laplace transform, solution to differential equations and system behavior.

Module 5: System Analysis of z-Transforms:
The z-Transform for discrete time signals and systems, system functions, poles and zeros of systems and sequences, z-domain analysis, s-plane to z-plane mapping, Inverse z-transform, Solution to difference equations using z-transform, Region of convergence, Stability analysis.

Module 6: Sampling and Reconstruction:

Suggested Text Books:

Suggested Reference Books:


Course Outcomes:

At the end of the course, the students will be able to:

- Classify systems based on their properties: in particular, to understand and exploit the implications of linearity, time-invariance, causality, memory, and bounded-input, bounded-output (BIBO) stability.
- Analyze and realize discrete system using z transform.
- Determine Fourier transforms for continuous-time and discrete-time signals (or impulse-response functions), and understand how to interpret and plot Fourier transform magnitude and phase functions.
- Understand the sampling theorem and how it links continuous-time signals to discrete-time signals.
Course Content:

Module 1: Introduction to Robot Safety:

Module 2: Robot Accidents:

Module 3: Robot Safety and Safety devices:

Module 4: Human Factors in Robotics:

Module 5: Robot Maintenance:

Module 6: Safety Standards for Robotic Technology:
Suggested Text Books:


Suggested Reference Books:


Course Outcomes:

At the end of this course, the students will be able to:

- Understand the safety factors of robots.
- Know the safety standards in case of Robots.
- Understand the concept of how to do maintenance.
- Analyze and rectify the Human errors causing accidents.

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Course Content:

- Robot Gripper design and considerations.
- Touch Sensors interfacing and feedback system.
- Manipulator kinematics analysis.
- Use of object detection and Image processing using Vision sensors in Robot system.
- Trajectory planning and analysis.
- Pick and place / path tracking using robot.
- Virtual lab experiments on Robot kinematics for Movemaster, PUMA 560 and KGP 50: http://vlabs.iitkgp.ernet.in/mr/

Suggested Text Books:


Suggested Reference Books:


Course Outcomes:

At the end of this course, the students will be able to:

- Design a gripper for different applications using design considerations.
- Learn working of touch sensors and their interfacing and feedback.
- Perform kinematic analysis.
- Perform trajectory planning.
- Detect the object and path tracing using vision sensor.

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Detailed Content:

List of Practical: Based on 8051 and PIC microcontroller mini-cards/kits by downloading the binary file in flash memory:

- Assignment exploiting the various addressing modes for accessing internal as well as external memory and unconditional/conditional branch, loop control instructions.
- Stack and Stack arithmetic operations, Subroutines and parameter passing via register, stack.
- Timers and its applications, PWM generation.
- Serial Communication.
- Interfacing – Push buttons LEDs Key Matrix Seven segment display LCD ADC/DAC Stepper motor.

Suggested Text Books:


Suggested Reference Books:


Course Outcomes:

At the end of laboratory course, the students will demonstrate the ability to:

- Understand and apply the fundamentals of assembly level programming of microprocessors and microcontrollers.
- Work with microcontroller real time interfaces including GPIO, serial ports, digital-to-analog converters and analog-to-digital converters.
- Analyze problems and apply a combination of hardware and software to address the problem.
Detailed Content:

- List of experiments to be performed on Matlab.
- To find convolution of two sequences.
- To check linearity property of Fourier transform.
- To check whether the system $y[n] = \cos(x[n])$ is time varying or time-invariant.
- To find Fourier transform of given sequence.
- To plot unit delta sequence, unit step sequence & unit ramp sequence.
- To study convolution property of Fourier transform.
- To study Discrete Fourier transform.
- To study inverse Discrete Fourier transform.
- To study time-shift property of Fourier transform.

Suggested Text Books:


Suggested Reference Books:


Course Outcomes:

At the end of the course, the students will demonstrate the ability to:

- Understand the concepts of ‘Signals and Systems’ by experimentation.
- Develop application based knowledge on theoretical concepts learned.
Guidelines:

- The mini-project is a team activity having 3-4 students in a team. Mini projects should include mainly Mechanical Engineering but can be multi-disciplinary too.
- The mini project may be a complete hardware or a combination of hardware and software. The software part in the mini project should be less than 50% of the total work.
- Mini Project should cater to a small system required in laboratory or real life.
- It should encompass components, devices etc. with which functional familiarity is introduced.
- After interactions with course coordinator and based on comprehensive literature survey/need analysis, the student shall identify the title and define the aim and objectives of the mini-project.
- Students are expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and submit the proposal within the first week of the semester.
- The student is expected to exert on design, development and testing of the proposed work as per the schedule.
- Completed mini project and documentation in the form of mini project report is to be submitted at the end of semester.

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

- Conceive a problem statement either from rigorous literature survey or from the requirements raised from need analysis.
- Design, implement and test the prototype/algorithm in order to solve the conceived problem.
- Write a comprehensive report on mini project work.
Detailed Content:

- Introduction to concepts of creativity / invention / innovation and their importance in the present knowledge world. Components of the creative process, Analogy/model to represent the creative process.
- Understanding persons’ Creative potential. Blockages in practicing the creative process – Mindset and belief systems. Myths and misconceptions about creativity.
- Practical Tips to discover and apply one’s creative potential, remove blockages, deal with external factors. Importance of synergistically working in a team. Harnessing creativity from nature.
- Applications Exercise / Assignment: at the end of the course, the student will create teams, present their innovative ideas, and apply their learning in practice.

Suggested Text Books:


Suggested Reference Books:


Course Outcomes:

At the end of the course, the students will demonstrate the ability to:

- Understand creativity and innovation terminologies.
- Explore personal and organizational roadblocks in participating in the creative process.
- Apply practical tips to discover the innovative potential within the human being.
- Study frameworks, strategies, techniques for conceiving ideas.
- Develop new ways of thinking and Learn the entire innovation cycle.
- Understand different ways to protect innovation, basics on Patents and process.
- Apply techniques learnt in the course to articulate, refine and pitch a new product or service project.

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SEMESTER – V
Course Content:

Module 1: Introduction:

Module 2: Stacks and Queues:
ADT Stack and its operations: Algorithms and their complexity analysis, Applications of Stacks: Expression Conversion and evaluation – corresponding algorithms and complexity analysis. ADT queue, Types of Queue: Simple Queue, Circular Queue, Priority Queue; Operations on each types of Queues: Algorithms and their analysis.

Module 3: Linked Lists:
Singly linked lists: Representation in memory, Algorithms of several operations: Traversing, Searching, Insertion into, Deletion from linked list; Linked representation of Stack and Queue, Header nodes, Doubly Linked List: operations on it and algorithmic analysis; Circular Linked Lists: all operations their algorithms and the complexity analysis.

Module 4: Trees:
Basic Tree Terminologies, Different types of Trees: Binary Tree, Threaded Binary Tree, Binary Search Tree, AVL Tree; Tree operations on each of the trees and their algorithms with complexity analysis. Applications of Binary Trees. B Tree, B+ Tree: definitions, algorithms and analysis.

Module 5: Sorting, Hashing and Graph:
Objective and properties of different sorting algorithms: Selection Sort, Bubble Sort, Insertion Sort, Quick Sort, Merge Sort, Heap Sort; Performance and Comparison among all the methods, Hashing. Basic Terminologies and Representations in graph, Graph search and traversal algorithms and complexity analysis.

Suggested Text Books:


Suggested Reference Books:

Course Outcomes:

At the end of this course, the students will demonstrate the ability to:

- Analyze the algorithms to determine the time and computation complexity and justify the correctness.
- Implement for a given Search problem (Linear Search and Binary Search).
- Implement for a given problem of Stacks, Queues and linked list it and Analyze the same to determine the time and computation complexity.
- Write an algorithm Selection Sort, Bubble Sort, Insertion Sort.
- Quick Sort, Merge Sort, Heap Sort and compare their performance in terms of Space and Time complexity.
- Implement Graph search and traversal algorithms and determine the time and computation complexity.

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Course Content:

**Module 1: Fundamentals of Kinematics and mechanisms:**

**Module 2: Velocity and Acceleration Analysis in Mechanisms:**

**Module 3: Static and Dynamic Force Analysis:**

**Module 4: Simple stresses and strains:**

**Module 5: Fundamental aspect of design:**
Types of loads, static, shock, impact and fluctuating loads, types of stresses, tensile, compressive, direct and torsional shear, bending stresses. Combined effect of direct, bending and torsional stresses. Design concepts, material and process selection design process, factor of safety & design codes, materials. Design of shafts and different types of levers based on torsional and lateral rigidity, combined loadings. Design of keys, keyways and splines. Standard threads, stresses in threads, preloaded fasteners in tension, joint stiffness factor, power screws.

**Module 6: Introduction to Gears:**

**Suggested Text Books:**

Suggested Reference Books:


Course Outcomes:

At the end of this course, the students will be able to:

- Draw velocity and acceleration diagrams for simple and complex mechanisms.
- Use graphical and analytical methods for solving problems in static and dynamic force analysis.
- Apply basic concepts and theory regarding friction, lubrication, belt, rope and chain drives.
- Evaluate the different types of stresses induced in a component due to different types of static loading conditions.
- Apply the principles of static loading to design couplings, screws, springs and welded joints.
- Apply balancing concept to various types of rotating and reciprocating machine element.
Detailed Content:

**Module 1: Conventional DC and AC Traction:**
Electric traction services, Nature of traction load, Coefficient of adhesion, Load sharing between traction motors, Main line and suburban train configurations, Calculation of traction drive rating and energy consumption. Important features of traction drives, Conventional DC and AC traction drives, Diesel electric traction.

**Module 2: Switched Mode Power Supplies (SMPS):**
DC Power supplies and Classification; Switched mode dc power supplies - with and without isolation, single and multiple outputs; Closed loop control and regulation; Design examples on converter and closed loop performance.

**Module 3: AC-DC Converters:**
Switched mode AC-DC converters. synchronous rectification - single and three phase topologies - switching techniques - high input power factor. reduced input current harmonic distortion. improved efficiency. with and without input-output isolation. performance indices design examples.

**Module 4: DC-AC Converters:**
Multi-level Inversion - concept, classification of multilevel inverters, Principle of operation, main features and analysis of Diode clamped, flying capacitor and cascaded multilevel inverters; Modulation schemes.

**Module 5: AC-AC Converters:**
Matrix converters. Basic topology of matrix converter; Commutation – current path; Modulation techniques - scalar modulation, indirect modulation; Matrix converter as only AC-DC converter; AC-AC converter with DC link - topologies and operation - with and without resonance link - converter with dc link converter; Performance comparison with matrix converter with DC link converters.

**Module 6: Soft-Switching Power Converters:**
Soft switching techniques. ZVS, ZCS, quasi resonant operation; Performance comparison hard switched and soft switched converters.AC-DC converter, DC-DC converter, DC-AC converter.; Resonant DC power supplies.

**Suggested Text Books:**


**Suggested Reference Books:**

Course Outcomes:

At the end of this course, the students will demonstrate the ability to:

- Simulate and analyze the semiconductor controlled ac and DC drive system.
- Equip the skill to design and develop a regulated power supply.
- Suggest converters for AC-DC conversion and SMPS.
Course Content:

Module 1: Humanoid Robotics Technology and Social Robots:

Module 2: Swarm Robotics:

Module 3: Human Robot Interaction (HRI):

Module 4: Industry 4.0 and Internet of Robotic things (IORT):
Introduction, Internet of Things and Robotics, Applications and developments of the Internet of Robotic Things.

Module 5: Natural Language Processing:
Introduction, Classical Approaches to Natural Language Processing, Text Preprocessing, Lexical Analysis, Syntactic Parsing, Semantic Analysis, Natural Language Generation, Applications.

Module 6: Logics for AI and Automated Reasoning:
What is Automated Reasoning, methods of Reasoning, reasoning types, use of Automated reasoning in AI, Reasoning and its types, applications for Automated Reasoning, Mathematical consideration.

Suggested Text Books:


Suggested Reference Books:

(i) S. Mukherjee, Robotics Process Automation, Khanna Book Publishing, 2021
(ii) Dr. Rajiv Chopra, Data Science with AI, ML, DL, Khanna Book Publishing, 2023

Course Outcomes:

At the end of this course, the students will able to:
- Understand the technologies used in advanced robots.
- Understand the technology used in Natural Language processing.
- Study NLP techniques and understand its utility in industrial applications.
- Apply automated reasoning in AI based programming.

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Course Content:

Module 1: Introduction to Control System:
Introduction to control system block diagram. Importance of Control Systems. Components of control. Explanation with the help of the liquid level control system. Significance of actuators and sensors. Types of actuators, Types of sensors. Open loop control and closed loop control. Use of relays, switches and contactors for simple and sequential control systems.

Module 2: Control system representation:
Mathematical representation of simple mechanical, electrical, thermal, hydraulic systems. Block diagram representation and reduction. Signal flow graph. Transfer function of these systems. Pole zero concepts.

Module 3: Time domain analysis:
Time response of first order, second order systems. Analysis of steady state error, Type of system and steady state error, Time response specifications. Effect of parameter variation on open loop and closed loop system response, sensitivity. Effect of feedback on system response, stability and disturbance.

Module 4: Stability:

Module 5: Control system analysis in frequency domain:
Concept of frequency domain behavior, Bode Plot for analyzing systems in frequency domain. Frequency domain performance specifications. Correlation between time domain and frequency domain specification. Nyquist Analysis.

Module 6: State Space Approach:
Representation of system in state space, Converting transfer function model into state space model. Non uniqueness of state space model, Canonical representation, Eigenvalues, Solution of state equations, Concept of State feedback control, controllability, Observability.

Suggested Text Books:


Suggested Reference Books:

Course Outcomes:

At the end of this course, the students will demonstrate the ability to:

- Appreciate the role of the control system.
- Analyze the mathematical model of the control system.
- Solve to get a time domain response.
- Analyze stability of the system.
- Use bode plot for frequency domain analysis.
- Analyze the control system in state space.

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Detailed Course Content:

**Module 1: Introduction:**

**Module 2: Fluid Power Systems:**

**Module 3: Control Valves:**
Fluid power control elements and standard graphical symbols, Directional, Pressure and Flow Control Valves – Construction and Working, Rotary Valves, Pilot-Operated Valves Servo-valves.

**Module 4: Hydraulic and Pneumatic Power Supplies:**
Hydraulic Power Packs, Hydraulic Loading Valve and Filters, Air Compressors & Receivers, Air Treatment and FRL Units, Pressure Regulation in Fluid Power Circuits.

**Module 5: Fluid Power Actuators:**
Linear actuators and their Construction, Rotary actuators and their Construction, Mounting Arrangements, Cylinder Dynamics, Speed Control.

**Module 6: Fluid Power Circuits & Control:**

**Suggested Text Books:**


**Suggested Reference Books:**

Course Outcomes:

After the completion of this course, the students will be able to:

- Select a fluid power actuation system for a given robotic application.
- Select components for designing a fluid power circuit.
- Assemble and operate a fluid power actuation system.
- Design fluid power actuation system for robotic application.

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Experiments:
- To study input output characteristic of various control system components.
- To obtain step response and find time response specification of electrical system, hydraulic system, pneumatic system and thermal system.
- To obtain transfer function and poles zeros of DC motor experimentally.
- To obtain root locus experimentally.
- Use Matlab to study the effect of feedback gain on system response.
- Use Matlab to study the effect of damping factor zeta on time control performance specifications.
- Use Matlab to obtain root locus for a given system and find performance specifications there from. Study effect of addition of zero and pole on root locus.
- Use Matlab to get a bode plot and obtain gain margin and phase margin for various systems.
- Use Matlab to obtain state space representation from transfer function, find Eigenvalues, Analyze controllability, observability and stability.

Suggested Text Books:

Suggested Reference Books:

Course Outcomes:
At the end of this course, the students will demonstrate the ability to:
- Develop the mathematical model of different components of linear feedback control system using simulation and experiments.
- Analyze the transient characteristics of different first order and second order systems using simulation and experiments.
- Determine the performance of system using root locus.
- Carry out the stability analysis of linear feedback control system using Bode plot and Nyquist plot.
- Carry out the stability analysis of linear feedback control system using Modern control techniques.
- Analyze the different types of controllers like PI, PD, PID and tuning of these controllers using simulation and experiments.
- Describe various applications like temperature controller experimentally.
- Demonstrate an industrial application (like Bottle filling/ Pick and Place control) using PLC Write and present effective technical reports.

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Detailed Content:

- Study of CRO and its applications - measurement of frequency, phase difference, voltage, vibration signals, temperature measurement using thermocouple etc. Instruments: 20 MHz dual trace CRO, Function-generator.
- Study of UPS systems Instruments: UPS kit, CRO, DMM.

Or

- Controlled rectifiers using SCR with UJT triggering for Lamp load. Instruments: Power-Scope, DMM.
- Op-Amp as comparator and Schmidt trigger.
- Instruments: Dual trace CRO, Dual Power supply, Function Generator.
- Sequential timer using IC555 and square wave generator Instruments: Power supply, Dual trace CRO, stop-watch.
- Application of logic gates (One-bit Comparator) and combinational circuits, e.g. traffic lights, combinational lock lift, control, code conversion.
- PLC Programming.
- Shift register IC7495 and its application as a sequence generator.

Or

- Programmable counter (frequency and time measurement).
- Instruments for digital experiments: Power supply, dual trace CRO, Pulse generator, DMM.
- Minimum two circuits of level detector, proximity detector, electronic weighing machine, non-contact type, Tachometer Annunciator.

Or

- Study and demonstration of resistance welding, R.F. Heating.

Suggested Text Books:


Suggested Reference Books:

Course Outcomes:

At the end of the laboratory work, the students will demonstrate the ability to:

- Perform basic Electrical Machines experiments and evaluate their suitability for a specified job from their electrical and mechanical characteristics.
- Get hands-on experience in using op amps and timer circuits in industrial electronics experiments.
- Predict, analyze, and test the performance of sensors of various kinds, including strain gages, thermocouples, tachometers, displacement transducers, dynamometers, pressure gages and transducers, Flow meters etc. Understand working of fully controlled half wave rectifier and circuits using triacs.
**Suggested List of Assignments**

- Implement A* algorithm.
- Implement AO* algorithm.
- Implementation of other Searching algorithms.
- Implementation of Min/MAX search procedure for game Playing.
- Implementation of variants of Min/Max search procedure.
- Implementation of a mini Project using the concepts studied in the AI course.

This list is a guideline. The instructor is expected to improve it continuously.

**Suggested Text Books:**


**Suggested Reference Books:**


**Course Outcomes:**

Upon successful completion of the course, the students will be able to:

- Develop an Explanation of what is involved in learning models from data.
- Implement a wide variety of learning algorithms.
- Apply principles and algorithms to evaluate models generated from data.
- Apply the algorithms to a real-world problem.

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PRACTICE TASKS

- To study components and functioning of a hydraulic power pack.
- To study components and functioning of a pneumatic fluid power supply.
- To study different types of DC control valves and actuators in hydraulic fluid power systems.
- To study different types of DC control valves and actuators in pneumatic fluid power systems.
- To study the working of speed and pressure control valves in fluid power circuits.
- To study a pneumatic logic circuit using a pilot operated DC valve.
- To operate a linear hydraulic actuator using 4/2 and 4/3 DC valves.
- To operate rotary pneumatic or hydraulic motors using two and three position DC valves.
- To operate single acting and double acting linear pneumatic actuators using 3/2 and 5/2 DC electro pneumatic valves respectively.
- To study the application of fluid power circuits in robots.

Suggested Text Books:


Suggested Reference Books:


Course Outcomes:

After the completion of this Lab, the students will be able to:

- Select a suitable DC control valve.
- Select a suitable actuator for a given robotic application.
- Understand the functioning of different valves, actuators and fluid power circuits.
- Design fluid power actuation system for robotic application.
LC RAI-505 | Theory of Machines & Mechanism Laboratory | 0L:0T:2P | 1 credit

Detailed Content:

List of Experiments (Any 3 experiments from the given list):

- Determination of Moment of Inertia of rigid bodies by bifilar or trifilar suspension method.
- Compound Pendulum.
- Experimental Verification of displacement relation for different shaft angles for single Hooke's Joint.
- Developing a computer program for velocity and acceleration of the slider crank mechanism.
- Graphical solution of problems on velocity & acceleration in mechanisms by Relative velocity & relative acceleration method including problem with Coriolis component of acceleration.
- Graphical solution of problems on velocity in mechanisms by ICR method.
- Klein’s constructions for the slider crank mechanism.
- Inertia force analysis with graphical methods.
- Straight line motion mechanisms.

Suggested Text Books:


Suggested Reference Books:


Course Outcomes:
At the end of the laboratory work, students will demonstrate the ability to:

- Determine Moment of Inertia of rigid bodies by bifilar or trifilar suspension method.
- Verify displacement relation for different shaft angles for single Hooke's Joint.
- Develop a computer program for velocity and acceleration of slider crank mechanism Non-destructive tests like Magnaflux testing, Dye penetrant test and Ultrasonic test.
- Graphical solution to problems on velocity & acceleration in mechanisms by Relative velocity & relative acceleration method including problem with Coriolis component of acceleration.
- Analyzing Inertia force with graphical methods.

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SEMESTER – VI
SEMESTER VI

PCC RAI-601  Kinematics of Robotics  3L:0T:0P  3 credits

Pre-Requisites  Basic Engineering Mathematics  Engineering Mechanics

Course Content:

Module 1: Introduction
Vector Representations and Operations, Transformations, Translational and Rotational, Coordinate Reference Frames, Properties of Transformation Matrices, Matrix Creation and Manipulation using MATLAB.

Module 2: Homogeneous Transformations
Pure Translation, Pure Rotation about an Axis, Representation of Combined Transformations, Transformations Relative to a Moving Frame, Homogeneous Transformations using MATLAB.

Module 3: Kinematics:
Kinematic Parameters, The Denavit-Hartenberg (DH) Representation, Forward & Inverse Kinematic Equations: Position, Cartesian Coordinates, Cylindrical Coordinates, Spherical Coordinates, Articulated Coordinates, Kinematics of Industrial Robots, Kinematics using MATLAB.

Module 4: Forward & Inverse Kinematic:

Module 4: Velocity & Acceleration Analysis:

Suggested Text Books


Suggested Reference Books

AICTE Model Curriculum for UG Degree Course in Robotics & Artificial Intelligence Engineering


Course Outcomes:
After the completion of this course, the students will be able to:

- Explain position and orientation parameters for describing the pose of industrial robots.
- Apply mathematical tools for solving robot kinematics problems.
- Assign the coordinate frames to industrial robots and derive their forward and inverse kinematic equations.
- Use software tools for obtaining solutions to forward and inverse kinematics problems.

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Course Content:

Module 1: ARM-Cortex Series Architecture:
Embedded systems, classification, ARM 32-bit microcontroller Tiva, architecture technology overview, Architectural Features of ARM Cortex M series: Tiva Block Diagram, CPU modes, register organization, ROM, RAM, timers, data and address bus, Memory and I/O interfacing concepts, memory mapped I/O. CISC Vs RISC design philosophy, Von-Neumann Vs Harvard architecture, instruction set, pipelining, exceptions and its handling, memory, I/O’s and addressing modes.

Module 2: Operating system based development:
Operating systems fundamentals, operating system services, memory management, process management, device management, file management, operating system services- program execution, I/O operation, file manipulation, communication, operating system properties- multitasking, parallel programming, interactivity, scheduling and scheduling algorithms. Linux: An overview of Red Hat Linux, installing Ubuntu, Linux commands, shell script programming, embedded Linux.

Module 3: Development Tools (Open Source):
GNU tools, text editors-vi, nano, pico, etc. IDE-Eclipse, code lite, compilers-gcc, g++, debuggers, cross-compilers, gcc- arm specific tool chains and in line assembly, Writing and compiling C/C++ programs, cross-compilation for ARM development board, Basics of make file, static and dynamic libraries.

Module 4: Kernel programming:
Kernel, basic functionalities of kernel, kernel module programming, Linux kernel sources, kernel configuration, booting kernel, kernel booting parameters, root file system, bootloader, U- boot, porting Linux ARM board, device driver programming, architecture, I/O communication, writing simple character device driver.

Module 5: RTOS:
RTOS concepts using Tiva: foreground and background systems, critical section, shared resources, tasks, multitasking, context switching, kernels, pre-emptive and non- pre-emptive schedulers, static and dynamic priorities, priority inversion, mutual exclusion, synchronization, inter task communication mechanisms, Interrupts: latency, response and recovery, clock tick, memory requirements.

Module 6: Interfacing and application development
Interfacing of peripherals using Tiva: LED and sensors, ADC, Timer, PWM, UART, SPI, I2C. Development of web server, wireless module interfacing, camera interfacing, open CV on Beagle Bone Black. Control application, Java programming on Beagle Bone Black, porting android for mobile applications like controlling Beagle Bone Black I/O through mobile.

Suggested Text Books:


Suggested Reference Books:


Course Outcomes:

- Hands on usage of IDE of processors and algorithm development.
- To understand the concept of OS, RTOS and application perspectives.
- Understanding of RISC architecture of processor, its features and application.
- Study, design, analyze and prototype various embedded systems.
Detailed Course Content:

**Module 1: Introduction to Data Science**

**Module 2: Predictive Modeling and Machine Learning**

**Module 3: Data Mining Techniques**

**Module 4: Frameworks and Visualization**

**Module 5: Data Science Using Python**

**Suggested Text Books:**
Suggested Reference Books:


Course Outcomes:

At the end of this course, students will demonstrate the ability to:

● Work with a data science platform and its analysis techniques.
● Design efficient algorithms for mining the data from large volumes.
● Model a framework for Human Activity Recognition.
● Development with cloud databases.

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Detailed Course Content:

**Module 1: Statics and Manipulator Design**
Forces and Moments Balance, Equivalent Joint Torques, Role of Jacobian in Statics, Manipulator Design.

**Module 2: Dynamics**

**Module 3: Robot Configuration Space**
Specifying a Robot's Configuration, Obstacles and the Configuration Space, The Dimension of the Configuration Space, The Topology of the Configuration Space, Example Configuration Spaces, Transforming Configuration and Velocity Representations.

**Module 4: Trajectory Planning**
Path and Trajectory, Basics of Trajectory Planning, Joint Space Trajectory Planning, Cartesian Space Trajectory Planning, Point-to-Point vs Continuous Path Planning.

**Module 5: Motion Control System**

**Suggested Text Books:**


**Suggested Reference Books:**


Course Outcomes:

After the completion of this course, the students will be able to:

- Formulate dynamic models of industrial robots.
- Formulate robot motion planning models using different schemes.
- Understand the theory and components of open and closed loop control systems.
- Understand different types of robot motion control approaches.

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Detailed Course Content:

Module 1:
Introduction, the history of knowledge-based expert systems, Characteristics of current expert systems, Basic concepts for building expert systems.

Module 2:
Building and Expert System, the architecture of expert systems, constructing an expert system, including computer inference and knowledge acquisition.

Module 3:
Knowledge representation schemes; conceptual data analysis; plausible reasoning techniques, Tools for building expert systems.

Module 4:
Evaluating an Expert System, Reasoning about reasoning, validation and measurement methods.

Module 5:

Module 6: A Case Study in Knowledge Engineering.

Suggested Text Books:

Suggested Reference Books:

Course Outcomes:
At the end of the course the students will be able to:

- Explain and describe the concepts central to the creation of knowledge bases and expert systems.
- Use the tools and the processes for the creation of an expert system.
- Conduct an in-depth examination of an existing expert system with an emphasis on basic methods of creating a knowledge base.
- Examine properties of existing systems in a case-study manner, comparing differing Approaches.
- Demonstrate proficiency developing applications in expert system shell.
Laboratory Experiments:

1. Endowing mobile autonomous robots with planning, perception, and decision-making capabilities.
2. Trajectory optimization.
3. Robot motion planning and perception.
4. Robot, localization, and simultaneous localization and mapping.
5. Robot Operating System (ROS) for demonstrations and hands-on activities.

Suggested Text Books:


Suggested Reference Books:


Course Outcomes:

At the end of the course the students will be able to:

- Learn fundamentals, including key ROS concepts, tools, and patterns.
- Program robots that perform an increasingly complex set of behaviors, using the powerful packages in ROS.
- See how to easily add perception and navigation abilities to your robots.
- Integrate your own sensors, actuators, software libraries, and even a whole robot into the ROS ecosystem.
- Learn tips and tricks for using ROS tools and community resources, debugging robot behavior using C++ in ROS.
Detailed Course Content:

Module 1:

Module 2:
Kinematics and Dynamics of Wheeled Mobile Robots (two, three, four-wheeled robots, omni-directional and macanum wheeled robots). Sensors for localization: magnetic and optic position sensor, gyroscope, accelerometer, magnetic compass, inclinometer, GNSS and Sensors for navigation: tactile and proximity sensors, ultrasound rangefinder, laser scanner, infrared rangefinder, visual system.

Module 3:
Localization and Mapping in mobile robotics. Motion Control of Mobile Robots (Model and Motion based Controllers): Lyapunov-based Motion Control Designs and Case Studies. Understand the current application and limitations of Mobile Robots. Introduction to Mobile Manipulators and Cooperative Mobile Robots.

Module 4:

Module 5:

Suggested Reference Books:


Suggested Reference Books:


Course Outcomes:

At the end of the course students will be able to:

- Identify and design a suitable manufacturing process for micro robots.
- Understand the importance of visual perception and recognition for cybernetic view.
- Program a robot for wandering and teleoperation.

*****
Module 1: Fundamentals of Data Analytics
Descriptive, Predictive, and Prescriptive Analytics, Data Types, Analytics Types, Data Analytics Steps: Data Pre-Processing, Data Cleaning, Data Transformation, and Data Visualization.

Module 2: Data Analytics Tools

Module 3: Data Pre-Processing
Understanding the Data, Dealing with Missing Values, Data Formatting, Data Normalization, Data Binning, Importing and Exporting Data in Python, Turning categorical variables into quantitative variables in Python, Accessing Databases with Python.

Module 4: Data Visualization
Graphic representation of data, Characteristics and charts for effective graphical displays, Chart types- Single variable: Dot plot, Jitter plot, Error bar plot, Box-and whisker plot, Histogram, Two-variable: Bar chart, Scatter plot, Line plot, Log-log plot, More than two variables: Stacked plots, Parallel coordinate plot.

Module 5: Descriptive and Inferential Statistics
Probability distributions, Hypothesis testing, ANOVA, Regression.

Module 6: Machine Learning Concepts
Classification and Clustering, Bayes’ classifier, Decision Tree, Apriori algorithm, K-Means Algorithm, Logistics regression, Support Vector Machines, Introduction to recommendation system.

Suggested Text books:


Suggested Reference Books:

Course Outcomes:

At the end of the course the students will be able to:

- Examine and compare various datasets and features.
- Analyze the business issues that analytics can address and resolve.
- Apply the basic concepts and algorithms of data analytics.
- Interpret, implement, analyze and validate data using popular data analytics tools.

*****
Detailed Course Content:

**Module 1:**

**Module 2:**

**Module 3:**

**Suggested Text Books:**

(ii) Pat Langley, “Computational Intelligence and Intelligent Systems”, 2006.

**Suggested Reference Books:**

Course Outcomes:

After completion of the course, the students will be able to:

- Summarize the concepts of computer integrated manufacturing systems and manufacturing communication systems.
- Identify various components of knowledge based systems.
- Demonstrate the concepts of artificial intelligence and automated process planning.
- Select the manufacturing equipment using knowledge based system for equipment selection.
- Apply various methods to solve group technology problems and demonstrate the structure for knowledge based system for group technology.

*****
Detailed Content:

Module 1: Introduction to Microprocessors:
Registers - File registers - Memory Organization - Tristate logic – Buses - Memory Address register – Read/Write operations. ROM, RAM, PROM, EPROM, E2PROM. Introduction to elementary processor – Organization - Data Transfer Unit (DTU)operation - Enhanced Data Transfer Unit (EDTU) – opcode - machine language - assembly language - pipeline and system clock. Architecture of 8085 – Addressing modes - Data transfer, data processing and program flow control instructions - Simple assembly language programs.

Module 2: Introduction to Microcontrollers:

Module 3: PIC Peripherals:

Suggested Text Books:


Suggested Reference Books:


Course Outcomes:

After completion of the course, the students will be able to:
- Understand the basic principles of Microcontroller based design and development.
- Design real world applications using Microcontroller.
- Understand interfacing technologies and its applications.
- Identify problem and strategy for designing the solution using appropriate microcontrollers.

*****
Laboratory Experiments:

1. Dynamic model development and simulation of simple mechanical systems using Matlab and Mathematica.
2. Numerical simulation of simple mechanical systems.
4. State space model development and dynamic simulation using Simulink.

Suggested Text Books:


Suggested Reference Books:


Course Outcomes:

After completion of the course, the students will be able to:

- Do Simulation in Matlab.
- Apply simulation theory concepts practically.
- Perform simulation of each task given to them.
Laboratory 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. Mailbox.
8. Interrupt performance characteristics of ARM and FPGA.
9. Flashing of LEDs.
10. Interfacing stepper motor and temperature sensor.
11. Implementing ZigBee protocol with ARM.

Suggested Text Books:


Suggested Reference Books:


Course Outcomes:

- Write programs in ARM for a specific Application.
- Interface memory and Write programs related to memory operations.
- Interface A/D and D/A convertors with ARM system.
- Analyze the performance of interrupt.
- Write programmes for interfacing keyboard, display, motor and sensor.
- Formulate a mini project using embedded system.

*****
Detailed Content:

- The mini-project is a team activity having 3-4 students in a team. Mini projects should include mainly Mechanical Engineering contains but can be multi-disciplinary too.
- The mini project may be a complete hardware or a combination of hardware and software. The software part in mini project should be less than 50% of the total work.
- Mini Project should cater to a small system required in laboratory or real life.
- It should encompass components, devices etc. with which functional familiarity is introduced.
- After interactions with course coordinator and based on comprehensive literature survey/ need analysis, the student shall identify the title and define the aim and objectives of the mini-project.
- Students are expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and submit the proposal within the first week of the semester.
- The student is expected to exert on design, development and testing of the proposed work as per the schedule.
- Completed mini project and documentation in the form of mini project report is to be submitted at the end of semester.

Course Outcomes:

At the end of the course, students will demonstrate the ability to:

- Conceive a problem statement either from rigorous literature survey or from the requirements raised from need analysis.
- Design, implement and test the prototype/algorithm in order to solve the conceived problem.
- Write a comprehensive report on mini project work.

*****
Course Education Objectives (CEO)

- To introduce and understand Entrepreneurship and its types.
- To understand how to evaluate risk in entrepreneurial ventures.
- To understand different type of finances available and financing methods.
- To understand marketing, digital marketing and their analytics.
- To understand detailed information about the principles, practices and tools involved in all aspects of the sales processes.
- To understand basics of operations management.
- To understand the nuances of Start-up.
- To understand how to use proven tools for transforming an idea into a product/service that creates value for others.

Suggested Textbook:


Course Outcomes:

At the end of the course, students will demonstrate the ability to:

- Students would understand different types of Entrepreneurial ventures and would be able to discover, develop, and assess opportunities.
- Students would learn about opportunity and risk analysis.
- Students would understand the strategies for valuing your own company, and how venture capitalist and angel investors use valuations in negotiating milestones, influence and control.
- Students would understand to pick correct marketing mix and how to position the company in the market by using analytical tools.
- Students would learn how to sale themselves and the product/service and to handle objections.
- Students would get to know how organizations operates and their process matrices.
- Students will learn how start new ventures.
- Students will learn how to write winning business plans.

*****
SEMESTER – VII
Detailed Course Content:

Module 1: Introduction:
Types of manufacturing systems and their characteristics, Computer aided Manufacturing (NC, CNC, DNC and adaptive control systems), Computer Network architectures and protocols, Industry 4.0 – Concept and elements.

Module 2: Computer Aided Engineering:

Module 3: Group Technology and Cellular Manufacturing:
Parts classification and part coding – approaches and systems, Benefits of group technology, Cellular manufacturing-basics, layout considerations, Cell formation approaches and evaluation of cell designs, Planning and control in cellular manufacturing.

Module 4: Flexible Manufacturing Systems:
FMS and its Components, Layout considerations in FMS, Material Handling in FMS.

Module 5: Reverse Engineering & Rapid Prototyping:

Module 6: Cloud Based Design & Manufacturing:
Internet of Things, Data Storage and Analytics, Cloud computing, Cyber-Physical Systems.

Suggested Text Books:


Suggested Reference Books:


Course Outcomes:
After the completion of this course, the students will be able to:

- Carry out modeling and analysis of simple components.
- Understand the operation of machines used in smart manufacturing.
- Comprehend the various CAM technologies and their features.
- Understand the various stages of product development from design to manufacturing including the interconnections in smart manufacturing.
Detailed Content:

Module 1: IoT Foundations:

Module 2: IoT Architecture and its Protocols:

Module 3: Sensors for IoT:
Sensing and actuation, types of sensors, Occupancy Sensors, Motion sensor, velocity, temperature, pressure, chemical, Gyroscopic sensor, Optical sensors, Humidity, Water Quality sensors, Sensor applications.

Module 4: Actuator for IoT:
Actuator types, working principle of actuators, integration of sensors and actuators with arduino, formation of actuators, selection criteria for right actuator, maintenance of actuators, smart material actuators.

Module 5: Applications of IoT in Robotics:
Future farming with the Internet of things, drones for surveillance, Soft low-power robotics, Tracking sensors for underwater robotics, Disaster response, Medical services, Smart restaurant, Analysis of IoT applications and Sensors, Space robotics for science and space exploration, Satellite based Internetworking, Tele operators, Space component systems like rover mobility, locomotion and guidance.

Module 6: Future of RIOT:
Powering insect-scale wireless robotics, Big data analysis, Augmented Reality, Additive manufacturing, Cyber security, the industrial internet of things, the cloud, Horizontal and vertical system integration, simulation, Autonomous robot.

Suggested Text Books:

AICTE Model Curriculum for UG Degree Course in Robotics & Artificial Intelligence Engineering


Suggested Reference Books:


Course Outcomes:
At the end of the course, the students will be able to:

- Understand the drivers and enablers of Industry 4.0.
- Appreciate the smartness in Smart Factories, Smart cities, smart products and smart services.
- Able to outline the various systems used in a manufacturing plant and their role in an Industry 4.0 world.
- Appreciate the power of Cloud Computing in a networked economy.
- Understand the opportunities, challenges brought about by Industry 4.0 and how organizations and individuals should prepare to reap the benefits.

*****
Detailed Course Content:

Module 1: Introduction Data Modeling:
Entity Relationship Model: Types of Attributes, Relationship, Structural Constraints – Relational Model, Relational model Constraints - Mapping ER model to a relational schema – Integrity constraint.

Module 2: Introduction to Data Visualization:
Overview of data visualization - Data Abstraction -Analysis: Four Levels for Validation- Task Abstraction - Analysis: Four Levels for Validation.

Module 3: Visualization Techniques:
Scalar and point techniques Color Maps Contouring Height Plots – Vector visualization techniques Vector Properties Vector Glyphs Vector Color Coding Stream Objects.

Module 4: Visual Analytics:
Visual Variables- Networks and Trees - Map Color and Other Channels- Manipulate View Arrange Tables Geo Spatial Data Reduce Items and Attributes.

Module 5: Types of Visual Analysis:
Time- Series data visualization -Text data visualization- Multivariate data visualization and case studies.

Module 6: Visualization Tools and Techniques:
Introduction to data visualization tools- Tableau - Visualization using R- Dashboard creation using visualization tools for the use cases: Finance-marketing-insurance- healthcare etc.

Suggested Text Books:


Suggested Reference Books:
Course Outcomes:

At the end of this course, students will demonstrate the ability to:

- Illustrate the design principles for data modeling, ER model and normalization and differentiate data types, visualization types to bring out the insight.
- Relate the visualization towards the problem based on the dataset.
- Identify and create various visualizations for geospatial and table data.
- Ability to visualize categorical, quantitative and text data. Illustrate the integration of visualization tools with hadoop.
- Ability to create and interpret plots using R/Python.

*****
Detailed Course Content:

Module 1: Image Formation and Representation:
Image acquisition, review of the digital camera, sampling and quantization, Image quality, Color Camera, Color Balance, Point Operators, Pixel transform, Color Transform, Histogram Equalization, Bandpass filters, 2D Convolution: Discrete & continuous, Segmentation: Edge detection, Linking, Thresholding, Region Based Segmentation.

Module 2: Shapes and Regions:
Binary shape analysis, connectedness, object labeling and counting, size filtering, distance functions, skeletons and thinning, deformable shape analysis, boundary tracking procedures, active contours, shape models and shape recognition – centroidal profiles, handling occlusion, boundary length measures, boundary descriptors, chain codes, Fourier descriptors region descriptors, moments.

Module 3: Hough Transform:
Line detection, Hough Transform (HT) for line detection, foot-of-normal method, line localization, line fitting, RANSAC for straight line detection, HT based circular object detection, accurate center location, speed problem, ellipse detection.

Module 4: Case study:
Human Iris location, hole detection, generalized Hough Transform (GHT), spatial matched filtering GHT for ellipse detection, object location, GHT for feature collation.

Module 5: 3D Vision and Motion:
Methods for 3D vision, projection schemes, shape from shading, photometric stereo, shape from texture, shape from focus, active range finding, surface representations, point-based representation, volumetric representations, 3D object recognition, 3D reconstruction, introduction to motion, triangulation, bundle adjustment, translational alignment, parametric motion, spline-based motion, optical flow, layered motion.

Module 6: Computer Vision Applications:

Suggested Text Books:


Suggested Text Books:


Course Outcomes:

At the end of this course, the students will demonstrate the ability to:

- Understand theory and models in image processing.
- Interpret and analyze 2D signals in Spatial and frequency domain through image transforms.
- Apply quantitative models of image processing for segmentation and restoration for various applications.
- Find shape using various representation techniques and classify the object using different classification methods.

*****
**Elective Course-II Autonomous Robotics and Telecherics**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>OEC RAI-701</td>
<td>Elective Course-II Autonomous Robotics and Telecherics (Tract: Robotics)</td>
<td>2</td>
</tr>
</tbody>
</table>

**Detailed Content:**

**Module 1:**
Introduction to the fundamentals of mobile robotics, basic principles of locomotion, Kinematics and Mobility, Classification of mobile robots, AI for Robot Navigation.
Introduction to modern mobile robots: Swarm robots, cooperative and collaborative robots, mobile manipulators, Current challenges in mobile robotics.

**Module 2:**

**Module 3:**
Telecheric robots – Concepts of teleoperations, Need and applications of Telecheric robots, Humanoid Robots, Swarm Robotics, Robot Applications and Ethics.

**Suggested Text Books:**


**Suggested Reference Books:**

(ii) Autonomous Mobile Robots, Edited by Shuzi Sam Ge, Frank L Lewis, Tylor and Francis, 2006

**Course Outcomes:**
At the end of this course, the students will be able to:
- Learn principles of working of autonomous robots.
- Demonstrating the sensing, perception, and cognition of autonomous robots.
- Understand the anatomy of autonomous robots.

*****
Detailed Content:

Module 1: Introduction:
Biological Neuron, Idea of computational units, McCulloch–Pitts unit and Thresholding logic, Linear Perceptron, Perceptron Learning Algorithm, Linear Separability. Convergence theorem for Perceptron Learning Algorithm.

Module 2: Neural Network:
Introduction to neural network and multilayer perceptrons (MLPs), representation power of MLPs, sigmoid neurons, gradient descent, feedforward neural networks representation, Backpropagation.

Module 3: Gradient Descent:

Module 4: Autoencoders:
Autoencoders, Regularization in autoencoders, De noising autoencoders, Sparse autoencoders, Contractive autoencoders, Regularization: Bias Variance Tradeoff, L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout, Greedy Layer Wise Pre-training, Better activation functions, Better weight initialization methods, Batch Normalization.

Module 5: Convolutional Neural Network:
Introduction to CNN, Building Blocks of CNN, Transfer Learning, LeNet, AlexNet, ZF-Net, VGGNet, GoogLeNet, ResNet, Visualizing CNNs, Guided Backpropagation, Fooling Convolutional Neural Network.

Module 6: Recurrent Neural Network:
Introduction to RCNN, Backpropagation through time (BPTT), Vanishing and Exploding Gradients, Truncated BPTT, Long Short Term Memory, Gated Recurrent Units, Bidirectional LSTMs, Bidirectional RNNs, Encoder Decoder Models, Attention Mechanism.

Suggested Text Books:

(ii) Dr. Rajiv Chopra, Data Science with AI, ML, DL, Khanna Book Publishing, 2023
Suggested Reference Books:


Course Outcomes:
At the end of this course, the students will be able to:

1. Understand the fundamentals of neural networks.
2. Design feed forward networks with backpropagation.
4. Apply attention mechanism to the neural network.

*****
Detailed Content:

Module 1: Mechanical Systems and Design:
Mechatronics approach - Control program control, adaptive control and distributed systems - Design process - Types of Design - Integrated product design - Mechanisms, load conditions, design and flexibility Structures, load conditions, flexibility and environmental isolation – Man machine interface, industrial design and ergonomics, information transfer from machine from machine to man and man to machine, safety.

Module 2: Real Time Interfacing:
Introduction Elements of data acquisition and control Overview of I/O Process-Installation of I/O card & software - Installation of application software, Over framing.

Module 3: Microcontrollers:
Introduction to use of open source hardware (Arduino & Raspberry Pi); shields/modules for GPS, GPRS/GSM, Bluetooth, RFID, and Xbee, integration with wireless networks, databases and web pages; web and mobile phone apps.

Module 4: Case studies on Data Acquisition:
Transducer calibration system for Automotive Applications Strain Gauge weighing system - Solenoid force - Displacement calibration system - Rotary optical encoder - Inverted pendulum control - Controlling temperature of a hot/cold reservoir -Pick and place robot - Carpark barriers.

Module 5: Case studies on Data Acquisition and Control:
Thermal cycle fatigue of a ceramic plate - pH control system - De-Icing Temperature Control System - Skip control of a CD Player - Autofocus Camera, exposure control.

Module 6: Case studies on design of Mechatronics products:
Motion control using D.C. Motor, A.C. Motor & Solenoids - Car engine management - Barcode reader.

Suggested Text Books:

Suggested Reference Books:


Course Outcomes:
At the end of this course, the students will be able to:

- Demonstrate how mechatronics integrates knowledge from different disciplines in order to realize engineering and consumer products that are useful in everyday life.
- Apply theoretical knowledge: understanding selection of suitable sensors and actuators; designing electro-mechanical systems.
- Work with mechanical systems that include digital and analogue electronics as a data acquisition model.
### Detailed Content:

**Module 1:**

**Module 2:**

**Module 3:**

### Suggested Text Books:


### Suggested Reference Books:

Course Outcomes:
At the end of this course, the students will be able to:

- Demonstrate non-linear system behavior by phase plane and describing function methods.
- Perform the stability analysis nonlinear systems by Lyapunov method.
- Derive discrete-time mathematical models in both time domain (difference equations, state equations) and z domain (transfer function using z-transform).
- Predict and analyze transient and steady-state responses and stability and sensitivity of both open-loop and closed-loop linear, time-invariant, discrete-time control systems.
- Acquire knowledge of state space and state feedback in modern control systems, pole placement, design of state observers and output feedback controllers.

*****
LC RAI-701  |  Smart Manufacturing Laboratory  |  0L:0T:2P  |  1 credit

Detailed Content:

- Solid Design in Autodesk Fusion.
- Advanced Solid Design in Autodesk Fusion.
- Freeform Design in Autodesk Fusion (Advance Freeform Design in Autodesk Fusion (Advanced Modeling).
- Machining Simulation in Autodesk Fusion (3 axis Milling).
- Machining Simulation in Autodesk Fusion (4+ axis Milling).
- Machining Simulation in Autodesk Fusion (Turning).
- Machining Simulation in Autodesk Fusion (Mill-Turning).

Suggested Text Books:

(i) Dr. Jeeva Jose, *Introduction to Internet of Things*, Khanna Book Publishing, 2023


Suggested Reference Books:


Course Outcomes:

At the end of this course, the students will be able to:

- Explain Autodesk Fusion software and its different tools.
- Perform simulation in the software.
- Describe different machining processes through simulation.
- Use Autodesk fusion software for multiple uses.

*****
AICTE Model Curriculum for UG Degree Course in Robotics & Artificial Intelligence Engineering

<table>
<thead>
<tr>
<th>LC RAI-702</th>
<th>Robotics and AI case studies with RIoT</th>
<th>0L:0T:2P</th>
<th>1 Credit</th>
</tr>
</thead>
</table>

Detailed Content:

Case study of:
- Collaborative Robot Systems
- Industry 4.0
- Autonomous vehicles
- Tesla Car

Suggested Text Books:


Suggested Reference Books:


Course Outcomes:

At the end of this course, the students will be able to:
- Understand the concept of IoT.
- Implement theoretical concepts in real life applications.
- Differentiate IoT and RIoT.

*****
Detailed Content:

- Find and describe 3 datasets that you’d like to potentially visualize for your project. Load and parse those 3 datasets using D3.js.
- Re-create one of the small graphics from Figure 5.1 (page 94) using D3.js.
- Create a visualization of the dataset you chose for your project using D3.js, including axes and legends.
- Add one of the interaction techniques discussed to your project using D3.js.
- Combine your 2 visualizations from week 4 with some form of linked interaction.
- Create a histogram or aggregated bar chart of your project dataset.
- Machining Simulation in Autodesk Fusion (Mill-Turning).

Suggested Text Books:

(i) Tamara Munzer, Visualization Analysis and Design -, CRC Press 2014

Suggested Reference Books:


Course Outcomes:

At the end of this course, the students will demonstrate the ability to:

- Illustrate the design principles for data modeling, ER model and normalization and differentiate data types, visualization types to bring out the insight.
- Relate the visualization towards the problem based on the dataset.
- Identify and create various visualizations for geospatial and table data.
- Ability to visualize categorical, quantitative and text data. Illustrate the integration of visualization tools with hadoop.
- Ability to create and interpret plots using R/Python.

*****
### Detailed Content:

To familiarize the students about the standards and practices used in industry/ research organization/ in-house research. The study leads towards finalization of the problem statement for project work, which is helpful to establish a link between industry and academia for low cost solution, identification of current needs of the society as well as industrial research.

### Course Outcomes:

At the end of this course, the students will demonstrate the ability to:

1. Ability to work effectively in a various team (may be multidisciplinary teams).
2. Identify, formulate and solve a problem of Robotics and Artificial Intelligence.
3. Understand the impact of Robotics and Artificial Intelligence solutions in a global, economic, environmental and societal context.

*****
Detailed Content:


- Integrated Circuits, Industrial Designs, Trademarks (Registered and unregistered trademarks), Copyrights, Traditional Knowledge, Geographical Indications, Trade Secrets, Case Studies

- New Developments in IPR, Process of Patenting and Development: technological research, innovation, patenting, development.

- International Scenario: WIPO, TRIPs, Patenting under PCT.

Suggested Text Books:


Suggested Reference Books:

(i) GVG Krishnamurthy, “The law of trademarks, Copyright, Patents and designs”, 2012.


Course Outcomes:
At the end of the course, the students will demonstrate the ability to:
- Understand research problem formulation and approaches of investigation of solutions for research problems.
- Learn ethical practices to be followed in research.
- Apply research methodology in case studies.
- Acquire skills required for presentation of research outcomes (report and technical paper writing, presentation etc.).
- Discover how IPR is regarded as a source of national wealth and mark of an economic leadership in context of global market scenario.
- Study the national and international IP system.
Detailed Content:

Identification of topic and resources, scope, and synthesize viewpoints for the areas such as performing arts, basic Sciences, business, philosophy, sports and athletics, defense studies and education.

Course Outcomes:

At the end of the course, the students will demonstrate the ability to:

- Exhibit self-learning capabilities and its use in effective communication.
- Inculcate impact of various areas to relate with society at large.
SEMESTER – VIII
SEMMESTER VIII

<table>
<thead>
<tr>
<th>PCC RAI-801</th>
<th>Robot System Design and SLAM (Simultaneous Localization and Area Mapping)</th>
<th>2L:0T:0P</th>
<th>2 credits</th>
</tr>
</thead>
</table>

| Pre-Requisites | Robot Kinematics, Robot Dynamics, Computer Programming |

Detailed Course Content:

**Module 1: Introduction:**


**Module 2: Robotic Operating System:**

Robotic Operating System (ROS) Fundamentals, Building a ROS Application, ROS Services, ROS Actions, Unified Robot Description Format (URDF).

**Module 3: Robot Navigation:**


**Module 4: Manipulation:**


**Module 5: Robot Vision:**

Object Detection, Pose Estimation, Logical Camera, ROS Tools for Vision.

Suggested Text Books:


Suggested Reference Books:

(v) SLAM for dummies: https://dspace.mit.edu/bitstream/handle/1721.1/119149/16-412j-spring-2005/contents/projects/1aslam_blas_repo.pdf
(vi) ROS Robot Programming; YoonSeok Pyo I HanCheol Cho I RyuWoon Jung I TaeHoon Lim; https://community.robotsource.org/t/download-the-ros-robot-programming-book-for-free/51

Course Outcomes:
After the completion of this course, the students will be able to:

- Understand the features and uses of Robotic Operating System (ROS) and allied software tools.
- Generate a robot manipulator and its working environment using simulation tools.
- Implement robot navigation and object manipulation for a given application.
- Incorporate and use robot vision for real-world applications.

******
Detailed Course Content:

**Module 1: Introduction to ROS2:**
Architectural overview of the Robot Operating System, Framework and setup with ROS2 environment, ROS2 workspace structure, essential command line utilities. ROS2 nodes, topics, services, parameters, actions and launch files. Programming nodes, topics, services, actions with C/C++/Python. Real time programming with ROS2.

**Module 2: Robot Simulation Engines:**
Physics simulations of Robots with Gazebo, Mujoco and Pybullet C++/Python APIs. Intro to Path Planning and Navigation, Classic Path Planning. Number of classic path planning approaches that can be applied to low-dimensional robotic systems. Coding the BFS and algorithms in C++. Sample-Based and Probabilistic Path Planning and improvement using the classic approach. Programming in Moveit framework.

**Module 3: Motion Planning, Mapping and SLAM:**

**Suggested Text Books:**

**Suggested Reference Books:**
Course Outcomes:
After the completion of this course, the students will be able to:

- Understand the basic principles of Robotics programming and development.
- Design real world applications using available software.
- Understand integration technologies and its applications.
- Identify problems in integrating the system / simulations / programming.
**Elective Course-III Advanced Artificial Intelligence (Tract: AI)**

<table>
<thead>
<tr>
<th>PEC RAI-802</th>
<th>2 credits</th>
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</thead>
<tbody>
<tr>
<td>Elective Course-III Advanced Artificial Intelligence (Tract: AI)</td>
<td>2L:0T:0P</td>
</tr>
</tbody>
</table>

**Detailed Course Content:**

**Module 1:**
Overview of Probability Theory, Bayes Networks, Independence, I-Maps, Undirected Graphical Models, Bayes Networks and Markov Networks, Local Models, Template Based Representations, Exact Inference: Variable Elimination; Clique Trees, Belief Propagation Tree Construction.

**Module 2:**
Intro to Optimization, Approximate Inference: Sampling, Markov Chains, MAP Inference, Inference in Temporal Models, Learning Graphical Models: Intro Parameter Estimation, Bayesian Networks and Shared Parameters.

**Module 3:**

**Suggested Text Books:**

**Suggested Reference Books:**
(i) M.C. Trivedi, Data Science and Data Analytics Using Python, Khanna Book Publishing.

**Course Outcomes:**
After the completion of this course, the students will be able to:

- Explain in detail how the techniques in the perceive-inference-action loop work.
- Choose, compare, and apply suitable basic learning algorithms to simple applications.
- Ability to explain how deep neural networks are constructed and trained, and apply deep neural networks to work with large scale datasets.
- Understand and develop deep reinforcement learning algorithms for suitable applications.

*****
PEC RAI-803 | Elective Course-III Micro Electro Mechanical Systems (Tract: Mechatronics) | 2L:0T:0P | 2 credits

Detailed Content:

Module 1: Introduction:
Overview of MEMS & Microsystems: Evolution of Micro sensors, MEMS & microfabrication typical MEMS and Microsystems and miniaturization – applications of Microsystems. Materials demand for Extreme conditions of operation, material property mapping, Processing, strengthening methods, treatment and properties.

Module 2: MEMS materials:

Module 3: Micro manufacturing/Micro fabrication:
Preparation of the substrate, Physical Vapor Deposition, Chemical Vapor Deposition, Ion Implantation, Coatings for high temperature performance, Electrochemical and spark discharge and Plasma coating methods, electron beam and laser surface processing, Organic and Powder coatings, Thermal barrier coating, LIGA process.

Module 4: Micro sensors:
Smart Sensor, Actuator and Transducer Technologies, Smart Sensors: Accelerometers; Force Sensors; Load Cells; Torque Sensors; Pressure Sensors; Microphones; Sensor Arrays Micro actuators.

Module 5: Smart Actuators:
Displacement Actuators; Force Actuators; Power Actuators; Vibration Dampers; Shakers; micro Fluidic Pumps; micro Motors Smart Transducers: Ultrasonic Transducers; Sonic Transducers.

Suggested Text Books:


Suggested Reference Books:


Course Outcomes:
At the end of the course, the students will be able to:

- Explain MEMS technology and challenges in it.
- Understand and explain micro sensors, micro actuators, their types and applications.
- Explain about fabrication processes for producing micro sensors and actuators.
- Do material selection appropriately according to fabrication processes.

*****
PEC RAI-804 | Elective Course-III Advanced Control Systems (Tract: Control Systems) | 2L:0T:0P | 2 credits

Detailed Content:

Module 1:

Module 2:

Module 3:

Suggested Text Books:


Suggested Reference Books:

Course Outcomes:
At the end of the course, the students will be able to:

- Demonstrate non-linear system behavior by phase plane and describing function methods.
- Perform the stability analysis nonlinear systems by Lyapunov method.
- Develop design skills in optimal control problems.
- Derive discrete-time mathematical models in both time domain (difference equations, state equations) and z domain (transfer function using z-transform).
- Predict and analyze transient and steady-state responses and stability and sensitivity of both open-loop and closed-loop linear, time-invariant, discrete-time control systems.
- Acquire knowledge of state space and state feedback in modern control systems, pole placement, design of state observers and output feedback controllers.

*****
OEC RAI-801 | Elective Course-IV Biomedical Robotics (Tract: Robotics) | 2L:0T:0P | 2 credits
---|---|---|---
Pre-Requisites | Modeling and control of robot |  |

Detailed Content:

Module 1:
Rigid Motions, Homogeneous transformations Forward/Inverse Kinematics Jacobian, redundant motions and singularities. Forward/Inverse Dynamics Force/Motion Control.

Module 2:
Biological movement control Robots for biomedical research teleoperation, cooperative manipulation, robots for endoscopy Physical human-robot interaction. Issues in the Control of Prosthetic Limbs.

Module 3:
Surgical Robots Biomimetic Systems Neuro-Rehabilitation Robotics Prosthetics Assistive robotics soft robotics for biomedical applications Biomimetic Robotics Surgery robotics.

Suggested Text Books:


Suggested Reference Books:

(ii) Habib, "Handbook of Research on Biomimetics and Biomedical Robotics Advances in Computational Intelligence and Robotics” (2327-0411), Maki Publishers, 2017.

Course Outcomes:

At the end of the course, the students will be able to:

- Identify and describe different types of medical robots and their potential applications.
- Know basic concepts in kinematics, dynamics, and control relevant to medical robotics.
- Understanding and analyzing biological signals (motion, muscle and brain activity).
● Control robots with bio signals.
● Develop the analytical and experimental skills necessary to design and implement robotic assistance for different biomedical applications.
● Be familiar with the state of the art in applied medical robotics and medical robotics research.
● Understand the various roles that robotics can play in healthcare.
Detailed Content:

Module 1: Introduction to Augmented Reality:

Module 2: Augmented Reality Architecture:

Module 3: AR Techniques:
Marker-based approach- Introduction to marker-based tracking, types of markers, marker camera pose and identification, visual tracking, mathematical representation of matrix multiplication Marker types- Template markers, 2D barcode markers, imperceptible markers. Marker-less approach- Localization based augmentation, real world examples Tracking methods- Visual tracking, feature based tracking, hybrid tracking, and initialisation and recovery.

Module 4: Introduction to Virtual Reality:

Module 5: Virtual World Motion tracking:

Module 6: Virtual Worlds & Human Vision:
Geometric Models, Changing Position and Orientation, Axis-Angle Representations of Rotation, Viewing Transformations, Chaining the Transformations, Human Eye, eye movements & implications for VR.

Suggested Text Books:


Suggested Reference Books:


Course Outcomes:
At the end of the course, the students will be able to:

- Understand and analyze the hardware requirement of AR.
- Describe AR systems work and list the applications of AR.
- Understand the design and implementation of the hardware that enables VR systems to be built.
- Explain the concepts of motion and tracking in VR systems.

******
**OEC RAI-803**

**Elective Course-IV Advanced Mechatronics**
*(Tract: Mechatronics)*

**2L:0T:0P**

**2 credits**

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**Detailed Content:**

**Module 1:**
Introduction to theoretical and applied mechatronics, design and operation of mechatronics systems; mechanical, electrical, electronic, and opto-electronic components; sensors and actuators including signal conditioning and power electronics.

**Module 2:**
Microcontrollers—fundamentals, programming, and interfacing; and feedback control. Includes structured and term projects in the design and development of proto-type integrated mechatronic systems.

**Module 3:**
Introduction to applications of, and hands-on experience with microcontrollers and single-board computers for embedded system applications. Specifically, gain familiarity with the fundamentals, anatomy, functionality, programming, interfacing, and protocols for the Arduino microcontroller, multi-core Propeller microcontroller, and single-board computer Raspberry Pi. Includes mini-projects and term projects in the design and development of proto-type integrated mechatronic systems.

**Suggested Text Books:**


**Suggested Reference Books:**


Course Outcomes:
At the end of the course, the students will be able to:

- Acquire knowledge of Mechatronic systems and its design.
- Gain Knowledge of Microcontrollers and its operation.
- Perform experiments on Microcontrollers.

*****
Detailed Content:

Module 1:
Introduction Rigid-body, DoF, Rotation and Forward Kinematics. (DH par.) Inverse Kinematics Workspace, Rigid Body Dynamics. Dynamics of Robot Arms.

Module 2:
System Dynamics and Control - Modeling of electrical, mechanical, and electromechanical systems. Analytic solution of open loop and feedback type systems. Root Locus methods in design of systems and evaluation of system performance. Time and frequency domain.

Module 3:
Introduction to Linear Control, State Space Modeling and Multivariable Systems, Nonlinear Control, Stability Theory Quadrotor Control Trajectory Generation Planning and Control of a Quadrotor design of control systems.

Suggested Text Books:


Course Outcomes:

After the completion of this course, the students will be able to:

- Select, design, analyze, implement, and evaluate effective controllers for a number of different robotics platforms and applications.
- The dynamics of robot arms, mobile robots and quadrotors.
- Position and force control for robots.
- How to generate complex trajectories.
- The basics of configuration spaces for robotic systems.
- Controller synthesis and stability.

*****
Detailed Content:

- To install ROS and set-up a ROS workspace on a computer.
- To write ROS talker-listener code in python.
- To create a mobile robot base URDF model.
- To create a 3-DOF robot arm URDF model.
- To simulate a mobile robot base in Gazebo.
- To attach the robot arm to base and simulate the complete mobile robot in Gazebo.
- To create an environment in Gazebo for simulating a mobile robot for an industrial application.
- To implement SLAM for industrial application using ROS open-source packages.
- To configure and interface a webcam with ROS.
- To use OpenCV with ROS for a vision application.

Suggested Text Books:


Suggested Reference Books:

(iv) SLAM for dummies: [https://dspace.mit.edu/bitstream/handle/1721.1/119149/16-412j-spring-2005/contents/projects/1aslam_blas_repo.pdf](https://dspace.mit.edu/bitstream/handle/1721.1/119149/16-412j-spring-2005/contents/projects/1aslam_blas_repo.pdf)
(v) ROS Robot Programming; YoonSeok Pyo I HanCheol Cho I RyuWoon Jung I TaeHoon Lim; [https://community.robotsource.org/t/download-the-ros-robot-programming-book-for-free/51](https://community.robotsource.org/t/download-the-ros-robot-programming-book-for-free/51)

Course Outcomes:

After the completion of this course, the students will be able to:

- Understand the features and uses of Robotic Operating System (ROS) and allied software tools.
- Generate a robot manipulator and its working environment using simulation tools.
- Implement robot navigation and object manipulation for a given application.
- Incorporate and use robot vision for real-world applications.

*****

201
**Detailed Content:**

Project should be research oriented experimental work, involving detail analysis or development of the industrial case studies related to Robotics & Artificial Intelligence.

**Course Outcomes:**

At the end of the course, the students will be able to:

- Apply the techniques learned during the course.
- Provide solution to the problem.
- Publish their work in conferences and Journals.

*****
Detailed Content:

Seminar topic would be an emerging technology/research/product, study and finalization of the topic, sharing of knowledge with peers and discussion, documentation in the form of a report.

Course Outcomes:

At the end of the course, the students will be able to:

- Understand the contemporary/emerging technology for various processes and systems.
- Share knowledge effectively in oral and written form and formulate documents.

******
Detailed Content:

Identification of topic and resources, scope, and synthesize viewpoints for the areas such as performing arts, basic Sciences, business, philosophy, sports and athletics, defense studies and education.

Course Outcomes:

At the end of the course, the students will be able to:

- Exhibit self-learning capabilities and its use in effective communication.
- Inculcate impact in various areas to relate with society at large.

*****
Appendix – I

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.

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1A 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.

\(^2\)Induction 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 teamwork. 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.

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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 under privileged.

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>
</tr>
</thead>
<tbody>
<tr>
<td>Day 0</td>
<td>Whole Day</td>
<td>Students Arrive – Hostel Allotment (Preferably do pre-allotment)</td>
</tr>
<tr>
<td>Day 1</td>
<td>09:00 AM – 03:00 PM</td>
<td>Academic Registration</td>
</tr>
<tr>
<td></td>
<td>04:30 PM – 06:00 PM</td>
<td>Orientation</td>
</tr>
<tr>
<td>Day 2</td>
<td>09:00 AM – 10:00 AM</td>
<td>Diagnostic test (for English etc.)</td>
</tr>
<tr>
<td></td>
<td>10:00 AM – 12:25 PM</td>
<td>Visit to respective depts.</td>
</tr>
<tr>
<td></td>
<td>12:30 PM – 01:55 PM</td>
<td>Lunch</td>
</tr>
<tr>
<td></td>
<td>02:00 PM – 02:55 PM</td>
<td>Director’s address</td>
</tr>
<tr>
<td></td>
<td>03:00 PM – 03:55 PM</td>
<td>Interaction with parents</td>
</tr>
<tr>
<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></td>
<td>06:30 AM – 07:10 AM</td>
<td>Physical Activity (Mild Exercise / Yoga)</td>
<td></td>
</tr>
<tr>
<td></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></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></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>
<tr>
<td>IV</td>
<td>Lectures by Eminent People</td>
<td>As scheduled 3-5 lectures</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</td>
</tr>
<tr>
<td></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.

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.

Contact: Prof. Rajeev Sangal, Director, IIT(BHU), Varanasi (director@iitbhu.ac.in).