B. Tech. Degree

in

INSTRUMENTATION AND CONTROL ENGINEERING

SYLLABUS FOR
FLEXIBLE CURRICULUM

(For students admitted in the year 2020 and 2021)

DEPARTMENT OF INSTRUMENTATION AND CONTROL ENGINEERING
NATIONAL INSTITUTE OF TECHNOLOGY
TIRUCHIRAPPALLI – 620 015
TAMIL NADU, INDIA.
INSTITUTE VISION

- To be a university globally trusted for technical excellence where learning and research integrate to sustain society and industry.

INSTITUTE MISSION

- To offer undergraduate, postgraduate, doctoral and modular programmes in multi-disciplinary / interdisciplinary and emerging areas.
- To create a converging learning environment to serve a dynamically evolving society.
- To promote innovation for sustainable solutions by forging global collaborations with academia and industry in cutting-edge research.
- To be an intellectual ecosystem where human capabilities can develop holistically

DEPARTMENT VISION

- To be a world class centre of excellence in Instrumentation and Control Engineering.

DEPARTMENT MISSION

- To inspire the students to realize their aspiration and potential through quality education in Instrumentation and Control Engineering.
- To enhance knowledge, create passion for learning, foster innovation and nurture talents towards serving the society and the country.
- To encourage faculty and students to keep in pace with the latest technological developments and to pursue research in those areas.
- To enable the students to engage themselves in entrepreneurship and product development for the benefit of the global community.
Programme Educational Objectives (PEOs)

The major objectives of the 4-year B. Tech (ICE) programme offered by the department of Instrumentation and Control engineering,

1: to prepare students for core industries/ manufacturing sectors/ IT Enabled Services (ITES)
2: to prepare students for research and development organizations
3: to prepare students for higher studies in engineering and management
4: to prepare students for starting and running enterprises

Program Outcomes (POs)

Graduates of the 4-year B.Tech. Instrumentation and Control Engineering (ICE) Programme

1. Have developed an ability to apply the knowledge of mathematics, sciences, and engineering fundamentals to solve complex engineering problems in the field of Instrumentation and Control Engineering,

2. Have possessed a comprehensive understanding of a wider range of electronic devices, analog and digital electronic circuits and the state-of-the-art advanced electronics used in Instrumentation and Control Systems,

3. Have the right knowledge and exposure to a variety of sensors, data acquisition systems, actuators, control methodologies, embedded systems, data structures, algorithms and computer programming, to readily provide innovative design solutions to the engineering problems in industries (e.g. process, power plants, automotive),
4. Have gained adequate knowledge to effectively use simulation software, relevant tools and methods to analytically investigate problems and interpret data to arrive at valid conclusions,

5. Have learnt necessary skills to develop mathematical models, and deploy appropriate techniques and IT tools to design advanced control systems and associated instrumentation,

6. Become responsible engineers who understand the socio economical, environmental and legal implications relevant to professional engineering practice,

7. Able to evaluate and deliver solutions by adopting appropriate sustainable resource management techniques, for optimally utilizing the available resources without endangering the environment,

8. Competent to apply ethical principles relevant to the professional engineering practices,

9. Able to function efficiently in various capacities as members, leaders and directors in multi-disciplinary teams to accomplish projects of different magnitudes,

10. Proficient in languages (spoken and written) in order to listen, understand and communicate effectively to all the stakeholders and society and, make comprehensive reports and presentations on complex engineering activities on a global scale,

11. Able to evaluate and complete the projects by effective utilization of resources within the stipulated time frame and budget in multi-disciplinary environments,

12. Able to recognize the need for engaging themselves independently in life-long learning of technological changes.

**Programme Specific Outcomes (PSO)**

**PSO1**: To be able to apply the basic knowledge of Mathematics, Computing and Sciences to develop mathematical models and, apply appropriate techniques and IT tools to identify, formulate and solve real life problems faced in industries and R&D

**PSO2**: To apply standard practices and combine the emerging technologies into the core area of ICE in the design and investigation of systems for sustainable development

**PSO3**: To commit themselves to the highest ethical standards and create and maintain professionalism in the work culture and outcome
CURRICULUM

The total minimum credits required for completing the B.Tech. programme in Instrumentation and Control Engineering is **157**.

MINIMUM CREDIT REQUIREMENT FOR THE VARIOUS COURSE CATEGORIES:

Course Structure

<table>
<thead>
<tr>
<th>Course Category</th>
<th>Courses</th>
<th>No. of Credits</th>
<th>Weightage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GIR (General Institute Requirement Courses)</td>
<td>22</td>
<td>50</td>
<td>30.67</td>
</tr>
<tr>
<td>PC (Programme Core)</td>
<td><strong>15</strong></td>
<td>49</td>
<td>30.06</td>
</tr>
<tr>
<td>(PE) Programme Electives / (OE) Open Electives</td>
<td>14$^1$</td>
<td>42</td>
<td>25.77</td>
</tr>
<tr>
<td>Essential Laboratory Requirements (ELR)</td>
<td>Maximum 2 per session up to 6th semester</td>
<td>16</td>
<td>9.81</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td><strong>157</strong></td>
<td><strong>100</strong></td>
</tr>
<tr>
<td>Minor (Optional)</td>
<td>Courses for 15 credits</td>
<td>15 Additional credits</td>
<td>-</td>
</tr>
<tr>
<td>Honours (Optional)</td>
<td>Courses for 15 credits</td>
<td>15 Additional credits</td>
<td>-</td>
</tr>
</tbody>
</table>

$^1$Minimum of 4 programme core courses shall be 4 credits each

$^2$Out of 14 elective courses (PE/OE), the students should study at least eight programme elective courses (PE)

Programme Electives (PE) are offered by the Department of Instrumentation and Control Engineering for students of B.Tech. in Instrumentation and Control Engineering programme.

To meet the minimum credit requirement for Electives, the remaining elective courses can be chosen from either PE courses offered by the Department of Instrumentation and Control Engineering, or Open Electives offered by any other Department within National Institute of Technology, Tiruchchirappalli and online courses to be approved by the department committee.

MI – Minor Degree: 15 credits over and above the minimum credit as specified by the departments. The details of MINOR will be mentioned only in the transcript not in the Degree certificate.

HO – Honours Degree: 15 credits over and above the minimum credit as specified by the departments.
## GIR Courses

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the course</th>
<th>Number of courses</th>
<th>Max. Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Mathematics</td>
<td>3</td>
<td>10</td>
</tr>
<tr>
<td>2.</td>
<td>Physics</td>
<td>1 Theory</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 Lab</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>Chemistry</td>
<td>1 Theory</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 Lab</td>
<td>2</td>
</tr>
<tr>
<td>4.</td>
<td>Industrial Economics and Foreign Trade</td>
<td>1 Theory</td>
<td>3</td>
</tr>
<tr>
<td>5.</td>
<td>English for Communication</td>
<td>1 Theory</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 Lab</td>
<td>2</td>
</tr>
<tr>
<td>6.</td>
<td>Energy and Environmental Engineering</td>
<td>1 Lab</td>
<td>2</td>
</tr>
<tr>
<td>7.</td>
<td>Professional Ethics</td>
<td>1 Theory</td>
<td>3</td>
</tr>
<tr>
<td>8.</td>
<td>Engineering Graphics</td>
<td>1 Lab</td>
<td>3</td>
</tr>
<tr>
<td>9.</td>
<td>Engineering Practice</td>
<td>1 Lab</td>
<td>2</td>
</tr>
<tr>
<td>10.</td>
<td>Basic Engineering</td>
<td>2 Lab</td>
<td>4</td>
</tr>
<tr>
<td>11.</td>
<td>Introduction to Computer Programming</td>
<td>1 Lab</td>
<td>3</td>
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<tr>
<td>12.</td>
<td>Branch Specific Course (Introduction to the Branch of study)</td>
<td>1 Lab</td>
<td>2</td>
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<tr>
<td>13.</td>
<td>Summer Internship</td>
<td>1 Lab</td>
<td>2</td>
</tr>
<tr>
<td>14.</td>
<td>Project work</td>
<td>--</td>
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</tr>
<tr>
<td>15.</td>
<td>Comprehensive Viva</td>
<td>1 Lab</td>
<td>1</td>
</tr>
<tr>
<td>16.</td>
<td>Industrial Lecture</td>
<td>1 Lab</td>
<td>1</td>
</tr>
<tr>
<td>17.</td>
<td>NSS/NCC/NSO</td>
<td>1 Lab</td>
<td>Compulsory participation</td>
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<td><strong>Total</strong></td>
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<td>22</td>
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### Credit Distribution

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<tr>
<th>Semester</th>
<th>I</th>
<th>II</th>
<th>III</th>
<th>IV</th>
<th>V</th>
<th>VI</th>
<th>VII</th>
<th>VIII</th>
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<tbody>
<tr>
<td>Credit</td>
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<td>21</td>
<td>24</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td>14</td>
<td>10</td>
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I. GENERAL INSTITUTE REQUIREMENT (GIR)

1. MATHEMATICS

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MAIR12</td>
<td>Linear Algebra and Calculus (Mathematics – I)</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>MAIR22</td>
<td>Complex Analysis and Differential Equations (Mathematics – II)</td>
<td>3</td>
</tr>
<tr>
<td>3</td>
<td>MAIR34</td>
<td>Probability and Distribution Theory (Mathematics-III)</td>
<td>4</td>
</tr>
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2. PHYSICS

<table>
<thead>
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<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>PHIR11</td>
<td>Physics (Circuit Branch)</td>
<td>3</td>
</tr>
<tr>
<td>2.</td>
<td>PHIR12</td>
<td>Physics Lab (Circuit Branch)</td>
<td>2</td>
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<tr>
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3. CHEMISTRY

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<th>Credits</th>
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<tbody>
<tr>
<td>1.</td>
<td>CHIR11</td>
<td>Chemistry (Circuit Branch)</td>
<td>3</td>
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<td>2.</td>
<td>CHIR12</td>
<td>Chemistry Lab (Circuit Branch)</td>
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<tr>
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4. HUMANITIES

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<thead>
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<th>Credits</th>
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<tbody>
<tr>
<td>1.</td>
<td>HSIR13</td>
<td>Industrial Economics and Foreign Trade</td>
<td>3</td>
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5. COMMUNICATION

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<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>HSIR11</td>
<td>English for Communication (Theory and Lab)</td>
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6. ENERGY AND ENVIRONMENTAL ENGINEERING

<table>
<thead>
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<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>ENIR11</td>
<td>Energy and Environmental Engineering</td>
<td>2</td>
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7. PROFESSIONAL ETHICS

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<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>HSIR14</td>
<td>Professional Ethics (Circuit Branch)</td>
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8. ENGINEERING GRAPHICS

<table>
<thead>
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<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>MEIR12</td>
<td>Engineering Graphics</td>
<td>3</td>
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9. ENGINEERING PRACTICE

<table>
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<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>PRIR11</td>
<td>Engineering Practice</td>
<td>2</td>
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10. BASIC ENGINEERING

<table>
<thead>
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<th>S.No.</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>MEIR11</td>
<td>Basics of Mechanical Engineering (For CE, EE, EC, IC and CS)</td>
<td>2</td>
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<tr>
<td>2.</td>
<td>CEIR11</td>
<td>Basics of Civil Engineering (Circuit Branch)</td>
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11. INTRODUCTION TO COMPUTER PROGRAMMING

<table>
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<th>S.No.</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>CSIR12</td>
<td>Introduction to Computer Programming (Theory &amp; Lab) (Circuit Branch)</td>
<td>3</td>
</tr>
<tr>
<td></td>
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12. BRANCH SPECIFIC COURSE

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>ICIR11</td>
<td>Introduction to Instrumentation and Control Systems Engineering</td>
<td>2</td>
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<td></td>
<td><strong>Total</strong></td>
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</table>

13. SUMMER INTERNSHIP

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>ICIR16</td>
<td>Internship / Industrial Training / Academic Attachment (2 to 3 Months Duration During Summer Vacation)</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td><strong>2</strong></td>
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</tbody>
</table>

Each student should undergo industrial training / internship for a minimum period of six weeks during the summer vacation. Registration of this course shall be along with the courses for 7th semester. A report is to be submitted to the head of the department and the evaluation (2 credit) will be based on the report and a viva-voce examination. The examiners for the viva voce examination shall be the head of the department and the program coordinator or their nominees.
14. PROJECT WORK

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>ICIR17</td>
<td>Project Work</td>
<td>6</td>
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<td><strong>Total</strong></td>
<td></td>
<td><strong>Total</strong></td>
<td><strong>6</strong></td>
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</tbody>
</table>

A student can opt for project work or equivalent credits of elective courses (PE/OE). At the completion of a project, the student will submit a project report which will be evaluated by duly appointed internal examiner(s). The evaluation will be based on the report and a viva-voce examination on the project.

15. COMPREHENSIVE VIVA

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>ICIR18</td>
<td>Comprehensive Viva-Voce Examination</td>
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<td><strong>Total</strong></td>
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</table>

The comprehensive examination in the final year of study shall have two objective test of 25 marks each. The final examination shall have 50 marks. The examination will be of objective type similar to GATE examination. A department committee comprising the head of the department or his/her nominee and two faculty members of the department shall conduct the examinations.

16. INDUSTRIAL LECTURES

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>ICIR19</td>
<td>Industrial Lectures</td>
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<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>Total</strong></td>
<td><strong>1</strong></td>
</tr>
</tbody>
</table>

A course based on industrial lectures shall be of 1 credit. A minimum of five lectures of two hours duration by industry experts will be arranged by the department. The evaluation methodology, will in general, be based on quizzes at the end of each lecture. Due weightage shall be given to attendance also. However, the head of the department or his/her nominee may devise a suitable methodology for evaluation and the same should be informed to the students before the commencement of the semester.

It is recommended that the percentage of syllabus covered by the industrial experts shall be limited to 25% for a given course. Prior approval must be obtained from the designated committee.
17. NSS/NCC/NSO

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
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</thead>
<tbody>
<tr>
<td>1.</td>
<td>SWIR11</td>
<td>NSS/NCC/NSO</td>
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II. PROGRAMME CORE (PC)

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Pre-Req</th>
<th>Credits</th>
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<tbody>
<tr>
<td>1.</td>
<td>ICPC11</td>
<td>Thermodynamics and Fluid Mechanics</td>
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<td>4</td>
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<tr>
<td>2.</td>
<td>ICPC12</td>
<td>Circuit Theory</td>
<td>---</td>
<td>4</td>
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<tr>
<td>3.</td>
<td>ICPC13</td>
<td>Sensors and Transducers</td>
<td>---</td>
<td>3</td>
</tr>
<tr>
<td>4.</td>
<td>ICPC14</td>
<td>Digital Electronics</td>
<td>---</td>
<td>3</td>
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<tr>
<td>5.</td>
<td>ICPC15</td>
<td>Signals and Systems</td>
<td>---</td>
<td>3</td>
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<tr>
<td>6.</td>
<td>ICPC16</td>
<td>Control Systems-I</td>
<td>---</td>
<td>4</td>
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<td>7.</td>
<td>ICPC17</td>
<td>Analog Signal Processing</td>
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<tr>
<td>8.</td>
<td>ICPC18</td>
<td>Microprocessors and Microcontrollers</td>
<td>ICPC14</td>
<td>3</td>
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<td>9.</td>
<td>ICPC19</td>
<td>Control Systems-II</td>
<td>-</td>
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<td>10.</td>
<td>ICPC20</td>
<td>Industrial Instrumentation</td>
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<td>11.</td>
<td>ICPC21</td>
<td>Electrical and Electronic Measurements</td>
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<td>3</td>
</tr>
<tr>
<td>12.</td>
<td>ICPC22</td>
<td>Process Control</td>
<td>ICPC16</td>
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<td>13.</td>
<td>ICPC23</td>
<td>Biomedical Instrumentation</td>
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<td>14.</td>
<td>ICPC24</td>
<td>Analytical Instrumentation</td>
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<td>15.</td>
<td>ICPC25</td>
<td>Logic and Distributed Control Systems</td>
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</table>
### III. ELECTIVE COURSES

1. **PROGRAMME ELECTIVES (PE)**

Students pursuing B.Tech. in Instrumentation and Control Engineering should complete at least eight courses from the Programme Electives listed below.

#### LIST OF PROGRAMME ELECTIVE COURSES

<table>
<thead>
<tr>
<th>S.No.</th>
<th>Course Code</th>
<th>Course Title</th>
<th>Pre-Req.</th>
<th>Credits</th>
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<td>Product Design and Development (Theory and Practice)</td>
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<td>NonLinear Control</td>
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<td>ICPE27</td>
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<td>ICPE38</td>
<td>Principles of Communication Systems</td>
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<td>ICPE45</td>
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<td>Engineering Mechanics</td>
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<td>ICPE51</td>
<td>Numerical Methods</td>
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2. **OPEN ELECTIVES (OE)**

The courses listed below are offered by the Department of Instrumentation and Control Engineering for students of other departments.

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3. MINOR (MI)

Students can register for the following minor courses offered by the department of Instrumentation and Control Engineering over and above the courses prescribed in their B.Tech curriculum.

<table>
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<td>ICMI11</td>
<td>Test and Measuring Instruments</td>
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<td>ICMI12</td>
<td>Measurements in Process Industries</td>
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<td>ICMI13</td>
<td>Essentials of Control Engineering</td>
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<td>Microprocessor and Microcontroller</td>
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IV. ESSENTIAL PROGRAMME LABORATORY REQUIREMENT (ELR)

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<td>2.</td>
<td>ICLR11</td>
<td>Circuits and Digital Laboratory</td>
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<td>ICLR12</td>
<td>Sensors and Transducers Laboratory</td>
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<td>Analog Signal Processing Laboratory</td>
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<td>Control Engineering Laboratory</td>
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<td>6.</td>
<td>ICLR15</td>
<td>Microprocessors and Microcontrollers Laboratory</td>
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<td>Instrumentation Laboratory</td>
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<td>Industrial Automation and Process Control Laboratory</td>
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Note: Students can register for 2 laboratory courses during one session along with the regular courses.
V. ADVANCED LEVEL COURSES FOR B.Tech. (HONOURS)

In addition to the B.Tech regulation specified, B.Tech (Honours) students must earn minimum of 15 additional specific honours credits and should not have obtained “V” or “X” grade in any course.

B.Tech (Honours) students can register an additional course from 5th semester from the honors basket of courses listed below over and above the courses prescribed in the B.Tech curriculum.

<table>
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<th>Course Code</th>
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<td>ICHO11</td>
<td>Instrumentation System Design</td>
<td>ICPC20</td>
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<td>Micro System Design</td>
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<td>Control System Design</td>
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<td>Advanced Process Control</td>
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<td>ICHO15</td>
<td>Optimal and Robust Control</td>
<td>ICPC16, ICPC19</td>
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<td>ICHO16</td>
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VI. ONLINE COURSES
A committee headed by the head of the department with two faculty members can decide the online courses to be offered to the students. A student can earn a maximum of 12 credits from these courses.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Course Name</th>
<th>Duration In Weeks</th>
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Note: In case any of the above listed courses are not offered in Swayam in that semester, the department will notify alternative courses offered in Swayam.
**Curriculum Structure**

**Semester I (July Session)**

<table>
<thead>
<tr>
<th>S No</th>
<th>Code</th>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>1</td>
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<td>Energy and Environmental Engineering</td>
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<td>Linear Algebra and Calculus (Mathematics – I)</td>
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<td>PHIR11</td>
<td>Physics (Circuit Branch)</td>
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<td>Physics Lab (Circuit)</td>
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<td>Introduction to Computer Programming (Theory &amp; Lab) (Circuit Branch)</td>
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<td>Basics of Mechanical Engineering (For CE, EE, EC, IC and CS)</td>
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<td>8</td>
<td>CEIR11</td>
<td>Basics of Civil Engineering (Circuit Branch)</td>
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**Total Credit** 19

**Semester II (January Session)**

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<tbody>
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<td>English for Communication (Theory and Lab)</td>
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<td>CHIR11</td>
<td>Chemistry (Circuit Branch)</td>
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<td>Chemistry Lab (Circuit Branch)</td>
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<td>GIR</td>
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<tr>
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<td>Introduction to Instrumentation and Control Systems Engineering</td>
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<td>GIR</td>
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<td>Engineering Graphics</td>
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<td>GIR</td>
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<td>Thermodynamics and Fluid Mechanics (Programme Core – I)</td>
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**Total Credit** 21

**Semester III (July Session)**

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<td>Sensors and Transducers (Programme Core – III)</td>
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**Total Credit** 24

**Note:** Department(s) to offer Minor (MI) Course, ONLINE Course (OC) and Honours course as 2/3/4 to those willing students in addition to 24 credits.
### Semester IV (January Session)

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<td>Analog Signal Processing (Programme Core - VII)</td>
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*Note: Department(s) to offer MI/PE/OE/OC and Honours course as 2/3/4 credits to those willing students in addition to 23 credits.*

### Semester V (July Session)

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*Note: Department(s) to offer MI/PE/OE/OC and Honours course as 2/3/4 credits to those willing students in addition to 23 credits.*

### Semester VI (January Session)

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*Note: Department(s) to offer MI/PE/OE/OC and Honours course as 2/3/4 credits to those willing students in addition to 23 credits.*
### Semester VII (July Session)

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*Note: Department(s) to offer MI/PE/OE/OC and Honours course as 2/3/4 credits to those willing students in addition to 14 credits.*

### Semester VIII (January Session)

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*Note: Department(s) to offer MI/PE/OE/OC and Honours course as 2/3/4 credits to those willing students in addition to 10 credits.*

$5 Optional course
GENERAL INSTITUTE REQUIREMENT (GIR)

(other than first year courses)
ICIR 11 – INTRODUCTION TO INSTRUMENTATION AND CONTROL SYSTEMS ENGINEERING (Branch Specific Course)

Course Type: GIR
No. of Credits: 2s

Pre-requisites: -

Course Objectives
To introduce the students on the role of Instrumentation and Control Engineering in the society.

Course Content
Place of engineers in the society and in an industrial organization. The technical manpower pyramid. Introduction to the program, subjects of study and its relevance, Opportunities for training, placement and for higher studies.

Overview of industry and scope of the discipline - Preliminary project design requirements – Various process conditions. Knowing client requirement and collection of specific data for projects.

Objectives, general concepts, terminologies, types and basic block diagram of instrumentation system.

Introduction to instrumentation and control engineering codes and standards and their relevance to industry.

Case studies: Introduction to instrumentation and control in a typical application like temperature, flow or pressure control.

Text Books

Reference Books
1. ISA standards
2. Bureau of Indian Standards

Course Outcomes
1. Students will know what an engineer does for the benefit of society.
2. Role of instrumentation and control engineering in an industrial organization.
3. They will know instrumentation and control engineering in a device or a plant.
4. They will know standards used in instrumentation and control engineering.
5. They will know how to apply basic building blocks of instrumentation and control engineering for a typical application.
MAIR34 – PROBABILITY AND DISTRIBUTION THEORY

Course Type: GIR

Pre-requisites: -

No. of Credits: 4

Course Objectives

To formally introduce the ideas of uncertainty and randomness that prevail in measurements and generation of controlled sequences in engineering applications. The course objective is to

1. Familiarize basic concepts of probability and random variables
2. Identifying and analyzing random variables in practical problems
3. Introduce important probability distributions for analyzing the data
4. Evaluate the mean, variance and moments of random variables
5. Solve real-world problem using probability techniques.

Course Content

Introduction to Basic Probability, Review of set theory and combinatorics, binomial probability law, computer simulations of real-world examples – communications and quality control, Conditional Probability, Joint events, statistically independent events, Bayes theorem, applications to cluster recognition

Probability of discrete random variables, Important probability mass functions (PMFs), Approximation of the binomial PMF with Poisson PMF, Transformations, Cumulative distribution functions, expected values of discrete random variables, functions of discrete random variables, variance and moments, characteristic functions, estimating means and variances, applications to data compression

Jointly distributed random variables, expectations, joint moments, prediction of outcomes, joint characteristic functions, Conditional PMFs.

Continuous random variables, expectations, Conditional probability density functions, continuous N-dimensional random variables, applications to signal detection.

Probability and moment approximations, Law of large numbers, central limit theorem, applications to cooperative control and opinion polling.

Text Books

Reference Books


Course Outcomes:

On successful completion of the course students will be able to

1. Identify an appropriate probability distribution for a given discrete or continuous random variable and use its properties to calculate probabilities
2. Evaluate probabilities for joint distributions including marginal and conditional probabilities
3. Evaluate mean, variance and moments of the random variables
4. Derive the probability density function of random variables and use techniques to generate data from various distributions
5. Translate real-world problems into probability models and apply probability and statistical techniques for solving them.
HSIR13 – INDUSTRIAL ECONOMICS AND FOREIGN TRADE

Course type: GIR

Pre-requisites: -

No. of Credits: 3

Course Objectives

The course intends
1. To provide knowledge to the students on the basic issues such as productivity, efficiency, capacity utilization and debates involved in industrial development;
2. To give thorough knowledge about the economics of industry in a cogent and analytical manner.

Course Content

Demand Analysis and Forecasting: Cardinal Ordinal Approaches. Demand and Supply, Elasticities, Forecasting techniques, Consumer behavior.

Production, Cost, and Market structure: Variable proportions, Returns to Scale, Isoquants Analysis, Production Function, Cost Curves, Cost Function, Market Analysis and game theory.

Types, Location, Efficiency and Finance: Mergers & Amalgamations, Location of Industries and Theories, Productivity and Capacity Utilization, Shares, Debentures, Bonds, Deposits, Loan etc. FDI, Foreign Institutional Investment, Euro Issues, GDR, ADR, External Commercial Borrowings.

Introduction: Features of International Trade. Inter-regional and international Trade. Problems of International Trade. Theories

Terms of Trade- Concept, Measurement, Types, Factors affecting Terms of Trade, Exchange rate.

Free Trade, Protection and Tariffs, Balance of Payments: Free Trade, Protection-Quotas, Dumping, etc. Balance of Trade and Balance of Payments.

Regional Economic Groupings and International Institutions: BRICS, EU, SAARC, OPEC, ASEAN. International Institutions: GATT, WTO, UNCTAD, IBRD, IMF.

References


Course outcomes

On completion of this course, the students will be able to

1. Define micro economics, demand analysis, supply analysis, consumption laws, in difference curve analysis and competitions.
2. Get knowledge on macroeconomics; differentiate with micro economics, importance, Keynes theory, functions of central and commercial bank.
3. To know the Contributions of Fayol, Taylor’ managerial functions, balance sheet, and sources of finance.
4. Differentiate marketing and selling, marketing myopia, and product lifecycle.
5. Describe recruitment and selection, job evaluation and performance appraisal methods, communication, motivation and leadership.
Course type: GIR
No. of Credits: 3
Pre-requisites: -

Course Objectives
1. To identify the core values that shapes the ethical behavior of an engineer.
2. To relate the code of ethics to social experimentation.
3. To understand the difference between moral standards and professional ethics.
4. To evaluate the need for computer ethics.
5. To appreciate the rights of others

Course Content
Introduction to Ethics, Moral and Values
Occupation-Profession-Professionalism-Concept of Ethics-need for Ethics in Engineering - impact of unethical conducts on society and professional - Importance of Moral & Value in profession – core values, Hollow values and its impact - Work Ethics – Styles of Ethics -Service Learning, components, reflections, evaluation and its assessment–Civic Virtue - Respect for Others in Engineering Work Place– Living Peacefully – Caring & Sharing in engineering → General Etiquette for students

Ethical Theories and Engineering

Engineering Projects and Expected Traits
Engineering as experimentation – engineers as responsible experimenters – Codes of ethics - Research ethics– Industrial Standard – purpose, types and use - Balanced outlook on law – – Collegiality and loyalty–respectforauthorityinindustry–collectivebargaining–Confidentiality–conflictsoffinterest and conflicting interest

Safety, Responsibilities and Rights

Ethics in Present Scenario and Engineers Role
Multinational corporations – Business ethics – Environmental ethics – computer ethics – Role in Technological Development – Ethics for Weapons development – engineers as managers – consulting engineers – engineers as expert witnesses and advisors – Leadership - sample code of conduct ethics like ASME, ASCE, IEEE, Institution of Engineers (India), Indian Institute of Materials Management, Institution of Electronics and Telecommunication Engineers (IETE), India, etc.,
Text Books

4. Charles E. Harris, Michael S. Protchard and Michael J. Rabins, Engineering Ethics – Concept and Cases, Wadsworth Thompson Learning, United States, 2000 (Indian Reprint now available).

Course Outcomes

1. The students will understand the basic perception of profession, professional ethics, and various moral and social issues.
2. Students will be aware of their rights and responsibility as engineers.
3. Students will acquire knowledge about various roles of engineers in a variety of global issues.
4. Students will have the ability to thrive in competitive professional spaces with integrity and responsibility.
5. They will learn to be empathetic and assertive leaders in their respective profession.
PROGRAMME CORE COURSES
ICPC11 - THERMODYNAMICS AND FLUID MECHANICS

Course type: Programme Core (PC)  
Pre-requisites: -
No. of Credits: 4

Course Objectives
1. To impart knowledge about the fundamentals of thermodynamic laws, concepts and principles.
2. To introduce the principles of various cycles and to apply the thermodynamic concepts in various applications.
3. To introduce the fundamental concepts of fluid mechanics, pressure distribution and dimensional analysis.
4. To comprehend the metering and transportation of fluids and fluid moving machinery performance.

Course Content
Basic concepts of thermodynamics: Thermodynamic equilibrium, quasi-static process, zeroth law, work and heat interactions, first law for a cycle and a process, steady flow processes, second law statements, reversibility, Carnot theorem, Clausius inequality, entropy principle. Available energy: Availability and irreversibility, properties of pure substances, phase equilibrium diagrams, Rankine cycle, reheat and regenerative cycle, properties of ideal gas, Stirling and Ericson cycles.

Heat engines: Otto, diesel and dual cycles, Brayton cycle with regeneration, inter cooling and reheat, Joule-Thompson effect.


Darcy Weisbach equation – Moody's diagram, minor losses – Boundary layer and its basic concepts.

Fluid machinery: Centrifugal pumps, Reciprocating pumps, Hydraulic ram, Impulse turbine, Reaction turbine.

Text Books

Reference Books

Course outcomes

On completion of this course, the students will be able to,

1. Apply the fundamentals of thermodynamics to various process.
2. Understand various thermodynamic cycles and their applications to heat engines.
3. Apply the knowledge of fundamental concepts in fluids mechanics and usage of dimensional analysis for scaling experimental results.
4. Select the metering equipment and fluid moving machinery for an appropriate process engineering operation.
ICPC12–CIRCUIT THEORY

Course type: Programme Core (PC)  
Pre-requisites: -  
No. of Credits: 4

Course Objectives

1. To teach the electrical circuit laws and theorems, to aid in circuit analysis.  
2. To impart problem solving technique of linear passive electrical circuits.  
3. To expose the students to the transient behaviour of different R-L-C circuits.  
4. To teach the methods of AC circuit analysis and synthesis of 2-port networks.

Course Content

Review of Networks and Circuits, Elemental laws (V-I characteristics) for Resistors, Inductors, and Capacitors, Circuital laws (Kirchhoff’s laws), Sign convention, Basic signals (dc and ac), Elementary signals (impulse, step, ramp, exponential), Synthesis of arbitrary waveforms (rectangular, triangular etc.) from elementary signals, Voltage and Current sources (Independent and Dependent), Ladder and Bridge Circuits.

Analysis of Resistive Circuits energized by dc voltages and currents – Source Transformations, Nodal and Mesh Analysis, Principle of Superposition, Network Theorems (Thevenin’s and Norton’s, Maximum Power Transfer), Circuits with dependent dc Sources.


Sinusoidal Sources and Response – Behavior of elements with ac signals, Impedance and Admittance, Generalization of Network Theorems and Circuit Analysis, Introduction to 3-φ power systems. Transient and Steady-state Response of Circuits – Laplace Transformation and its application to circuit analysis, State Variables, Network Functions (Driving point impedance and admittance), Transfer function, Two-port Networks, Applications of Two-port networks, Introduction to General Linear Systems.


Text Books

Reference Books

4. SC Dutta Roy, Circuit Theory, NPTEL video lectures

Course outcomes:

On completion of this course, the students will be able to,
1. Analyze and solve the basic circuits using mesh and node analysis
2. Analyze and solve the DC and AC circuits using network theorems and mathematical tools
3. Apply the knowledge of the time domain and frequency domain characteristics of electrical circuits for design
4. Apply Laplace Transform for circuit analysis
5. Design and synthesis two port networks
ICPC13 - SENSORS AND TRANSDUCERS

Course type: Programme Core (PC)  
No. of Credits: 3

Pre-requisites: -

Course Objectives:
1. To expose the students to various sensors and transducers for measuring mechanical quantities.
2. To make the students familiar with the specifications of sensors and transducers.
3. To teach the basic conditioning circuits for various sensors and transducers.
4. To introduce about advancements in sensor technology.

Course Content:
General concepts and terminology of measurement systems, transducer classification, general input-output configuration, static and dynamic characteristics of a measurement system, Statistical analysis of measurement data.

Resistive transducers: Potentiometers, metal and semiconductor strain gauges and signal conditioning circuits, strain gauge applications: Load and torque measurement.

Self and mutual inductive transducers- capacitive transducers, eddy current transducers, proximity sensors.


Introduction to semiconductor sensor, materials, scaling issues and basics of micro fabrication. Smart sensors. Introduction to flexible sensors and sensor fusion.

Text Books:

Reference Books:

Course outcomes:

On completion of this course, the students will be,
1. Familiar with the basics of measurement system and its input, output configuration.
2. Familiar with both static and dynamic characteristics of measurement system.
3. Familiar with the principle and working of various sensors and transducers.
4. Able to design signal conditioning circuit for various transducers.
5. Able to identify or choose a transducer for a specific measurement application.
Course type: Programme Core (PC)  
No. of Credits: 3

Course Objectives:
The subject aims to provide the student with
1. An understanding of number systems, codes and their conversions.
2. The capability to reduce Boolean expression using K-map and tabular methods.
3. The ability to design and analyze combinational and sequential logic circuits for a given problem statement.
4. An understanding of digital hardware, different types of logic families and their characteristics

Course Content:
Review of number systems and logic gates, Algebraic reductions, Binary codes -Weighted and non-weighted, number complements, Binary arithmetic, Error detecting and error correcting codes, SOP, POS Canonical logic forms, Karnaugh maps and Quine-McClusky methods, Don’t care conditions, minimization of multiple output functions.

Synthesis of combinational functions: Arithmetic Circuits-Adder/ Subtractor, carry look-ahead adder, signed number addition and subtraction, BCD adders. IC adders. Multiplexers, implementation of combinational functions using multiplexers, de-multiplexers, decoders, code converters, Digital ICs for combinational logic circuits.


Digital Hardware: Logic levels, Realization of logic gates, different logic families (TTL, ECL, CMOS, HC, HCT, ACT and HSCMOS), Logic levels, voltages and currents, fan-in, fan-out, speed, power dissipation. Comparison of logic families, interfacing between different families.

Text Books:

Reference Books:


Course outcomes:

On completion of this course, the students will be able to,
1. Understand various number systems, conversions and simplify the logical expressions using Boolean functions.
2. Design and develop arithmetic and other special functions using combinational logic circuits and PLDs.
3. Design and develop synchronous and asynchronous for the given problem statement.
4. Understand how logic gates are built from the fundamental semiconductor electronics and be able to select logic ICs from different families based on requirement.
ICPC15 - SIGNALS AND SYSTEMS

Course type: Programme Core (PC)  Pre-requisites: -
No. of Credits: 3

Course Objectives:

1. To introduce the student to identify and represent the type of signals and systems.
2. To introduce the mathematical tools available to analyze continuous time signals and systems.
3. To introduce the mathematical tools available to analyze discrete time signals and systems.
4. To introduce about the random phenomena in the real world, the mathematical models and pseudo-random signals in identifying systems.

Course Content:


Representation of signals in terms of elementary signals – Condition of orthogonality – Representation of signals by elementary sinusoids – Fourier series representation of periodic signals – Power spectrum.


Auto-correlation function of system output - Cross-correlation between system input and output. White noise - Analysis of linear systems in time-domain using white noise - Mean and mean square value of system output. Generation of pseudo random binary noise (PRBN) and its use in system identification - Analysis in the frequency domain.
Text Books:

Reference Books:

Course outcomes:
On completion of this course, the students will be able to,
1. Classify the signals and systems based on their properties and determine the response of LTI system using convolution
2. Analyze the spectral characteristics of continuous and discrete time signals and systems using Fourier transforms.
3. Apply Laplace and Z transform to analyze continuous and discrete time systems
4. Understand the process of sampling and the effects of under sampling
5. Classify random signals using statistical concepts and characterize systems using pseudo-random signals.
Course type: Programme Core (PC)  
No. of Credits: 4  

Pre-requisites: -  

Course Objectives:  
1. To introduce the concept of feedback control system.  
2. To impart knowledge in mathematical modeling of physical systems.  
3. To impart knowledge in characteristics and performance of feedback control system.  
4. To teach a variety of classical methods and techniques for analysis and design of control systems.

Course Content:  
Review of Systems, Mathematical Models – Differential Equations, Linear Approximations and Transfer Functions, Block Diagrams and Signal Flow Graphs


Frequency Response Methods, Nyquist’s Stability Criterion, Bode Plots, Performance Specifications in Frequency-Domain, Stability Margins.

Design of Lead, Lag and PID controller in Frequency Domain.

Text Books  

Reference Books  
Course outcomes:
On completion of this course, the students will be able to

1. Generate mathematical models of dynamic control system by applying differential equations.
2. Analyze and characterize the behavior of a control system in terms of different system, performance parameters and assess system stability.
3. Evaluate and analyses system performance using frequency and transient response analysis.
4. Design and simulate control systems (linear feedback control systems, PID controller, and multivariable control systems), using control software, to achieve required stability, performance and robustness.
ICPC17 - ANALOG SIGNAL PROCESSING

Course type: Programme Core (PC)  
Pre-requisites: -
No. of Credits: 3

Course Objectives:

1. To teach the properties of analog signals and systems and random signal analysis
2. To familiarize the students to DC and AC characteristics of operational amplifiers and its influence on output and their compensation techniques
3. To impart the students to design signal conditioning circuits using Op-Amp
4. To introduce the concepts of switched capacitor filters, Voltage regulator and PLL and its applications

Course Content:

Introduction to analog signals and systems, Random signal analysis, application of statistical methods to the measurement of waveforms.

Analog signal processing circuits: amplifiers, analog multipliers, integrators, differentiators, active and passive filters. Universal Filters and their application

Current-to-voltage and voltage-to-current converter, analog-to-digital converter, digital-to-analog converter, voltage-to-frequency converter, frequency-to-voltage converter.

Switched capacitor filter, Phase locked loop, Schmitt trigger, automatic gain control, regulators, wave form generators, oscillators.

Case studies: bridge linearization, PLL design using divider and multipliers, regulator design with low voltage dropout, transmitter design and realization of controllers.

Text Books:


Reference Books:

3. NPTEL - Lecture Series on Analog ICs, Analog circuits and system’s by Prof. K. Radhakrishna Rao, Department of Electrical Engineering, I.I.T. Madras.

Course outcomes:

On completion of this course, the students will be able to

1. Understand the implications of the properties of systems and signals
2. Design and simulate various analog signal conditioning circuits
3. Implement various analog signal conditioning circuits in real time
4. Trouble shoot analog signal conditioning circuits
ICPC18 - MICROPROCESSORS AND MICROCONTROLLERS

Course type: Programme Core (PC)  
Pre-requisites: ICPC14  
No. of Credits: 3

Course Objectives:

1. To introduce the architecture of 8, 16 and 32-bit microprocessor and microcontroller.  
2. To impart microcontroller programming skills in students.  
3. To familiarize the students with data transfer and interrupt services.  
4. To familiarize the students with communication protocols for peripheral interfacing.

Course Content:

Introduction to computer architecture and organization, Architecture of 8-bit, 16-bit, 32-bit and 64-bit microprocessors, CISC/RISC design philosophy, bus configurations, CPU module. Embedded system overview.

Introduction to embedded C and assembly language, instruction set of a typical 8-bit and 16-bit microprocessor, subroutines and stacks, energy efficient ultra-low power modes, programming exercises.

Timing diagrams, Memory families, Flash Vs FRAM, on-chip peripherals- working with IO ports, ADC, comparators, timers, PWM, Watchdog, Low power modes.

Architectures of 8 and 16-bit Microcontrollers, comparison, programming exercises, applications of energy efficient systems.

Serial and parallel data transfer schemes, interrupts and interrupt service procedure. Internal peripherals of microcontrollers – SPI, I2C UART, USB and DNA. Interfacing with RTC, EEPROM and DAC.

Text Books:


Reference Books:


Course outcomes:

On completion of this course, the students will be able to,

1. Understand the various functional blocks of microprocessor and microcontrollers.  
2. Understand and write the assembly and C language programs.  
3. Interface the peripherals with microprocessors and microcontrollers  
4. Design and develop microcontroller-based applications.
ICPC19 –CONTROL SYSTEMS-II

Course type: Programme Elective (PE)  
Pre-requisites: -  
No. of Credits: 3

Course Objectives

1. To introduce about the system states and state-space modeling of dynamical systems.  
2. To teach the advanced methods and techniques of linear system analysis and stability using Lyapunov theory.  
3. To demonstrate how algebraic methods can be deployed in developing feedback controllers for a larger scale of systems.  
4. To develop practical control systems using digital computers through data acquisition and computing.

Course Content


Text Books:

Reference Books:
1. John J.D., Azzo Constantine, H. and Houpis Stuart, N Sheldon, Linear Control System Analysis and Design with MATLAB, CRC Taylor& Francis Reprint
Course Outcomes

On completion of this course, the students will be,

1. Exposed to an appropriate modern paradigm for the study of larger scale multi-input-multi-output systems.
2. Able to use linear algebra and matrix theory in the analysis and design of practical control systems.
3. Able to determine the stability of systems using Lyapunov’s theory.
4. Motivated to implement modern control systems using a digital computer.
ICPC20- INDUSTRIAL INSTRUMENTATION

Course type: Programme Core (PC)  
Pre-requisites: -  
No. of Credits: 3

Course Objectives:
1. To expose the students to the importance of process variable measurements.
2. To expose the students to various measurement techniques used for the measurement of temperature, flow, pressure and level in process industries.
3. Make the students how to select and maintain the performance of new technology flow instruments.
4. To make the students knowledgeable in the design, installation and troubleshooting of process instruments.

Course Content:
Temperature measurement: Introduction to temperature measurements, Thermocouple, Resistance Temperature Detector, Thermistor and its measuring circuits, Radiation pyrometers and thermal imaging.

Pressure measurement: Introduction, definition and units, Mechanical, Electro-mechanical and electronic pressure measuring instruments. Low pressure measurement, Transmitter definition types, I/P and P/I Converters.

Level measurement: Introduction, Differential pressure level detectors, Capacitance level sensor, Ultrasonic level detectors and Radar level transmitters and gauges.


Flow measurement: Hot wire anemometer, laser Doppler anemometer, ultrasonic, vortex and cross correlation flow meters, and measurement of mass flow rate.

Text Books:

Reference Books:
6. Alok Baura, Fundamentals of Industrial Instrumentation, Wiley India Pvt. Ltd
Course outcomes:

On completion of this course, the students will be,

1. Familiar with the different temperature, pressure, flow and level measurement techniques used in process industries.
2. Able to explain the basic principles of measuring instruments used for measuring the four important variables.
3. Will be able to identify a suitable measuring instrument for an application.
4. Able to design signal condition and compensation circuits for temperature and pressure measuring instruments.
5. Able to trouble shoot and maintain the temperature, flow, pressure and level measuring device for a specific process.
Course type: Programme Core (PC)  
Pre-requisites: -
No. of Credits: 3

Course Objectives:

1. To give an overview of current, voltage and power measuring electrical, electronics and digital instruments.
2. To expose the students to the design of bridges for the measurement of resistance, capacitance and inductance.
3. To give an overview of test and measuring instruments.
4. To provide the working knowledge of various waveform generators, analyzers and display devices.

Course Content:

Electrical measurements: General features and Classification of electro mechanical instruments. Principles of Moving coil, moving iron, dynamometer type, rectifier type, thermal instruments. Extension of instrument range: shunt and multipliers, CT and PT.

Measurement of Power: Electrodynamy wattmeter’s, Low Power Factor (LPF) wattmeter, errors, calibration of wattmeter. Single and three phase power measurement, Hall effect wattmeter, thermal type wattmeter.


DSO, MSO, Function generators, Signal generators, Waveform analyzers, Spectrum analyzers, Distortion analyzers, LED, LCD and Organic LED displays.

Text Books:

2. Shawney A K, A course in Electrical and Electronic Measurements and Instrumentation, Dhanpat Rai and Sons, Jan 2015.
Reference Books:


Course outcomes:

On completion of this course, the students will be,

1. Familiar with various measuring instruments (ammeters, voltmeters, wattmeters, energy meters, extension of meters, current and voltage transformers) used to measure electrical quantities.
2. Able to design suitable DC and AC bridges for the measurement of R, L, C and Frequency measurement.
3. Able to suggest the kind of instrument suitable for typical measurements.
4. Able to use the test and measuring instruments effectively.
ICPC22- PROCESS CONTROL

Course type: Programme Core (PC)  Pre-requisites: ICPC16
No. of Credits: 3

Course Objectives:
1. To introduce the terminology and concepts associated with Process control domain.
2. To impart knowledge in the design of control systems and PID controller tuning for processes.
3. To familiarize the students with characteristics, selection, sizing of control valves.
4. To elaborate different types of control schemes such as cascade control, feed forward control and Model Based control schemes.

Course Content:


Advanced control system: Cascade control, ratio control, feed forward control. Over-ride, split range and selective control. Multivariable process control, interaction of control loops. Introduction to Dynamic Matrix Control. Case Studies: Distillation column, boiler drum level control and chemical reactor control.

Text Books
Reference Books


Course outcomes:

On completion of this course, the students will be able

1. To understand technical terms and concepts associated with process control domain.
2. To build models using first principles approach as well as analyze models.
3. To design, tune and implement PID Controllers to achieve desired performance for various processes.
4. To analyze the systems and implement control schemes for various processes.
5. To comprehend on advanced process control strategies.
Course Type: Programme Elective (PC)
No. of Credits: 3

Pre-requisites: -

Course Objectives:
The course introduces the human physiological system with respect to medical instrumentation and its design and the instrumentation for measuring and analyzing the physiological parameters.

1. To educate the students on the different medical instruments.
2. To familiarize the students with the analysis and design of instruments to measure bio-signals like ECG, EEG, EMG, etc.
3. To have a basic knowledge in therapeutic devices
4. To introduce about the clinical laboratory instruments and familiar about electrical safety.

Course Content:
Electro physiology: Review of physiology and anatomy, resting potential, action potential, bioelectric potentials, electrode theory, bipolar and uni-polar electrodes, surface electrodes, needle electrode and microelectrode, physiological transducers-selection criteria and its application.

Bioelectric potential and cardiovascular measurements: ECG recording system, Heart sound measurement - stethoscope, phonocardiograph (PCG), Foetal monitor-ECG- phonocardiography, vector cardiograph, cardiac arrhythmia’s monitoring system. EMG, EEG - Evoked potential response, ERG and EOG recording system. Measurement of blood pressure using sphygmomanometer instrument based on Korotkoff sound, indirect measurement of blood pressure, automated indirect measurement, and direct measurement techniques.


Respiratory and pulmonary measurements: Physiology of respiratory system, respiratory rate measurement- artificial respirator- oximeter, pulmonary function measurements–spirometer–photo plethysmography and body plethysmography. Principal and techniques of impedance pneumography, Apnea monitor.

Electrical safety: Sources of electrical hazards in medical environment and safety techniques for checking safety parameters of biomedical equipment.
Text Books:
5. Shakti Chatterjee and Aubert Miller, Biomedical Instrumentation Systems, CENGAGE Learning publishing, 2016.

Reference Books:

Course Outcomes:
On completion of this course the students will be,
1. To understand, design and evaluate systems and devices that can measure, test and/or acquire bio-signal information from the human body.
2. Familiar with patient monitoring equipment used in hospitals.
3. Ability to explain the medical diagnostic and therapeutic techniques.
4. Familiar with various clinical laboratory instruments used for diagnosis.
ICPC24- ANALYTICAL INSTRUMENTATION

Course type: Programme Core (PC)                          Pre-requisites: -
No. of Credits: 3

Course Objectives:

1. To teach the students about the analysis of materials which is an important requirement of process control and quality control in industry
2. To expose the students to principles of various analytical methods.
3. To impart knowledge on various spectroscopic instruments used in the analysis of materials
4. To introduce the concept of analytical instruments used in drug and pharmaceutical lab
5. To introduce different analytical instruments used in environmental pollution monitoring

Course Content:


Text Books:

Reference Books:


Course outcomes:

On completion of this course, the students will be able to,

1. Appreciate the relevance of material sampling and analysis in process control and quality control in industry.
2. Understand the physical principles behind the various widely used analytical methods in the industry.
3. Understand the important components and concepts of various spectroscopic instruments and instruments used in drug and pharmaceutical lab and pollution monitoring.
4. Select an appropriate analytical instrument for an industrial requirement.
ICPC25 - LOGIC AND DISTRIBUTED CONTROL SYSTEMS

Course type: Programme Core (PC)  
Pre-requisites: -
No. of Credits: 3

Course Objectives:
1. To introduce the importance of process automation techniques.
2. To impart knowledge in PLC based programming.
3. To introduce distributed control system and different communication protocols.
4. To have adequate information with respect to interfaces used in DCS

Course Content:
Review of PC based control design for process automation: Functional Block diagram of Computer control of process - Mathematical representation – Sampling Consideration- Data Acquisition system and SCADA, Hybrid, Direct Digital Control System, Distributed Control System architecture and Comparison with respect to different performance attributes.

Programmable logic controller (PLC) basics: Definition, overview of PLC systems, Block diagram of PLC. General PLC programming procedures: ON/OFF instruction, Timer instruction sets, Counter Instruction sets -Design, development and simulation of PLC programming using above instruction sets for simple applications.

PLC Data manipulation instruction - Arithmetic and comparison instruction- Skip, Master Control Reset (MCR) and Zone Control Last state (ZCL) instruction – PID and other important instruction set. PLC Installation, troubleshooting and maintenance. Design of alarm and interlocks, networking of PLC – Case studies using above instruction sets.

Distributed Control System: Local Control Unit (LCU) architecture - Comparison of different LCU architectures – LCU Process Interfacing Issues: - Block diagram, Overview of different LCU security design approaches, secure control output design, Manual and redundant backup designs.

LCU communication Facilities - Communication system requirements – Architectural Issues – Operator Interfaces – Engineering Interfaces. Development of Field Control Unit (FCU) diagram for simple control applications. Introduction to HART and Field bus protocol. Interfacing Smart field devices (wired and wireless) with DCS controller. Introduction to Object Linking and Embedding (OLE) for Process Control, Automation in the cloud with case studies.

Text Books:
**Reference Books**


**Course outcomes:**

On completion of this course, the students will be

1. Familiar with process automation technologies.
2. Able to design and develop a PLC ladder programming for simple process applications.
3. Able to apply different security design approaches, engineering and operator interface issues for designing of Distributed Control System.
4. Familiar with latest communication technologies like HART and Field bus protocol.
PROGRAMME ELECTIVE (PE) COURSES
ICPE10- INSTRUMENTATION PRACTICES IN INDUSTRIES

Course type: Programme Elective (PE)  
Pre-requisites: ICPC20  
No. of Credits: 3

Course Objectives:

1. To expose the students to requirement of standards and calibration techniques, safety mechanisms in instruments used in process industries.
2. To impart knowledge about EMI and EMC problems in industrial measurements.
3. To make the students to draw the specification of the industrial instruments and prepare the instrumentation project documents.

Course Content:

Selection and Application: Selection and application of temperature, pressure, flow and level measuring instruments.

Standards and Calibration: Introduction to standards and calibration, calibration of temperature, pressure and flow measuring devices. Introduction to ISO, IEC and API standards pertaining to temperature, pressure and flow instrumentation.

EMI and EMC: Introduction, interference coupling mechanism, basics of circuit layout and grounding, concepts of interfaces, filtering and shielding.

Safety: Introduction, electrical hazards, hazardous areas and classification, non-hazardous areas, enclosures-NEMA types, fuses and circuit breakers. Protection methods: Purging, explosion proofing and intrinsic safety.


Text Books:

Reference Books:


Course outcomes:

On completion of this course, the students will be able to,

1. Select the appropriate instrument for a given process measurement problem.
2. Identify and classify the use of instruments in process industries according to the safety practices in industry.
3. Prepare instruments specification and understand the procedure and process involved in project documentation.
4. Understand and implement the safety standards and preventive action in industries.
ICPE11 - OPTICAL INSTRUMENTATION

Course type: Programme Elective (PE)  Pre-requisites: -
No. of Credits: 3

Course Objectives:
1. To expose the students on the basics of optical sources and detectors, optical fiber and fiber optic sensors.
2. To impart knowledge on the characteristics of optical sources and detectors.
3. To provide adequate knowledge about the optical fiber and their characteristics.
4. To introduce about the Industrial applications of fiber optic sensors and lasers.

Course Content:
Introduction: Characteristics of optical radiation, luminescence.

Optoelectronic sources:
LED – LED power and efficiency, structures- planar, dome, ELED, SLED, super luminescent LEDs, characteristics and applications.
LASERS – structures- gain guided and index guided lasers, types- semiconductor- homo and hetero junction lasers. Non-semiconductor lasers - gas, liquid and solid. Single frequency Lasers, characteristics, Q switching and mode locking, cavity dumping.

Optoelectronic detectors: General characteristics of photodetectors, Photodiode, junction photodiodes – heterojunction diode and PIN diode, APD, Special detectors- Schottky barrier diode, photo- transistor and photo-thyristor, solar cells.

Optical fiber- Fundamentals, types, transmission characteristics. Fibers splicing, connector and couplers. Optocouplers and optrodes.

Industrial applications – Fiber optic sensors -temperature, pressure, flow and level measurement.
LASERS – Distance, length, velocity, acceleration, current and voltage measurements. Material processing: Laser heating, melting, scribing, splicing, welding and trimming of materials, removal and vaporization, calculation of power requirements. Laser gyroscope.

Text Books:
Reference Books:

5. John Wilson and John Hawkes, Optoelectronics, Pearson India, 2018

Course Outcomes:

On completion of the course the students will be,

1. Familiar with the fundamental principles of various types of optical sources, characteristics and its applications.
2. Able to understand the operation of different types of optical detectors and its limitations in industrial use.
3. Apply the gained knowledge on optical fibers for its use as communication medium in industrial use.
4. Knowledgeable on fiber-optical components and systems and its industrial applications.
ICPE12 – MEASUREMENT DATA ANALYSIS

Course Type: Programme Elective (PE)  
No of credit: 3

Pre-requisites: -

Course Objectives:

1. To give basic information about measuring instruments
2. To expose the students about the Statistical methods for estimating errors and uncertainties of real measurements:
3. To introduce the fundamental techniques of measurement for data analysis
4. To apply different measurement techniques that are performed in industry, commerce and experimental research for determination of parameters

Course Content:

General information about measurements, measuring instruments and their properties.


Direct measurements: Method for calculating the errors and uncertainties, Methods for combining systematic and random errors.

Indirect measurements: Correlation coefficient and its calculation, the method of reduction, method of transformation, errors and uncertainty of indirect measurement. Examples of measurements and measurement data processing.

Combined Measurements:
Method of least squares, linearization of nonlinear conditional equations, and determination of the parameters in formulas from empirical data and construction of calibration curves. Combining the results of measurements. Calculation of the errors of measuring instruments.

Text Books:

Reference Books:


Course Outcomes:

On completion of this course, the students will be able to,

1. Estimate measurement inaccuracies.
2. Evaluate the measurement system based on its quality and cost.
3. Acquire both theoretical knowledge and practical skills in working with measurement data.
4. Design and conduct experiments to analyze and interpret the data and generate reports.
ICPE13 - MICRO ELECTRO MECHANICAL SYSTEMS

Course Type: Programme Elective (PE)  
Pre-requisites: -  
No. of Credits: 3

Course Objectives
1. To introduce the fundamental concepts of MEMS and Micro systems and their relevance to current scientific needs.
2. To introduce the state-of-art micromachining techniques including surface micromachining, bulk micromachining, and related methods.
3. To make the students knowledgeable in the design concepts of micro sensors and micro actuators.
4. To introduce the challenges and limitations in the design of MEMS devices
5. To make the students knowledgeable in computer aided design tools for modeling MEMS device.

Course Content:
Introduction, emergence, MEMS application, scaling issues, materials for MEMS, Thin film deposition, lithography and etching.

Bulk micro machining, surface micro machining and LIGA process.


Theory and design: Micro Pressure Sensor, micro accelerometer – capacitive and piezoresistive, micro actuator.

Electronic interfaces, design, simulation and layout of MEMS devices using CAD tools.

Text Books:

Reference Books:

Course Outcomes:
On completion of this course the students will be,
1. Able to understand the fundamental principles behind the working of micro devices/ systems and their applications.
2. Able to knowledgeable in the standard micro fabrication techniques.
3. Able to identify micro sensors and actuators for a specific application.
4. Able to do acquire skills in computer aided design tools for modeling and simulating MEMS devices.
ICPE14 - AUTOMOTIVE INSTRUMENTATION AND CONTROL

Course type: Programme Elective (PE)  Pre-requisites:-
No. of Credits: 3

Course Objectives:
1. To impart knowledge on automobile system, its subsystems and components.
2. To expose the students to the concepts of various sensors used in automobile systems.
3. To teach the basic and advanced controls in automotive systems.
4. To impart knowledge about the electronics and software involved in automotive systems.

Course Content:
Automobile Fundamentals:
Introduction, Electronics in automotive and its evolution, Automotive physical configuration, Engine block, Cylinder head, Piton, Crankshaft, Camshaft, Connecting rod, Valve, 4-stroke cycle, Engine control, Ignition system, Spark plug, High voltage circuit and distribution, Spark pulse generation, Ignition timing, Drivetrain, Transmission, Drive shaft, Differential, Suspension, Brakes, Steering system.

Electronic engine control:

Sensors and actuators:
Automotive variable, Air flow rate sensor, Pressure measurement, Strain gauge MAP sensor, Engine crankshaft angular position sensor, Magnetic reluctance position sensor, Engine angular speed sensor, Timing sensor for ignition and fuel delivery, Hall effect and optical position sensor, Optical crankshaft position sensor, Throttle angle sensor, temperature sensor, coolant sensor, Exhaust gas oxygen (EGO) sensor, Desirable and switching characteristics, Knock sensor, Angular rate sensor, LIDAR, Flex fuel sensor, Acceleration sensor, Fuel injection, Exhaust gas recirculation actuator, Variable valve timing, Electric motor actuator, Ignition system.

Vehicle power train and motion control:
Electronic transmission control, adaptive power Steering, adaptive cruise control, safety and comfort systems, anti-lock braking, traction control and electronic stability, active suspension control.

Active and passive safety system:
Body electronics including lighting control, remote keyless entry, immobilizers etc., electronic instrument clusters and dashboard electronics, aspects of hardware design for automotive including electro-magnetic interference suppression, electromagnetic compatibility etc., (ABS) antilock braking system, (ESP) electronic stability program, air bags.
Automotive standards and protocols:
Automotive standards like CAN protocol, LIN protocol, FLEX RAY, Head-Up Display (HUD), OBD-II, CAN FD, automotive Ethernet etc. Automotive standards like MISRA, functional safety standards (ISO 26262).

Text Books:

Reference Books:

Course Outcomes:
On the completion of this course the students will be able to,
1. Identify the automotive system and its components.
2. Attain knowledge of various sensors and conditioning circuit used in automotive systems.
3. Gain knowledge about various control strategies, the electronics and software used in automotive application.
4. Gain the basic ideas about the standards and protocols and energy management.
ICPE15 - INSTRUMENTATION AND CONTROL FOR POWER PLANT

Course type: Programme Elective (PE)  Pre-requisites: -
No. of Credits: 3

Course Objectives:
1. To expose the students to various power generation methods.
2. To impart knowledge on various processes/systems involved in thermal power generation.
3. To provide the knowledge on specific measurement techniques and control systems practiced in boiler and turbine units.
4. To impart basic knowledge in nuclear power plant and associated instrumentation.

Course Content:

Measurement in boiler and turbine: Metal temperature measurement in boilers, impulse-piping system for pressure measuring devices, flame monitoring. Introduction to turbine supervising system, pedestal vibration, shaft vibration, eccentricity measurement. Installation of non-contracting transducers for speed measurement, rotor and casing movement and expansion measurement.

Controls in boiler: Problems associated with control of multiple pulverizes. Draught plant: Introduction, natural draught, forced draught, induced draught, balanced draught, power requirements for draught systems. Fan drives and control, control of airflow. Combustion control: Fuel/Air ratio, oxygen, CO and CO\textsubscript{2} trimming, combustion efficiency, excess air, parallel and cross limited combustion control, control of large systems.

Controls in boiler: Boiler drum level measurement methods, feedwater control, soot-blowing operation, steam temperature control, coordinated control, boiler following mode operation, turbine following mode operation, constant/ sliding pressure operation, selection between boiler and turbine following modes. Distributed control system in power plants-interlocks in boiler operation. Turbine control: Shell temperature control-steam pressure control – lubricant oil temperature control – cooling system.

Nuclear power plant instrumentation: Piping and instrumentation diagram of different types of nuclear power plant, Nuclear reactor control loops, reactor dynamics, excess reactivity, pulse channel and logarithmic instrumentation, control and safety instrumentation, reliability aspects.
Text Books:

Reference Books:

Course Outcomes:
On the completion of this course, the students will be familiar with,
1. Various power generation processes.
2. Important parameters to be monitored and controlled in a thermal power plant.
3. Major control systems involved in the thermal power plant and nuclear power plants.
ICPE16 - INSTRUMENTATION AND CONTROL FOR PETROCHEMICAL INDUSTRIES

Course type: Programme Elective (PE)  
Pre-requisites: -  
No. of Credits: 3

Course Objectives:
1. To expose the students to various petroleum production processes.  
2. To impart knowledge on various processes involved in petroleum refinery.  
3. To provide knowledge on specific measurement techniques practiced, control systems and automation involved in petrochemical industry.

Course Content:
Brief survey of petroleum formation, petroleum exploration, Petroleum production, Petroleum refining and its methods, refining capacity and consumption in India, constituents of Crude Oil, Recovery techniques – Oil – Gas separation, Processing wet gases.

P & I diagram of petroleum refinery, Atmospheric distillation process, Vacuum distillation process, Thermal cracking, Catalytic cracking, Catalytic reforming, and Utility plants – Air, N₂, and cooling water.

Basics of field instruments, Parameters to be measured in Petrochemical industry, Distillation Column control, Selection of instruments, Basics of intrinsic safety of instruments, Area classification.

Control of furnace, Reboiler Control, Reflux Control, Control of catalytic crackers, Control of heat exchanger, Control of cooling tower.


Text Books:

Reference Books:

Course Outcomes:
On completion of this course, the students will be familiar with,
1. Various petrochemical process and important parameters to be monitored and controlled.  
2. Various instruments involved in and the control of petrochemical process.  
3. The automation and safety standards of a petrochemical industry.
ICPE17 - INSTRUMENTATION AND CONTROL FOR PAPER INDUSTRIES

Course type: Programme Elective (PE)  
Pre-requisites: -  
No. of Credits: 3

Course Objectives:
1. To familiarize the students to the paper making process.  
2. To expose the students to the instrumentation used in Paper industries.  
3. To expose the students to the control operations employed in paper industries.

Course Content:
Paper making process: Raw materials, pulping and preparation, screening – bleaching, cooking, chemical addition, approach system, paper machine, drying section, calenders, drive, finishing, other after treatment processes, coating.  
Properties of paper: physical, electrical, optical and chemical properties.

Wet end Instrumentation: Conventional measurements at wet end, pressure and vacuum, temperature, liquid density and specific gravity, level, flow, consistency measurement, pH and ORP measurement, freeness measurement.

Dry end Instrumentation: Conventional measurements, moisture, basis weight, caliper, coat thickness, optical variables, measurement of length and speed.

Digester: Rotary and Batch type.

Control aspects: Machine and cross direction control techniques, control of pressure, vacuum, temperature, liquid density and specific gravity, level, flow, pH, freeness, thickness, consistency, basis weight and moisture.

Pumps and control valves used in paper industry, flow box and wet end variables, evaporator feedback and feed forward control, lime mud density control, stock proportioning system, refiner control instrumentation, basic pulper instrumentation, headbox – rush/drag control. Instrumentation for size preparation, coating preparation, coating weight control. Batch digester, K/Kappa number control, Bleach plant chlorine stage control.

Text Books
Reference Books


Course Outcomes:

On completion of this course, the students will be able to,

1. Appreciate the need of instrumentation and control in paper making.
2. Understand the instrumentation and control used in paper and pulp industry.
3. Suggest and analyse new instruments and control options in paper and pulp industry.
ICPE18 - INSTRUMENTATION FOR AGRICULTURAL AND FOOD PROCESSING INDUSTRIES

Course type: Programme Elective (PE)  
No. of Credits: 3  
Pre-requisites: -

Course Objectives:

1. To provide an understanding on the need of instrumentation in agriculture and food processing sector.
2. To provide an understanding of food quality assessment and instruments used for the same.
3. To provide an understanding on agriculture associated activities and instruments used for the same.
4. To provide some knowledge in food processing equipment.

Course Content:

Introduction: Necessity of instrumentation and control for food processing and agriculture sensor requirement, remote sensing, biosensors in Agriculture, standards for food quality.

Instrumentation for food quality assurance: Instrumental measurements and sensory parameters. Inline measurement for the control of food processing operations: color measurements of food, food composition analysis using infrared, microwave measurements of product variables, pressure and temperature measurement in food process control, level and flow measurement in food process control, ultrasonic instrumentation in food industry. Instrumental techniques in the quality control, Major Processes: Flow diagram of sugar plant, sensors and instrumentation set-up for it, Oil extraction plant and instrumentation set-up, Juice extraction control set-up.


Green houses and Instrumentation: Ventilation, cooling and heating wind speed, temperature and humidity, rain gauge, carbon dioxide enrichment measurement and control.

Design considerations of agricultural and food Processing Equipments: Design of Food Processing equipments, dryers, design of dryers PHTC, RPEC, LSU and Drum Dryer, determination of heat and air requirement for drying grains.

Text Books:


**Reference Books:**


**Course Outcomes:**

On completion of this course, the students will be,

1. Able to understand the necessity of instrumentation in agriculture and food processing.
2. Familiarized with instrumentation requirement in agriculture and food processing.
3. Able to analyse and design systems/instruments for agriculture and food processing.
4. Able to understand problems in agriculture and food processing and provide technological solution to the same.
ICPE19 – PIPING AND INSTRUMENTATION DIAGRAMS

Course type: Programme Elective (PE)  
Pre-requisites: ICPC20  
No. of Credits: 3

Course Objectives:

1. To introduce various flow sheet design using process flow diagram.
2. To impart knowledge on P&I D symbols for pumps, compressors and process vessels.
3. To teach the line diagram symbols, logic gates of instruments.
4. To learn the simulation software for P&ID implementations

Course Content:

Flow sheet design: Types of flow sheets, flow sheet presentation, flow sheet symbols, line symbols and designation, process flow diagram, synthesis of steady state flowsheet, flow sheeting software.

Piping and instrumentation diagram evaluation and preparation: P & I D Symbols, line numbering, line schedule, P&I D development, various stages of P&I D, P&I D for pumps, compressors process vessels, absorber, evaporator.

Control systems and interlocks for process operation: Introduction and description, need of interlock, types of interlocks, interlock for pumps, compressor, heater-control system for heater, distillation column, expander

Instrument line diagram: Line diagram symbols, logic gates, representation of line diagram.

Application of P&ID’S: Applications of P& ID in design state, construction stage, commissioning state, operating stage, revamping state, applications of P&ID in HAZAMPS and risk analysis

Text Books


Reference Books


Course Outcomes:

On completion of this course, the students will be able to,

2. Select different fittings for instruments installation used for the preparation of P&IDs.
3. Apply software for preparation of P&IDs.
4. Apply the P and ID concepts for industrial applications
ICPE20 - ASSISTIVE DEVICES

Course Type: Programme Elective (PE)  Pre-requisites: -
No. of Credits: 3

Course Objectives

1. To understand the concepts of various rehabilitation equipments for human movements and applications
2. To understand and gain knowledge about different hearing aids
3. To study various assist devices for visually and auditory impaired
4. To study the various orthotic devices and prosthetic devices to overcome orthopedic problems
5. Understand the various mobility aids
6. Learn about manual and powered wheelchairs for the evaluation of human-technology interfaces
7. Understand key terminology used by various aids within the disability community and its roles.

Course Content

Introduction to the Human body system, Principles of Assistive and Rehabilitation Technology, Design considerations, standards and key approaches to rehabilitation and Assistive Technology.


Anatomy of upper and lower extremities, Classification of amputation types, Prosthesis prescription - Components of upper and lower limb prosthesis, Different types of models for limb prosthetics- Body powered prosthetics- Myoelectric controlled prosthetics and Externally powered limb prosthetics. Functional Electrical Stimulation Systems-Restoration of hand function, restoration of standing and walking, Hybrid Assistive Systems (HAS).

Concepts of Manipulation and mobility Aids, Grabbers, feeders, and page turners, Classification of manual and special purpose wheelchairs - Manual wheelchairs – Electric power wheel chairs - Power assisted wheel chairs - Wheel chair standards & tests, sports and racing wheel chairs.

Text Books

Reference Books


Course Outcomes

1. Gain adequate fundamental knowledge about the needs of rehabilitations and its future development.
2. Design and apply different types of Hearing aids, visual aids and their application in biomedical field and hence the benefit of the society.
3. Gain in-depth knowledge about various assistive technologies for vision and hearing
4. Develop and Compare the different methods of orthopedic prosthetics for rehabilitation.
5. Select the appropriate rehabilitation concept for various disabilities.
6. Apply basic design and analytical skills to model various types of Wheel Chairs for varied needs.
This course will cover the various medical diagnostics and Therapeutic Equipment’s used in health care.

**Course objectives:**

1. To familiarise on patient monitoring systems and telemedicine
2. To understand medical imaging systems
3. To explain extracorporeal devices used in critical care
4. To educate the importance of patient safety against electrical hazard

**Course contents:**

Patient monitoring systems, Intensive cardiac care, bedside and central monitoring systems - Infusion pumps, Central consoling controls. Patient monitoring through telemedicine.

X ray machine, Computer tomography, ultrasonic imaging system, magnetic resonance imaging system, thermal imaging system, positron emission tomography.


IR, UV lamp and LASER application, Short wave diathermy, ultrasonic diathermy, Microwave diathermy, Electro surgery machine - Current waveforms, Tissue Responses, Lithotripsy, Principles of Cryogenic technique and application, Endoscopy, Laparoscopy, Otoscopes, Audiometer, Tonometer

Sources of electrical hazards and safety techniques, Built-in safety features for medical instruments, physiological effects of electricity, Patient ‘s electrical environment, Electrical safety codes and standards.

**Text Books**

2. John G. Webster, Medical Instrumentation Application and Design1 , 5th edition, Wiley India Pvt Ltd, New Delhi,2020.
References:

Course outcomes:
At the end of the course, the student should be able to:
1. Familiar with patient monitoring equipment used in hospitals and in telemedicine.
2. Familiar with various imaging techniques used for diagnosis.
3. Discuss extracorporeal devices used in hospital
4. Explain the types of diathermy and its applications.
5. Understand the importance of patient safety against electrical hazard
ICPE22 - PRODUCT DESIGN AND DEVELOPMENT (THEORY & PRACTICE)

Course type: Programme Elective (PE)  
No. of Credits: 3  
Pre-requisites: -

Course Objectives

1. The aim of this course is to inculcate into the student the spirit of innovation and entrepreneurship. This is achieved in this course by making the students to develop a marketable product on their own as a group. At the end of this semester course, the students will learn how to know the needs of the society and solve them using the technical knowledge at their disposal.

2. The students will learn some of the general concepts needed for new product development and simultaneously learn how to interact with the society outside the campus to learn about its needs. They also learn about how to get prototypes fabricated outside the campus.

3. The students will fabricate an alpha prototype and test it for its conformity to the design specifications at the beginning of the next academic session.

4. After demonstration of the alpha prototype, they proceed to fabricate a beta prototype that is acceptable in the market-place.

Course Content

TOPICS COVERED BY LECTURES

Introduction to product design – Product planning – Identifying customer needs – Project selection – Concept generation – Concept testing – Concept selection. Product specification – Product architecture

PRACTICAL WORK

Interaction with public outside the campus - identifying customer needs - product selection based on customer needs - concept generation - concept testing.

Identifying fabrication requirements - Identifying fabricators for the project - costing - financial model for the product development - finding outside finance for product development if possible and required - patent search for the product.

1. Alpha prototype fabrication and testing - to be submitted at the end of the semester with customer acceptance survey.

Course Evaluation

Theoretical and Practical part will be evaluated separately and grades will be awarded. Theoretical component will be evaluated during the semester (50%) and the practical component (50%) will be evaluated at the end of the semester.
Course Outcomes
On completion of this course, the students will be able to,
1. Make market surveys for new product development
2. Select an appropriate product design and development process for a given application
3. Plan the entire cycle of new product design and development.
4. Fabricate prototypes of new products and test them.
5. Choose an appropriate agronomy for the product and adopt methods to minimize the cost

Text Books

References:
1. Journals related to Engineering design.
ICPE23 - DIGITAL CONTROL SYSTEMS

Course type: Programme Elective (PE)  
No. of Credits: 3  
Pre-requisites: -

Course Objectives:
1. To introduce the digital implementation of control systems
2. To review the classical techniques and highlight the practical difficulties
3. To emphasize on the time-domain and state-space implementation using digital processors, and expose the students to industrial practice using PLCs.
4. To design discrete-time controllers for hybrid systems

Course Content:
Introduction to digital control systems, Review of discrete-time signals and systems, difference equations, transfer functions, Z-transforms

Digital Controller Design using root locus and Bode plot, digital PID controllers design using time domain and frequency domain techniques.

Review of Modern Control systems, Modelling multi-variable difference equations as state-space canonical models, Solution of discrete-time state equation. Computational methods.

Stability analysis of discrete-time systems, Jury ’s criterion, Lyapunov theory

Design using state-space methods: controllability and observability, control law design, pole placement, Full order and reduced order discrete observer design – Introduction to Kalman filter

Implementation of digital control systems using DSPs and Microcontrollers, Large-scale industrial applications using PLCs and SCADA, Introduction to Discrete-event systems and Hybrid Systems

Text books:

Reference books:

Course outcomes:
On completion of this course, the students will be able to,
1. Analyze the performance and stability of a discrete-time control system.
2. Design state-space digital controllers and implement using processors and PLCs.
3. Learn about event driven and hybrid systems.
4. Understand implementation issues for computer-based control systems
Course type: Programme Elective (PE)  
Pre-requisites: -
No. of Credits: 3

Course Objectives:

1. To introduce the basic blocks of Building Management System.
2. To impart knowledge in the design of various sub systems (or modular system) of building automation.
3. To provide insight into some of the advanced principles for safety in automation.
4. To Design energy management system.

Course Content:

Introduction:
Concept and application of Building Management System (BMS) and Automation, requirements and design considerations and its effect on functional efficiency of building automation system, architecture and components of BMS.

HVAC system:
Different components of HVAC system like heating, cooling system, chillers, AHUs, compressors and filter units and their types. Design issues in consideration with respect to efficiency and economics, concept of district cooling and heating.

Access control & security systems:
Concept of automation in access control system for safety, Physical security system with components, Access control components, Computer system access control – DAC, MAC, and RBAC.

Fire & alarm system:
Different fire sensors, smoke detectors and their types, CO and CO₂ sensors, Fire control panels, design considerations for the FA system, concept of IP enabled fire & alarm system, design aspects and components of PA system.

CCTV system & energy management system:
Components of CCTV system like cameras, types of lenses, typical types of cables, controlling system, concept of energy management system, occupancy sensors, fans & lighting controller. Introduction to structural health monitoring and methods employed.

Text Books:

Reference Books:


Course Outcomes:

On completion of this course, the students will be able to,

1. Understand the concept behind building automation.
3. Design sub systems for building automation and integrate those systems.
4. Learn to design energy efficient system.
ICPE25 – NONLINEAR CONTROL

Course type: Programme Elective (PE)  
Pre-requisites: IC PC 19
No. of Credits: 3

Course Objectives:

1. To introduce and elaborate the characteristics of nonlinear systems.
2. To gain understanding in the methods (both classical and modern) of analysis of stability and performance of nonlinear systems.
3. To study the design of controllers as applicable to various case studies in robotics, aerospace and other domains.
4. To introduce the notion of complex systems theory and large-scale real-world problems.

Course Content:

Introduction – Modeling one-dimensional and two-dimensional dynamics, Existence and uniqueness of solutions.

Approximate analysis methods: The phase plane, Index theory, Poincare-Bendixson theorem, Describing function analysis.

Lyapunov theory for autonomous and non-autonomous systems, Attractors and Basins, Poincare maps.

Nonlinear control system design: Sliding control, Basics of Differential geometry, feedback linearization, single-input and multi-input cases.


Text Books:


Reference Books:


Course Outcomes:

On completion of this course, the students will be able to,

1. Differentiate between linear and nonlinear systems and their behaviour.
2. Apply various graphical and analytical tools to describe and analyse nonlinear systems.
3. Understand Lyapunov theory.
4. Learn a range of controller design techniques suitable for nonlinear control systems.
ICPE26 – SYSTEM IDENTIFICATION

Course type: Programme Elective (PE)  
Pre-requisites: -  
No. of Credits: 3

Course Objectives:

1. To introduce empirical and data-based modeling of large-scale systems.
2. To train the students in parametric and nonparametric statistical models and estimation techniques.
3. To expose to the students, the algorithms and computational overheads involved in large-scale system modeling and control.

Course Content:


Estimates of the plant impulse, step and frequency responses from identification data, Correlation and spectral analysis for non-parametric model identification, parametric Models-Equation error, output error models, and determination of model order.

Parametric estimation using one-step ahead prediction error model structures and estimation techniques for ARX, ARMAX, Box-Jenkins, FIR, Output Error models. Residual analysis for determining adequacy of the estimated models. Recursive system identification.

Kalman filtering and other nonlinear filters

Reference Books:

Course Outcomes

On completion of this course, the students will be able to,

1. Conduct experiments, design suitable inputs and generate data for system identification.
2. Identify the model structure & order determination for an unknown process from empirical data.
3. Apply estimation techniques for parametric & nonparametric models.
4. Identify and validate the model for practical process applications
ICPE27 - FAULT DETECTION AND DIAGNOSIS

Course type: Programme Elective (PE)  Pre-requisites: ICPC16
No. of Credits: 3

Course Objectives:

1. To impart knowledge in fault detection and identification.
2. To introduce different structure residual technique for the fault identification.
3. To introduce different directional residual technique for the fault identification.
4. To impart the knowledge in soft computation technique based FDI design

Course Content:

Introduction to Fault Detection and Diagnosis: Scope of FDD: Types of faults and different tasks of Fault Diagnosis and Implementation - Different approaches to FDD: Model free and Model based approaches. Classification of Fault and Disturbances- Different issues involved in FDD- Typical applications.


Text Books:


Reference Books:


Course Outcomes:

On completion of this course, the students will be able to,

1. Identify the different type of faults occurred in a system.
2. Apply mathematical techniques to detect faults.
3. Apply structured and directional techniques for FDI design.
4. Apply soft computation technique for FDI development.
ICPE28 - COMPUTATIONAL TECHNIQUES IN CONTROL ENGINEERING

**Course type:** Programme Elective (PE)  
**Pre-requisites:** ICPC 19  
**No. of Credits:** 3

**Course Objectives:**
1. To impart knowledge with an emphasis on control system design in the current computer era.
2. To teach the interdisciplinary necessity of linear algebra, control theory, and computer science.
3. To demonstrate that control problems in practice demand efficient algorithms.
4. To discuss about algorithms useful for practicing engineers for easy implementation on a range of computers.

**Course Content:**


- **Numerical Linear Algebra** – Floating point numbers and errors in computations, Conditioning, Efficiency, Stability, and Accuracy, LU Factorization, Numerical solution of the Linear system $Ax = b$, QR factorization, Orthogonal projections, Least Squares problem, Singular Value Decomposition, Canonical forms obtained via orthogonal transformations.


- **Control Systems Design** – Feedback stabilization, Eigen value assignment, Optimal Control, Quadratic optimization problems, Algebraic Riccati equations, Numerical methods and conditioning, State estimation and Kalman filter.

Large scale Matrix computations, Some Selected Software – MATLAB, MATHEMATICA, SCILAB.

**Text Books:**

**Reference Books:**
1. www.scilab.org
2. G. Strang, Linear Algebra and Learning from Data, Wellesley-Cambridge Press, 2019
Course Outcomes:

On completion of this course, the students will,

1. Acquire skills and numerical solutions of state equations and frequency response computations.
2. Be able to develop numerical algorithms for evaluation of controllability, observability, and stability.
3. Acquire skills in numerical solutions for conditioning of Lyapunov and algebraic Riccati equation
4. Be able to obtain large-scale solutions of control problems.
ICPE29 - PROCESS MODELLING AND OPTIMIZATION

Course type: Programme Elective (PE)  
Pre-requisites: -  
No. of Credits: 3

Course Objectives:
1. To impart knowledge with an emphasis on control system design in the current computer era.  
2. To teach the interdisciplinary necessity of linear algebra, control theory, and computer science.  
3. To demonstrate that control problems in practice demand efficient algorithms.  
4. To discuss about algorithms useful for practicing engineers for easy implementation on a range of computers.

Course Content:

Numerical Linear Algebra – Floating point numbers and errors in computations, Conditioning, Efficiency, Stability, and Accuracy, LU Factorization, Numerical solution of the Linear system Ax = b, QR factorization, Orthogonal projections, Least Squares problem, Singular Value Decomposition, Canonical forms obtained via orthogonal transformations.


Text Books:

Reference Books:
1. www.scilab.org  
2. G. Strang, Linear Algebra and Learning from Data, Wellesley-Cambridge Press, 2019  
3. Jitendra R. Raol, Ramakalyan Ayyagari, Control Systems – Classical, Modern and AI-Based Approaches, CRC Press Taylor & Francis Group

Course Outcomes:
On completion of this course, the students will,
1. Acquire skills and numerical solutions of state equations and frequency response computations.  
2. Be able to develop numerical algorithms for evaluation of controllability, observability, and stability.  
3. Acquire skills in numerical solutions for conditioning of Lyapunov and algebraic Riccati equation.
4. Be able to obtain large-scale solutions of control problems.
ICPE30 – CONTROL SYSTEM COMPONENTS

Course type: Programme Elective (PE)  
No. of Credits: 3

Pre-requisites:

Course Objectives:

1. To expose the students to various electrical components used in industrial control systems.
2. To expose the students to various mechanical components used in industrial control systems.
3. To teach various mechanical and pneumatic systems used in industrial control systems.
4. To introduce the concept of hydraulic pumps, actuators and valves.

Course Content:

Motors:
Types, working principle, characteristic, and mathematical model of following: Motors AC/DC motors, Brushless DC motor, stepper, servo, linear, Synchronous, Generators, and Alternator.


Sequencing & Interlocking for motors: Concept of sequencing & Interlocking, Standard symbols used for Electrical Wiring Diagram, Electrical Wiring diagrams for Starting, Stopping, Emergency shutdown, (Direct on line, star delta, soft starter) Protection devices for motors: Short circuit protection, Over load Protection, Over/ under voltage protection, Phase reversal Protection, high temperature and high current Protection, over speed, Reversing direction of rotation, Braking, Starting with variable speeds, Jogging/Inching Motor Control Center: Concept and wiring diagrams.


Text Books:


Reference Books:

Course Outcomes:

On completion of this course, the students will be able to,

1. Select and use of different process control components for electrical systems.
2. Select and use of different process control components for mechanical system.
3. Identify, formulate and solve a problem using pneumatic system in instrumentation and control engineering.
4. Identify, formulate and solve a problem using hydraulic system in instrumentation and control engineering.
ICPE31 – NETWORK CONTROL SYSTEMS

Course type: Programme Elective (PE)  
Pre-requisites: - 
No. of Credits: 3

Course Objectives:

1. To expose the students to the emerging field of multi-agent and network control systems
2. To expand the scope of traditional control systems to include large-scale interconnected systems
3. To demonstrate consensus and leader-follower paradigms in a distributed environment
4. To introduce different applications that fall in the gamut of network control systems.

Course Content:

Introduction to multi-agent systems, Information exchange via local interactions, Basics of graph theory

Reaching agreement in undirected and directed networks, Agreement via Lyapunov functions, Agreement over random networks

Formation control, Shape based control, Dynamic formation selection, Assigning roles, Cooperative robotics, Wireless sensor networks

Graph theoretic controllability, Network formation, Optimizing the weighted agreement, Planning over proximity graphs, Higher order networks

Introduction to social networks, opinion dynamics, epidemics, games etc.

Text Books:


Reference Books:


Course Outcomes:

On completion of this course, the students will be able to,

1. Design control system in the presence of quantization, network delay or packet loss.
2. Understand distributed estimation and control suited for network control system.
3. Develop simple application suited for network control systems.
4. Technically understand larger-scale techno-socio-economic networks and models prevalent in today’s society.
ICPE32 – ROBOTICS

Course type: Programme Elective (PE)  
No. of Credits: 3

Pre-requisites: ICPC16

Course Objectives:

1. To trace the development of machines that have been aiding humans to simplify mundane jobs
2. To introduce the importance of automation in the modern world.
3. To introduce robotics in the fields of manufacturing, medicine, search and rescue, service, and entertainment.
4. To teach robotics as the synergistic integration of mechanics, electronics, controls, and computer science.

Course Content:

Introduction: Basic concepts, definition and origin of robotics, different types of robots, robot classification, applications, robot specifications.

Introduction to automation: Components and subsystems, basic building block of automation, manipulator arms, wrists and end-effectors, user interface, machine vision, implications for robot design, controllers.

Kinematics, dynamics and control:

Robot programming: Robot programming languages and systems, levels of programming robots, problems peculiar to robot programming, control of industrial robots using PLCs.

Automation and robots: Case studies, multiple robots, machine interface, robots in manufacturing and non-manufacturing applications, robot cell design, selection of a robot.

Robotic network models, complexity notion, connectivity, maintenance, and rendezvous

Text Books


Reference Books


**Course Outcomes:**

On completion of this course, the students will,

1. Understand robot dynamics and multivariable control.
2. Learn how control theoretic ideas can be extended to design automation systems.
3. Be introduced to the most popular methods for motion planning and obstacle avoidance.
4. Be familiar with robot programming, computer vision, and robotic networks and applications in the industry.
ICPE33 - POWER ELECTRONICS

Course type: Programme Elective (PE)  
Pre-requisites: -  
No. of Credits: 3

Course Objectives:
1. To introduce the students about the theory and applications of power electronic systems for high efficiency, renewable and energy saving conversion systems.
2. To impart knowledge on the characteristics of different power electronics switches, drivers and selection of components for different applications.
3. To teach about the switching behavior and design of the converter, inverter and chopper circuits.
4. To foster the ability to understand the use of power converters in commercial and industrial applications

Course Content:
Power semiconductor switches: SCRs - series and parallel connections, driver circuits, turn-on characteristics, turn off characteristics.

AC to DC converters: Natural commutation, single phase and three phase bridge rectifiers, semi controlled and fully controlled rectifiers, dual converters.

DC to DC converters: Voltage, Current, load commutation, thyristor choppers, design of commutation elements, MOSFET/IGBT choppers, AC choppers.

DC to AC converters: Thyristor inverters, McMurray-Mc Murray Bedford inverter, current source inverter, voltage control, inverters using devices other than thyristors, vector control of induction motors.

AC to AC converters: Single phase and three phase AC voltage controllers, integral cycle control, single phase cyclo-converters - effect of harmonics and Electro Magnetic Interference (EMI).

Applications in power electronics: UPS, SMPS and Drives.

Text Books:
Reference Books:


Course Outcomes:

On completion of this course, the students will be able to,

1. Work professionally in the area of power and power related fields.
2. Have good understanding of the basic principles of switch mode power conversion.
3. Apply knowledge of mathematics and engineering and identify formulas to solve power and power electronics engineering problems.
4. Choose appropriate power converter topologies and design suitable power stage and feedback controllers for various applications like microprocessor power supplies, renewable energy systems and control of motor drives.
ICPE34 - DIGITAL SIGNAL PROCESSING

Course type: Programme Elective (PE)  Pre-requisites: ICPC15
No. of Credits: 3

Course Objectives:

1. To provide higher level of understanding of discrete-time and digital signal in time and frequency domains.
2. To provide knowledge to analyze linear systems with difference equations
3. To design and implement different structures of FIR and IIR filters.
4. To introduce about DSP processors and FFT processors.

Course Content:

Discrete-time systems, Difference equations and the Z-transform, Analysis of discrete-time LTI systems, Stability and Jury’s test.


IIR Filters: Design of analog prototype filters, Analog frequency transformations, Impulse invariance method and digital frequency transformations, Bilinear transformation, Analog prototype to digital transformations, Difficulties in direct IIR filter design, Comparisons with FIR filters.

Filter Realization: Structures for FIR filters, Structures for IIR filters, State-space analysis and filter structures, fixed point and floating-point representation of numbers, Errors resulting from rounding and truncating, Quantization effects of filter coefficients, Round-off effects of digital filters.

DSP Processors: Computer architectures for signal processing – Harvard architecture and pipelining, General purpose digital signal processors, Selection of DSPs, Implementation of DSP algorithms on a general purpose DSP, Special purpose hardware – hardware digital filters and hardware FFT processors, Evaluation boards for real-time DSP.
Text Books:


Reference Books:


Course Outcomes:

On completion of this course, the students will be able to,

1. Analyze the signals in both time and frequency domain
2. Design FIR and IIR filters for signal pre-processing
3. Implement and realize the filters using different structures.
4. Explain the selection of DSP processor for signal processing applications.
ICPE35 - INDUSTRIAL ELECTRIC DRIVES

Course type: Programme Elective (PE)  Pre-requisites: ICPE33  No. of Credits: 3

Course Objectives:

1. To introduce to the students on the concept of employing power convertors for the design of electric drives.
2. To impart knowledge on the analysis of electric drive system dynamics.
3. To apply the knowledge of drives to choose the right solid-state drive for a given application.
4. To impart knowledge on the design and development of control methods for electric drive systems.

Course Content:

Electric Drive System - Dynamics and steady state stability

Components of electrical Drives – electric machines, power converter, controllers - dynamics of electric drive - torque equation - equivalent values of drive parameters - components of load torques types of load - four quadrant operation of a motor — steady state stability – load equalization – classes of motor duty-determination of motor rating


Text Books:


Reference Books:


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

1. Design suitable power electronic circuit for an electric drive system
2. Analyse the dynamics and steady state stability of motors
3. Select appropriate control method for the electric drives.
4. Select a suitable electric drive for a particular industrial application.
ICPE36 REAL-TIME EMBEDDED SYSTEMS

Course type: Programme Elective (PE)  
Pre-requisites: ICPC18
No. of Credits: 3

Course Objectives:
1. To introduce the basic concepts of Embedded Systems
2. To expose to the design principles of advanced level ARM processors.
3. To provide basic understanding of the concepts of OS and RTOS.
4. To develop the embedded systems for real time system

Course Content:

ARM Cortex Architecture, Programming: Internal blocks – Processor core features, system peripherals, Memory map, bus system, debug support, User Peripherals, Serial Interfaces, Programming the peripherals using C – examples. Case studies of hardware design and software development.

OS Concepts and types, tasks & task states, process, threads, inter process communication, task synchronization, semaphores, role of OS in real time systems, scheduling, resource allocation, interrupt handling, other issues of RTOS. Examples of RTOS. Working with RTOS with ARM Cortex embedded controllers

Text Books:

Reference Books:

Course Outcomes:
On completion of this course, the students will be able to,
1. Design an embedded system for simple applications.
2. Develop applications using embedded ‘C’ language.
3. Understand RTOS structure & types
4. Develop the real time embedded systems
Course type: Programme Elective (PE)  
Pre-requisites: -  
No. of Credits: 3

Course Objectives:

1. To expose to the basics of sensors used in industries.
2. To provide adequate knowledge on smart instrumentation and wireless sensor networks.
3. To impart knowledge on various standard protocols used in wireless instrumentation.
4. To apply the knowledge of sensors, transceivers, controllers and power supplies to implement a WSN for a required application.

Course Content:

Sensor Classification:  
- Thermal sensors  
- Humidity sensors  
- Capacitive Sensors  
- Planar Inter digital Sensors  
- Planar Electromagnetic Sensors  
- Light Sensing Technology  
- Moisture Sensing Technology  
- Carbon Dioxide (CO₂) sensing technology

Sensors Parameters

Frequency of Wireless communication  
- Development of Wireless Sensor Network based Project
- Wireless sensor based on microcontroller and communication device (Zigbee Communication device)

Power sources
- Energy Harvesting  
- Solar and Lead acid batteries  
- RF Energy /Harvesting  
- Energy Harvesting from Vibration  
- Thermal Energy Harvesting  
- Energy Management Techniques  
- Calculation for Battery Selection

Brief description of API mode data Transmission  
- Testing the communication between coordinator and remote XBee
- Design and development of graphical user interface for receiving sensor data using C++
- A brief review of signal processing techniques for structural health monitoring

WSN based physiological parameters monitoring system  
- Intelligent sensing system for emotion recognition  
- WSN based smart power monitoring system  
- Digital light processor (DLP)

Text Books:


Reference Books:


Course Outcomes:

On completion of this course, the students will be able to,

1. Understand about smart instrumentation system
2. Acquire knowledge on ZigBee transceivers
3. Design self-diagnosing instrumentation system.
4. Identify the issues in power efficient systems and implement energy management techniques in WSN
5. Design wireless instrumentation systems for the given requirement.
ICPE38 - PRINCIPLES OF COMMUNICATION SYSTEMS

Course type: Programme Elective (PE)  Pre-requisites: -
No. of Credits: 3

Course Objectives:
1. To introduce the concept of communication systems.
2. To understand the need for modulation.
3. To impart knowledge in the different methods of analog and digital communications and their significance.
4. To make students familiar with various sources of noise and its characteristics.

Course Content:

Principles of angle modulation: frequency and phase modulation, narrow and wide band FM, generation and demodulation of FM signals. FM transmitter and Receiver.

Pulse modulation systems- Sampling theorem, Pulse Amplitude Modulation (PAM), Pulse width modulation (PWM), Pulse time modulation (PTM): PDM and PPM. TDM systems.

Pulse code modulation- Pulse Code Modulation - quantization - PCM systems- DPCM and Delta modulation. Digital modulation schemes: ASK-PSK-FSK-Generation and detection

Noise-Source and classification, atmospheric noise, thermal noise and shot noise. Noise equivalent bandwidth, noise figure and equivalent noise temperature of a two-terminal network.

Text Books:

Reference Books:

Course outcomes:
On completion of this course, the students will be able to,
1. Explain the basic concepts of communication systems.
2. Establish understanding of various analog modulation techniques and demodulation techniques.
3. Understand various analog pulse modulation techniques and demodulation
4. Understand digital pulse modulation and digital modulation techniques and calculate capacity
5. Describe different types of noise and calculate the noise equivalent bandwidth and noise figure of a two-port network.
ICPE39 - MULTISENSOR DATA FUSION

Course type: Programme Elective (PE)  
Pre-requisites: ICPE22  
No. of Credits: 3

Course Objectives:
1. To introduce the fundamentals of data fusion and multisensor data fusion
2. To expose the students to the different techniques used in sensor data fusion.
3. To impart skills needed to develop and apply data fusion algorithms.
4. To expose the students, the state of the art in multi sensor/source integration, target tracking and identification.

Course Content:
Taxonomy of algorithms for multisensor data fusion. Data association. Identity declaration.


High performance data structures: Tessellated, trees, graphs and function. Representing ranges and uncertainty in data structures. Designing optimal sensor systems with in dependability bounds. Implementing data fusion system.

Text Books:

Reference Books:

Course Outcomes:
On completion of this course, the students will be able to,
1. Understand the importance of data fusion
2. Identify and characterise the principle components of data fusion and information systems.
3. Apply the concepts of data fusion in sensing.
4. Select fusion techniques appropriate to system and mission needs.
ICPE40 - DIGITAL IMAGE PROCESSING

Course type: Programme Elective (PE)  Pre-requisites: -
No. of Credits: 3

Course Objectives:
1. To introduce the fundamentals of image processing
2. To introduce to the concept of image restoration and reconstructions
3. To introduce the concepts of image segmentation and compressions
4. To impart knowledge on the design and realization of various image processing algorithms.

Course Content:

Introduction and Digital Image Fundamentals:
Introduction to image processing, origin, examples of fields, steps in image processing, components of image processing system, digital image fundamentals – elements of visual perception, light and electromagnetic spectrum, image sensing and acquisition, mathematical tools used in image processing.

Intensity Transformations, Spatial Filtering and Filtering in frequency domain:
Basics intensity transformation functions, histogram processing, fundamentals of spatial filtering, smoothing and sharpening spatial filtering, combinations of image enhancement method, filtering in the frequency domain – Fourier transform of sample functions, DFT of one variable, extension to two variables, properties of 2 D DFTs, selective filtering, realization of FDT, FFT, filter design aspects.

Image Restoration and Reconstruction:
Model of the image degradation / restoration process, noise models, restoration in the presence of noise only – spatial filtering, periodic noise reduction by frequency domain filtering, estimating the degradation functions, inverse filtering, image reconstruction from projections.

Image Segmentation:
Image segmentation - point, line and edge detection, Thresholding, Regions Based segmentation, segmentation using morphological watersheds, usage of motion in segmentation, edge linking and boundary detection, Hough transform, chain codes, boundary segments, skeletons, boundary descriptors, Fourier descriptors.

Image Compression:
Image compression - image compression - data redundancies elements of information, variable-length coding, predictive coding, transform coding, image compression standards, wavelets and multi-resolution processing - image pyramids, sub-band coding.

Object Recognition and Case studies:
Object Recognition- patterns and pattern classes, recognition based on decision – theoretic methods, structural methods, case studies – image analysis
Text Books:


Reference Books:


Course Outcomes:

On completion of this course, the students will be able to,

1. Understand the importance of image processing
2. Perform image restoration and reconstruction
3. Perform image segmentation and compressions
4. Design, realize and troubleshoot various algorithms for the case studies based on image processing.
ICPE41 BIO MEDICAL SIGNAL PROCESSING

Course type: Programme Elective (PE)  Pre-requisites: -
No. of Credits: 3

Course Objectives
1. To expose the students to the importance of biomedical signals and analysis
2. To introduce different types of bio signals and their characteristics
3. To study different noise removal mechanisms for biomedical signals
4. To analyse the signals using time and frequency domain measures

Course Content
Introduction to signals, Continuous time and discrete time signals and LTI systems, Introduction and properties of Fourier transform, Laplace transform and Z-transform

Nature of biomedical signals; origin and dynamics of electroneurogram (ENG), electromyogram (EMG), electrocardiogram (ECG), electroencephalogram (EEG), event related potentials (ERP), electrogastrogram (EGG), phonocardiogram (PCG), vibromyogram (VMG) and vibroarthogram (VAG), Objectives of biomedical signal analysis and difficulties in biomedical signal analysis

Random, structured and physiological noise, noises and artefacts in ECG, EMG and EEG signals, Filtering for removal of artefacts; Introduction to filter design; Time domain filters, Frequency domain filters, and optimal filters and selection of appropriate filters

Event detections in ECG, EEG and heart sounds, Analysis of wave shape and waveform complexity, QRS complex, analysis of ERPs and analysis of electrical activity using time and frequency domain measures

Analysis of nonstationary and multicomponent signals, heart sound and murmurs, EEG rhythms and waves and case studies

Text Books

Reference Books

Course outcomes
On completion of the course, the students will be able to
1. understand the issues associated with the interpretation of biomedical signals
2. familiar with different signals such as ECG, EMG and EEG
3. able to remove the noises in bio signals by selecting appropriate filters
4. implement appropriate signal processing methods to extract reliable information
**ICPE42 – MEDICAL IMAGING SYSTEMS**

**Course type:** Programme Elective (PE)  
**No. of Credits:** 3  
**Pre-requisites:**

**Course Objectives:**

1. To introduce the methods of medical imaging.
2. To impart knowledge in the physics behind the various imaging techniques.
3. To teach the construction and working of various imaging techniques.
4. To study the methods of image reconstruction

**Course Content:**

Introduction to image processing in medical applications, X-Ray tubes, cooling systems, removal of scatters, Fluoroscopy- construction of image Intensifier tubes, angiographic setup, mammography, digital radiology, DSA.

Need for sectional images, Principles of sectional scanning, CT detectors, Methods of reconstruction, Iterative, Back projection, convolution and Back-Projection. Artifacts, Principle of 3D imaging

Alpha, Beta and Gamma radiation, Radiation detectors, Radio isotopic imaging equipments, Radio nuclides for imaging, Gamma ray camera, scanners, Positron Emission tomography, SPECT, PET/CT.

Wave propagation and interaction in Biological tissues, Acoustic radiation fields, continuous and pulsed excitation, Transducers and imaging systems, Scanning methods, Imaging Modes, Principles and theory of image generation.

NMR, Principles of MRI, Relaxation processes and their measurements, Pulse sequencing and MR image acquisition, MRI Instrumentation, Functional MRI.

**Text Books:**

2. Dwight G. Nishimura, Lulu, Principles of Magnetic Resonance Imaging, Stanford Univ,2010
Reference Books:


Course Outcomes:

On completion of this course, the students will be able to,

1. Acquire basic domain knowledge about the various medical imaging techniques.
2. Understand the construction and working of various medical imaging equipments.
3. Provide a foundational understanding of algorithms used in medical imaging
4. Analyze the medical images for diagnosis.
Course Type: Programme Elective (PE)  
Pre-requisites: -  
No of credit: 3

Course Objectives:

1. To introduce basic energy harvesting techniques using smart materials and structures and combining with mechanisms.
2. To impart knowledge in the design of power converter circuits for ambient energy harvesters.
3. To introduce mathematical modelling of piezoelectric based energy harvesters.
4. To introduce on certain case studies.

Course Content:


Vibrational energy harvesting- Electromechanical Modelling of Cantilevered Piezoelectric Energy Harvester for Persistent Base Motion-lumped parameter model, correction factors, coupled distributed parameter model, modelling assumptions, closed form solution for unimorph and bimorph configuration, harvesting techniques for broadband excitation

Piezoelectric energy harvesting circuits-low power rectifier circuits with resistive, linear and nonlinear reactive input impedance, piezoelectric pre-biasing, self-tuning, DC-DC switch mode converters, impedance matching circuits for maximum output power.

Electromagnetic energy harvesting- Wire wound coil properties, micro fabricated coils, magnetic materials, scaling of electromagnetic vibration generators and damping, maximizing power from an EM generator, micro and macro scale implementation.


Case study- harvester driven by muscle power, knee joint movement harvesting, etc. strategies to improve energy conversion efficiency for different ambient sources.

Text Books:

Reference Books:


Course Outcomes:

On the completion of this course, the students will be able to,

1. Comprehend in the concept of various ambient energy harvesting techniques.
2. Design optimal power converting circuits for different harvesters.
3. Design vibration energy harvester for narrow and wide band excitation.
4. Design electromagnetic and thermoelectric based energy harvesters.
5. Apply the energy harvesting concepts to common engineering problems.
ICPE44 – SMART MATERIALS AND SYSTEMS

**Course type:** Programme Elective (PE)  
**Pre-requisites:** -  
**No. of Credits:** 3

**Course Objectives:**

1. To familiarize the students with the different smart materials and their characteristics.
2. To expose the students to understand the functionalities through the mathematical equations.
3. To teach the students about the significant features of smart materials in sensing, actuation and control.
4. To teach the students to design and develop smart structures using smart material-based actuators and sensors.

**Course Content:**


Actuators and Sensor based on Piezoelectric Materials: Induced Strain actuation model, Unimorph and Bimorph Actuators, Actuators embedded in composite laminate, Impedance matching in actuator design, Feedback Control, Pulse Drive, Resonance Drive, Piezoelectric as a Sensor and its applications.


**Text Books:**


**Reference Material:**

1. www.iop.org/sms
2. http:jim.sagepub.com

**Course Outcomes:**

On the completion of this course, the students will be able to,

1. Acquire knowledge about the smart materials, their characteristics and design aspects.
3. Choose appropriate smart materials for sensing and actuation.
4. Analyze and design techniques, to offer solutions to industrial problems using smart materials.
ICPE45 - HYDRAULICS AND PNEUMATICS

Course type: Programme Elective (PE)  Pre-requisites: -
No. of Credits: 3

Course Objectives:

1. To provide an understanding of the working of hydraulic and pneumatic systems.
2. To provide an understanding of energy transfer in hydraulic actuators and motors
3. To provide knowledge about controlling components of hydraulic and pneumatic systems.
4. To provide knowledge of design of hydraulic and pneumatic systems and analyze them.

Course Content:


Introduction to Pneumatic Control: Choice of working medium, characteristics of compressed air. Structure of pneumatic control system. Compressed air: Production of compressed air – compressors, preparation of compressed air- Driers, filters, regulators, lubricators, distribution of compressed air. Pneumatic Actuators: Linear cylinders – types, conventional type of cylinder working, end position cushioning, seals, mounting arrangements applications.

Directional Control Valves: Symbolic representation as per ISO 1219 and ISO 5599. Design and constructional aspects, poppet valves, slide valves spool valve, suspended seat type slide valve. Simple Pneumatic Control: Direct and indirect actuation pneumatic cylinders, use of memory valve. Flow control valves and speed control of cylinders supply air throttling and exhaust air throttling, use of quick exhaust valve. Signal Processing Elements: Use of Logic gates – OR and AND gates pneumatic applications,
practical examples involving the use of logic gates, Pressure dependent controls types construction–practical applications, time dependent controls – principle, construction, practical applications.

**Text Books:**

**Reference Books:**

**Course Outcomes:**
On the completion of this course, the students will be able to,
1. Acquire knowledge about working of hydraulic and pneumatic systems.
2. Identify the controlling components of hydraulic and pneumatic systems.
3. Select and prepare a distribution system for compressed air.
4. Compile the design of hydraulic and pneumatic systems and analyze them.
5. Demonstrate the need of pressure and time dependent controls.
ICPE46 – ENGINEERING MECHANICS

Course type: Programme Elective (PE)  
No. of Credits: 3  
Pre-requisites: -

Course Objectives:

1. To introduce the fundamentals of mechanics and machines to the instrumentation and control engineering students.
2. To explain the application of basic mechanical science concepts
3. To apply different physical principles to the analysis of mechanics and machines
4. To identify the different element of a mechanical system and write the mathematical equations for them.

Course Content:


Strain energy – Dynamic loading – Strain energy due to shear – Impact torsional loading – Strain energy due to bending – Impact loading of beams.


Degrees of freedom – Two rotor system – Forced vibrations.

Text Books:


Reference Books


Course outcomes:

On completion of this course, the students will be able to,

1. Analyze simple mechanisms and their principles of operation.
2. Write the mathematical equations for static and dynamic loading in simple mechanical systems.
3. Write the equations for energy and power in simple mechanical systems.
4. Analyze free and forced oscillations in simple dynamic systems.
ICPE47 – INTERNET OF THINGS SYSTEM DESIGN

Course type: Programme Elective (PE)  
Pre-requisites: -  
No. of Credits: 3

Course Objectives:

1. To provide a good understanding of Internet of Things (IoT) and its envisioned deployment domains.
2. To provide an understanding of smart sensors/actuators with their internet connectivity for experimentation and designing systems.
3. To provide an overview about the various protocol standards deployed in the Internet of Things (IoT) domain and to make informed choices.
4. To impart knowledge in the design and development of IoT systems with enablement ensuring security and assimilated privacy.

Course Content:

Introduction to Internet of Things: Overview of Internet of Things- the Edge, Cloud and the Application Development, Anatomy of the Thing, Industrial Internet of Things (IIoT - Industry 4.0), Quality Assurance, Predictive Maintenance, Real Time Diagnostics, Design and Development for IoT, Understanding System Design for IoT, Design Model for IoT.


System Design Perspective for IoT – Products vs Services, Value Propositions for IoT, Services in IoT, Design views of Good Products, Understanding Context, IoT Specific Challenges and Opportunities.


Text Books:


Reference Books:

1. The Internet of Things – Opportunities and Challenges
2. Single Chip Controller and Wi-Fi SOC
4. Wireless Connectivity for the Internet of Things – One size does not fit all

Course Outcomes:

On the completion of this course, the students will be able to,

1. Understand the design architecture of IoT.
2. Make choice of protocols and deployment in solutions.
3. Comprehend the design perspective of IoT based products/services.
4. Understand the importance of security requirements for IoT design.
ICPE48 – SOFTWARE DESIGN TOOLS FOR SENSING AND CONTROL

Course type: Programme Elective (PE)  
Pre-requisites: ICPC13, ICPC16

No. of Credits: 3

Course Objectives:

1. To expose the students to the software tools available for sensor and control system design.
2. To teach the analytical and numerical modelling of various sensors in macro, meso and micro scale and to study its characteristics through simulation.
3. To expose the students to modelling of physical systems, design and evaluation of various control methods.
4. To expose the students to real time control implementation platforms and to practice on implementation of simple controllers.

Course Content:

Software tools for sensor design: Introduction to history of sensor design software tools, importance and need of software tools. Recent developments in sensor design and analysis software tools. Introduction to COMSOL Multiphysics. Structural Mechanics: Analysis of mechanical structures to static or dynamic loads. Stationary, transient, eigenmode/modal, parametric, quasi-static and frequency-response analysis. Electrical: AC/DC Module for simulating electric, magnetic, and electromagnetic fields in static and low-frequency applications. Design and simulation of sensors and actuators using COMSOL.


Software tools for control design: Introduction to MATLAB, Simulink and Scilab. Introduction to toolboxes. Control design problems using classical control. Control design problems using state space approach.

Implementation of controllers in real time: Introduction to various hardware platforms, control design and implementation for electrical/mechanical/electromechanical/chemical processes using dSPACE, LabVIEW and OPAL-RT.

Text Books:

Reference Books:


Course Outcomes:

On the completion of this course, the students will be able to,

1. Select an appropriate software tools for sensor and actuator design.
2. Design, model and simulate various sensing and actuating mechanisms.
3. Design controller and evaluate its performance through simulation.
4. Design a controller using state space method and evaluate its performance through simulation.
5. Acquire knowledge in the selection and usage of hardware for real time implementation of controllers.
ICPE49 - NEURAL NETWORKS AND FUZZY LOGIC

Course type: Programme Elective (PE)  Pre-requisites: -
No. of Credits: 3

Course Objectives:

1. To provide an overview of intelligent techniques.
2. Develop skills to gain a basic understanding of neural network and fuzzy logic theory.
3. To introduce different architectures and algorithms of Neural Networks.
4. To impart knowledge on Fuzzy set theory and Fuzzy rules.

Course Content:

Introduction to fuzzy logic and neural networks, Classification, Merits and demerits of intelligent techniques compared to conventional techniques. Need of an intelligent technique for real world Engineering applications.


Neural networks for control systems: Schemes of Neuro-control, identification and control of dynamical systems, case studies.

Fuzzy set and operations, Fuzzy relations, Fuzzifications, Fuzzy rule-based systems, defuzzification fuzzy learning algorithms.

Fuzzy logic for control system with case studies. Introduction to neuro-fuzzy system and genetic algorithm.

Text Books:


Reference Books:


Course Outcomes:

On completion of this course, the students will be,

1. Familiar with the basic concepts of Neural Network and Fuzzy logic.
2. Able to develop Neural Network based modelling and control for different process applications.
3. Able to design Fuzzy logic-based control system for process applications.
4. Able to design hybrid neuro-fuzzy architecture for engineering optimization problems.
ICPE50 - INDUSTRIAL DATA COMMUNICATION

Course type: Programme Elective (PE)  
Pre-requisites: IC PE 38  
No. of Credits: 3

Course Objectives:
This course gives an overview to real-time communication between systems in industries and to adopt suitable protocol thereby prepare the students to take up challenges in industrial environment.

1. To expose the students to communication systems emerging in the field of instrumentation.
2. To introduce to the system interconnection and protocol standards.
3. To give an overview of HART Protocols
4. To impart knowledge in Field bus and Profi bus protocol

Course Content:

Fieldbus: Use of fieldbuses in industrial plants, functions, international standards, performance, use of Ethernet networks, fieldbus advantages and disadvantages. Fieldbus design, installation, economics and documentation.


PROFIBUS-PA: Basics, architecture, model, network design and system configuration. Designing PROFIBUS-PA and Foundation Fieldbus segments: general considerations, network design.

Text Books:

Reference Books:

Course Outcomes:
On the completion of this course, the students will be able to,
1. Explain the rationale behind the technological development of industrial networks.
2. Understand various buses and serial//parallel interface.
3. Exposure to the HART protocol functions and features.
4. Understand and configuration of Field bus and Profibus protocols.
5. Evaluate and select protocol for particular application
ICPE51 - NUMERICAL METHODS

Course type: Programme Elective (PE)  Pre-requisites: -  No. of Credits: 3

Course Objectives
To introduce
1. Numerical methods for Solving Linear Systems
2. Numerical methods to solve equations of one variable as well as system of equations with two variables.
3. Interpolating Polynomials and best curve fitting methods for the given data.
4. Numerical differentiation and integration

Course Content
Digital representation of numbers, Finite precision arithmetic, Machine Precision, Measuring errors, convergence of iterative sequences, Taylor series, Order Notation. Numerical Solution of \( f(x) = 0 \): Bisection method, Secant method, Newton’s method, Newton’s method for \( f(x, y) = 0, g(x, y) = 0 \). Order of convergence.


Interpolation: Lagrange’s method, Newton’s divided difference, forward and backward difference interpolation method. Least squares fitting of a curve to data-Polynomial curve fitting, exponential curve \( y = ae^{bx} \) fitting to data.

Numerical Differentiation based on interpolation and finite difference. Numerical Integration-Closed and open type integration rules-Trapezoidal rule, Simpson’s1/3ruleand3/8 rule, mid-point and two-point rule. Adaptive integration based on Simpson’s rule. Gauss quadrature methods, Integrals with infinite limits \( \int_{-\infty}^{\infty} e^{-x^2} dx \).


Reference Books:
Course Outcomes

On completion of the course, students should be able to

1. Compute numerical solution of given system $AX=B$ by direct and iterative methods.
2. Compute largest eigenvalue and its corresponding eigenvector of matrix $A$.
3. Compute numerical solution of $f(x)=0$ and nonlinear equations with two variables.
4. Interpolate function and approximate the function by polynomial.
5. Compute numerical differentiation and integration of $f(x)$.
6. Compute best curve fit for the given data by curve fitting method.
7. Compute numerical solution of ordinary differential equations by finite difference method.


BJTs: Basic BJT theory, Different modes of operation and configurations. Transistor current components. Ebers – Moll model and Gummel – Poon model of BJTs. Transistor α, Current amplification β, Bipolar transistor switch, SPICE BJT model, Punch through and other breakdown mechanisms, Photo-voltaic effect, Photo-cell transistors.

MOSFETs: Device structure and physical operation, Current – voltage characteristics, MOSFET circuits at DC, MOSFET as an amplifier and as a switch, Small signal model, MOSFET internal capacitance and high frequency model, Depletion type MOSFET, SPICE MOSFET model, CMOS structure, operation, BiCMOS operation, CCDs.

Power devices: Thyristor family – UJT, SCR, TRIAC, DIAC – operation and V-I characteristics. Triggering. Power diodes, power transistors, IGBTs and GTOs fabrication and V-I characteristics.

Text Books:

Reference Books:
ICPE53 - DATA STRUCTURES AND ALGORITHMS

Course type: Programme Elective (PE)  Pre-requisites: -  
No. of Credits: 3

Course Objectives:

- To introduce first level topics covering basics in Algorithms and Data Structures
- To provide examples for various design paradigms
- To identify the basic properties of graphs and trees and model simple applications

Introduction to problem solving, Mathematical preliminaries, Growth of functions, time complexity and space complexity, worst-case and average-case analyses, use of order notations and related results, recurrence relations: substitution method, recurrence trees, Master’s theorem and its applications.

Insertion-Sort, Divide & Conquer Strategy and Merge-Sort, Heap-sort, Quick-sort, Randomized versions of Quick-sort, sorting in linear time,

Elementary data structures (Arrays, Stacks, Queues, Linked Lists), Hash tables, Binary search trees, Advanced data structures: B-Trees, Fibonacci heaps, Data structures for disjoint sets (for applications in control system design).


Advanced Topics – NP-Completeness, Approximation Algorithms, Randomized Algorithms, Applications in Engineering – Control Systems, VLSI Design, etc.

Course Outcomes:

Students will be able to
1. Use linear and nonlinear data structures to solve real-time problems
2. Apply basic searching and sorting techniques in different application domains
3. Use design strategies to solve complex problems

Text Books:

ICPE-54 – NUCLEAR INSTRUMENTATION

Course Type: Program Electives (PE)  Pre-requisites: -
No. of Credits: 3

Course Learning Objectives:

- To introduce the basic concept of radioactivity, properties of alpha, beta and gamma rays
- To study various radiation detectors, detector classification
- To study the electronics and counting systems
- To study applications of nuclear instrumentation in medicines, Industry and in Agriculture.

Course Content:

Radioactivity: General properties of Nucleus, Radioactivity, Nature of Nuclear Radiation's, Properties of Alpha, Beta and Gamma rays, Natural and artificial radio-activity. Radioactivity Laws, Half-life period, radioactive series, Isotopes and Isobars, Various effects- photoelectric, Compton scattering and pair production, stopping power and range of charged nuclear particles

Radiation Detectors: Techniques for radiation detection, Detectors for Alpha, beta and gamma rays, Detector classification, Gas filled detectors - volt ampere characteristics, Ionization chamber, Proportional counter, Geiger Muller counter, designing features, Scintillation detectors, Photomultiplier tube, dark currents, pulse resolving power, efficiency of detection, Solid state detectors (Lithium ion drifted – Si-Li, Ge-Li, Diffused junction, surface barrier detectors)

Electronics and Counting systems: Pre-amp, shaping amplifiers, Discriminators, Scalars and count rate meters, Pulse shaping, peak stretchers, photon counting system block diagram, single channel analyser SCA (pulse height analyser - PHA), Coincidence detection

Nuclear Spectroscopy systems: Factors influencing resolution of gamma energy spectrum, Energy resolution in radiation detectors, Multichannel analysers (MCA), Role of Nuclear ADC’s – performance parameters.


Applications in Industry: Basic Nuclear Instrumentation system – block diagram, Personal monitors like Thermo Luminescence Detectors (TLD), Dosimeters, Tele-detectors. Nuclear Instrumentation for power reactor. Nuclear Instrumentation for Toxic fluid tank level measurement, weighing, thickness gauges, Agriculture applications like food irradiation, Underground Piping Leak detection, water content measurement etc.
Text Books:


Reference Books:


Course Outcomes

1. The students get well versed with construction and working of various radiation detectors.
2. Students also get thorough knowledge of electronics and counting systems used in nuclear instrumentation
3. Students get detailed information about applications of nuclear instrumentation in medicine, industry etc.
ICPE-55 CONDITION MONITORING

Course Type: Program Electives (PE)  
No. of Credits: 3  
Pre-requisites:

Course Learning Objectives:
1. To introduce the importance of condition monitoring in the automotive, structural and process industries.
2. To make understand the role of different sensors and signal conditioning techniques in the condition monitoring.
3. To expose to wireless sensor networks and their protocols.
4. To provide knowledge of machine learning and its relation with condition monitoring.
5. To provide real time exposure in continuous condition monitoring.

Course Content:


Case study 1 – Machine Fault Diagnosis using Vibration analysis (Wired sensing).  
Case study 2 – Crack characterization of metallic structures using RFID Sensor (Wireless sensing).
Text Books:


Course Outcomes:

On completion of the course, the students will be able to

1. Familiar with the need of condition monitoring in the automotive, structural and process industries.
2. Gain the knowledge of sensors and signal conditioning techniques used for effective condition monitoring.
3. Understand the operation of wireless sensor networks and their deployment.
4. Gain the knowledge of machine learning and its application in condition monitoring.
5. Develop/Design an application specific condition monitoring system for fault diagnosis and Prognosis.
ICPE56 – SAFETY INSTRUMENTED SYSTEM

Course type: Programme Elective (PE)  Pre-requisites: -
No. of Credits: 3

Course Objectives

1. To make the students aware of basic concepts of safety instrumented system, standards and risk analysis techniques.
2. To make the students understand different layers of protection.
3. To make student conscious about safety instrumentation applications.
4. To make the students aware of potential events and impact of failures.
5. To make students aware of design, installation and maintenance procedures.

Course Content


Text books:


Reference books:


Course Outcomes:

On completion of the course, the students will develop

1. Ability to analyse the role of safety instrumented system in the industry.
2. Ability to Identify and analyse the hazards.
3. Ability to determine the safety integrity level for an application.
4. Ability to characterize the safety environment in industry.
5. Ability to analyse the failure modes, failure rates and MTBF using various reliability engineering tools.
6. Ability to apply the design, installation and maintenance procedures for SIS applied to industrial processes.
7. Ability to present the results in written and oral forms.
ICPE57 – CYBER SECURITY FOR INDUSTRIAL AUTOMATION

Course type: Programme Elective (PE)  Pre-requisites: -
No. of Credits: 3

Course Objectives
1. To understand the Industrial security environment and cyberattacks
2. To analyze and assess risks in the industrial environment
3. To access, design and implement cybersecurity
4. To test and troubleshoot the industrial network security system

Course Content:

INTRODUCTION: Industrial security environment-Industrial automation and control system (IACS) culture Vs IT Paradigms-Cyberattacks: Threat sources and steps to successful cyberattacks

RISK ANALYSIS :Risk identification, classification and assessment, Addressing risk: Cybersecurity Management System (CSMS), organizational security, physical and environmental security, network segmentation, access control, risk management and implementation.


CYBERSECURITY DESIGN AND IMPLEMENTATION ;Cybersecurity lifecycle- conceptual design process- detailed design process- firewall design remote access design- intrusion detection design

TESTING AND MAINTENANCE; Developing test plans- cybersecurity factory acceptance testing- site acceptance testing- network and application diagnostics and troubleshooting- cybersecurity audit procedure- IACS incident response

Text books:

Reference books:
Course Outcomes:

On completion of the course, the students will develop

1. Ability to apply basis of science and engineering to understand Industrial security environment and cyberattacks.
2. Ability to analyze and assess risks in the industrial environment
3. Ability to access the cybersecurity of IACS
4. Ability to design and implement cyber security
5. Ability to test and troubleshoot the industrial network security system.
6. Ability to understand, investigate and explore feasible solution for a moderate industrial problem.
OPEN ELECTIVE (OE) COURSES
ICOE10- BIOMEDICAL INSTRUMENTATION

Course Type: Open Elective (OE)  Pre-requisites: -
No. of Credits: 3

Course Objectives
The course introduces the human physiological system with respect to medical instrumentation and its design and the instrumentation for measuring and analyzing the physiological parameters.
1. To educate the students on the different medical instruments.
2. To familiarize the students with the analysis and design of instruments to measure bio-signals like ECG, EEG, EMG, etc.
3. To have a basic knowledge in therapeutic devices
4. To introduce about the clinical laboratory instruments and familiar about electrical safety.

Course Content

Electro physiology: Review of physiology and anatomy, resting potential, action potential, bioelectric potentials, electrode theory, bipolar and unipolar electrodes, surface electrodes, needle electrode and microelectrode, physiological transducers-selection criteria and its application.

Bioelectric potential and cardiovascular measurements: ECG recording system, Heart sound measurement-stethoscope, phonocardiograph (PCG), Foetalmonitor-ECG-phonocardiography, vector cardiograph, cardiac arrhythmia’s monitoring system. EMG, EEG - Evoked potential response, ERG and EOG recording system. Measurement of blood pressure using sphygmomanometer instrument based on Korotkoff sound, indirect measurement of blood pressure, automated indirect measurement, and direct measurement techniques.


Respiratory and pulmonary measurements: Physiology of respiratory system, respiratory rate measurement- artificial respirator- oximeter, pulmonary function measurements–spirometer–photo plethysmography and body plethysmography. Principal and techniques of impedance pneumography, Apnea monitor.

Electrical safety: Sources of electrical hazards in medical environment and safety techniques for checking safety parameters of biomedical equipment.

Text Books
5. Shakti Chatterjee and Aubert Miller, Biomedical Instrumentation Systems, CENGAGE Learning publishing, 2016.

Reference Books

1. Onkar N. Pandey, Rakesh Kumar, Bio Medical Electronics and Instrumentation, Katson Books, 2011
5. Andrew G. Webb, Principles of Biomedical Instrumentation, Cambridge University Press, 2018;

Course Outcomes

On completion of this course the students will be,

1. To understand, design and evaluate systems and devices that can measure, test and/or acquire bio-signal information from the human body.
2. Familiar with patient monitoring equipment used in hospitals.
3. Ability to explain the medical diagnostic and therapeutic techniques.
4. Familiar with various clinical laboratory instruments used for diagnosis.
ICOE11–BIO MEDICAL SIGNAL PROCESSING

Course type: Open Elective (OE)  
Pre-requisites: -  
No. of Credits: 3

Course Objectives
1. To expose the students to the importance of biomedical signals and analysis
2. To introduce different types of bio signals and their characteristics
3. To study different noise removal mechanisms for biomedical signals
4. To analyze the signals using time and frequency domain measures

Course Content
Introduction to signals, Continuous time and discrete time signals and LTI systems, Introduction and properties of Fourier transform, Laplace transform and Z-transform

Nature of biomedical signals; origin and dynamics of electroneurogram (ENG), electromyogram (EMG), electrocardiogram (ECG), electroencephalogram (EEG), event related potentials (ERP), electrogastrogram (EGG), phonocardiogram (PCG), vibromyogram (VMG) and vibroarthrogram (VAG), Objectives of biomedical signal analysis and difficulties in biomedical signal analysis

Random, structured and physiological noise, noises and artefacts in ECG, EMG and EEG signals, Filtering for removal of artefacts; Introduction to filter design; Time domain filters, Frequency domain filters, and optimal filters and selection of appropriate filters

Event detections in ECG, EEG and heart sounds, Analysis of wave shape and waveform complexity, QRS complex, analysis of ERPs and analysis of electrical activity using time and frequency domain measures

Analysis of nonstationary and multicomponent signals, heart sound and murmurs, EEG rhythms and waves and case studies

Text Books

Reference Books
Course Outcomes

On completion of the course, the students will be able to

1. understand the issues associated with the interpretation of biomedical signals
2. familiar with different signals such as ECG, EMG and EEG
3. able to remove the noises in bio signals by selecting appropriate filters
4. implement appropriate signal processing methods to extract reliable information
## ICOE12 - MICRO ELECTRO MECHANICAL SYSTEMS

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### Course Objectives

1. To introduce the fundamental concepts of MEMS and Micro systems and their relevance to current scientific needs.
2. To introduce the state-of-art micromachining techniques including surface micromachining, bulk micromachining, and related methods.
3. To make the students knowledgeable in the design concepts of micro sensors and micro actuators.
4. To introduce the challenges and limitations in the design of MEMS devices.
5. To make the students knowledgeable in computer aided design tools for modeling MEMS device.

### Course Content

Introduction, emergence, MEMS application, scaling issues, materials for MEMS, Thin film deposition, lithography and etching.

Bulk micro machining, surface micro machining and LIGA process.


Theory and design: Micro Pressure Sensor, micro accelerometer – capacitive and piezoresistive, micro actuator.

Electronic interfaces, design, simulation and layout of MEMS devices using CAD tools.

### Text Books


### Reference Books


### Course Outcomes:

On completion of this course the students will be,

1. Able to understand the fundamental principles behind the working of micro devices/ systems and their applications.
2. Able to knowledgeable in the standard micro fabrication techniques.
3. Able to identify micro sensors and actuators for a specific application.
4. Able to do acquire skills in computer aided design tools for modeling and simulating MEMS devices.
ICOE13 - MEASUREMENT AND CONTROL

Course Type: Open Elective (OE)
No. of Credits: 3

Pre-requisites:

Course Objectives

1. To impart knowledge in the basics of measurement system.
2. To expose the students to various measurement techniques used for the measurement of important process variables.
3. To expose the students to the basics of control systems.

Course Content

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

Strain and Displacement Measurement:
Factors affecting strain measurements, Types of strain gauges, theory of operation, strain gauge materials, gauging techniques and other factors, strain gauge circuits and applications of strain gauges. Resistive potentiometer (Linear, circular and helical), L.V.D.T., R.V.D.T. and their characteristics, variable inductance and capacitance transducers, Piezo electrical transducers, Hall Effect devices and Proximity sensors.

Pressure and Temperature Measurement:
Mechanical devices like Diaphragm, Bellows, and Bourdon tube for pressure measurement, Variable inductance and capacitance transducers, Piezo electric transducers, L.V.D.T. for measurement of pressure. Resistance type temperature sensors – RTD & Thermistor, Thermocouples & Thermopiles, Laws of thermocouple, Fabrication of industrial thermocouples, Radiation methods of temperature measurement.

Flow and Level Measurement:
Differential pressure meters like Orifice plate, Venturi tube, flow nozzle, Pitot tube, Rotameter, Turbine flow meter, Electromagnetic flow meter, Ultrasonic flowmeter. Resistive, inductive and capacitive techniques for level measurement, Ultrasonic methods, Air purge system (Bubbler method).

Elements of control systems, concept of open loop and closed loop systems, Examples and application of open loop and closed loop systems, brief idea of multivariable control systems. Brief idea of proportional, derivative and integral controllers.

Text Books

5. N. C. Jagan, Control Systems, BSPublications.2015

Reference Books


Course Outcomes

On completion of this course the students will be,
1. Familiar with the basics of measurement system, its characteristics and principles of few transducers.
2. Familiar with the different temperature, pressure, flow and level measurement techniques used in process industries.
3. Able to select and make measurements of temperature, flow, pressure and level in any process industry.
4. Familiar with the concept of closed loop control system.
ICOE14- INDUSTRIAL MEASUREMENTS

Course Type: Open Elective (OE)  Pre-requisites:
No. of Credits: 3

Course Objectives

1. To expose the students to the importance of process variable measurements.
2. To expose the students to various measurement techniques used for the measurement of temperature, flow, pressure and level in process industries.
3. To make the students knowledgeable in the design, installation and troubleshooting of process instruments.

Course Content:

Temperature measurement: Introduction to temperature measurements, Thermocouple, Resistance Temperature Detector, Thermistor and its measuring circuits, Radiation pyrometers and thermal imaging.

Pressure measurement: Introduction, definition and units, Mechanical, Electro-mechanical pressure measuring instruments. Low pressure measurement, Transmitter definition types, I/P and P/I Converters.

Level measurement: Introduction, Mechanical and electrical methods of level measurement.


Text Books


Reference Books

5. Tony.R. Kuphaldt, Lessons in Industrial Instrumentation, Version 2.02, April2014

Course outcomes

On completion of this course, the students will be,

1. Familiar with the different temperature, pressure, flow and level measurement techniques used in process industries.
2. Able to select and make measurements of temperature, flow, pressure and level in any process industry.
3. Able to identify or choose temperature, flow, pressure and level measuring device for specific process.
Course Type: Open Elective (OE)  
No. of Credits: 3

Course Objectives

1. To introduce to the students about the interfacing techniques of various transducers.
2. To expose the students to different signal conditioning circuits.
3. To impart knowledge on the hardware required to build Virtual Instrument.
4. To impart knowledge to build GUI for Virtual Instrument.

Course Content


Data Acquisition and Hardware Selection: Overview of DAQ architecture – Analog IO & Digital IO - Finite and continuous buffered acquisition – Data acquisition with C language - Industrial Communication buses – Wireless network standards - Micro-controller selection parameters for a virtual instrument – CPU, code space (ROM), data space (RAM) requirements.


Text Books

Reference Books

Course Outcomes
On completion of this course the students will be able to,
1. Interface the target transducer to the signal conditioning board.
2. Condition the acquired signal from the transducer to standard data formats.
3. Select the most appropriate hardware for the virtual instrument to be built.
4. Implement the real-time OS for the selected micro-controller and the GUI interface for the virtual instrument.
Course Objectives

1. To provide an overview of intelligent techniques.
2. Develop skills to gain a basic understanding of neural network and fuzzy logic theory.
3. To introduce different architectures and algorithms of Neural Networks.
4. To impart knowledge on Fuzzy set theory and Fuzzy rules.

Course Content

Introduction to fuzzy logic and neural networks, Classification, Merits and demerits of intelligent techniques compared to conventional techniques. Need of an intelligent technique for real world Engineering applications.


Neural networks for control systems: Schemes of Neuro-control, identification and control of dynamical systems, case studies.

Fuzzy set and operations, Fuzzy relations, Fuzzifications, Fuzzy rule-based systems, defuzzification fuzzy learning algorithms.

Fuzzy logic for control system with case studies. Introduction to neuro-fuzzy system and genetic algorithm.

Text Books


Reference Books

Course Outcomes

On completion of this course, the students will be,

1. Familiar with the basic concepts of Neural Network and Fuzzy logic.
2. Able to develop Neural Network based modelling and control for different process applications.
3. Able to design Fuzzy logic-based control system for process applications.
4. Able to design hybrid neuro-fuzzy architecture for engineering optimization problems.
ICOE17 – NETWORK CONTROL SYSTEMS

Course type: Open Elective (OE)  Pre-requisites: -
No. of Credits: 4

Course Objectives
1. To expose the students to the emerging field of multi-agent and network control systems
2. To expand the scope of traditional control systems to include large-scale interconnected systems
3. To demonstrate consensus and leader-follower paradigms in a distributed environment
4. To introduce different applications that fall in the gamut of network control systems.

Course Content
Introduction to multi-agent systems, Information exchange via local interactions, Basics of graph theory

Reaching agreement in undirected and directed networks, Agreement via Lyapunov functions, Agreement over random networks

Formation control, Shape based control, Dynamic formation selection, Assigning roles, Cooperative robotics, Wireless sensor networks

Graph theoretic controllability, Network formation, Optimizing the weighted agreement, Planning over proximity graphs, Higher order networks

Introduction to social networks, opinion dynamics, epidemics, games etc.

Text Books

Reference Books

Course Outcomes
On completion of this course, the students will be able to,
1. Design control system in the presence of quantization, network delay or packet loss.
2. Understand distributed estimation and control suited for network control system.
3. Develop simple application suited for network control systems.
4. Technically understand larger-scale techno-socio-economic networks and models prevalent in today’s society.
ICOE18 - CONTROL SYSTEMS

Course type: Open Elective (OE)
No. of Credits: 4

Pre-requisites: -

Course Objectives
1. To introduce the concept of feedback control system.
2. To impart knowledge in mathematical modeling of physical systems.
3. To impart knowledge in characteristics and performance of feedback control system.
4. To teach a variety of classical methods and techniques for analysis and design of control systems.

Course Content
Review of Systems, Mathematical Models – Differential Equations, Linear Approximations and Transfer Functions, Block Diagrams and Signal Flow Graphs


Frequency Response Methods, Nyquist’s Stability Criterion, Bode Plots, Performance Specifications in Frequency-Domain, Stability Margins.
Design of Lead, Lag and PID controller in Frequency Domain.

Text Books

Reference Books
Course outcomes

On completion of this course, the students will be able to

1. Generate mathematical models of dynamic control system by applying differential equations.
2. Analyze and characterize the behavior of a control system in terms of different system, performance parameters and assess system stability.
3. Evaluate and analyses system performance using frequency and transient response analysis.
4. Design and simulate control systems (linear feedback control systems, PID controller, and multivariable control systems), using control software, to achieve required stability, performance and robustness.
ICOE19 - ENERGY HARVESTING TECHNIQUES

Course Type: Open Elective (OE)  
Pre-requisites: -  
No of credit: 3

Course Objectives

1. To introduce basic energy harvesting techniques using smart materials and structures and combining with mechanisms.
2. To impart knowledge in the design of power converter circuits for ambient energy harvesters.
3. To introduce mathematical modelling of piezoelectric based energy harvesters.
4. To introduce on certain case studies.

Course Content


Vibrational energy harvesting- Electromechanical Modelling of Cantilevered Piezoelectric Energy Harvester for Persistent Base Motion-lumped parameter model, correction factors, coupled distributed parameter model, modelling assumptions, closed form solution for unimorph and bimorph configuration, harvesting techniques for broadband excitation

Piezoelectric energy harvesting circuits-low power rectifier circuits with resistive, linear and nonlinear reactive input impedance, piezoelectric pre-biasing, self-tuning, DC-DC switch mode converters, impedance matching circuits for maximum output power.

Electromagnetic energy harvesting- Wire wound coil properties, micro fabricated coils, magnetic materials, scaling of electromagnetic vibration generators and damping, maximizing power from an EM generator, micro and macro scale implementation.


Case study- harvester driven by muscle power, knee joint movement harvesting, etc. strategies to improve energy conversion efficiency for different ambient sources.

Text Books

Reference Books


Course Outcomes

On the completion of this course, the students will be able to,

1. Comprehend the concept of various ambient energy harvesting techniques.
2. Design optimal power converting circuits for different harvesters.
3. Design vibration energy harvester for narrow and wide band excitation.
4. Design electromagnetic and thermoelectric based energy harvesters.
5. Apply the energy harvesting concepts to common engineering problems.
ICOE20 –SMART MATERIALS AND SYSTEMS

Course type: Open Elective (OE) Pre-requisites: -
No. of Credits: 3

Course Objectives
1. To expose to the basics of sensors used in industries.
2. To provide adequate knowledge on smart instrumentation and wireless sensor networks.
3. To impart knowledge on various standard protocols used in wireless instrumentation.
4. To apply the knowledge of sensors, transceivers, controllers and power supplies to implement a WSN for a required application.

Course Content
Sensor Classification-Thermal sensors -Humidity sensors -Capacitive Sensors-Planar Inter digital Sensors-Planar Electromagnetic Sensors-Light Sensing Technology-Moisture Sensing Technology-Carbon Dioxide (CO2) sensing technology-Sensors Parameters


Brief description of API moded data Transmission-Testing the communication between coordinator and remote XBee - Design and Development of graphical user interface for receiving sensor data using C++; A brief review of signal processing techniques for structural health monitoring.

WSN based physiological parameters monitoring system- Intelligent sensing system for emotion recognition-WSN based smart power monitoring system. Digital light processor (DLP)

Text Books

Reference Books

Course Outcomes:
On completion of this course, the students will be able to,
1. Understand about smart instrumentation system
2. Acquire knowledge on ZigBee transceivers
3. Design self-diagnosing instrumentation system.
4. Identify the issues in power efficient systems and implement energy management techniques in WSN
5. Design wireless instrumentation systems for the given requirement.
ICOE21 - PRODUCT DESIGN AND DEVELOPMENT (THEORY & PRACTICE)

Course type: Open Elective (OE)  
Pre-requisites: -  
No. of Credits: 4

Course Objectives

1. The aim of this course is to inculcate into the student the spirit of innovation and entrepreneurship. This is achieved in this course by making the students to develop a marketable product on their own as a group. At the end of this semester course, the students will learn how to know the needs of the society and solve the musing the technical knowledge at their disposal.

2. The students will learn some of the general concepts needed for new product development and simultaneously learn how to interact with the society outside the campus to learn about its needs. They also learn about how to get prototypes fabricated outside the campus.

3. The students will fabricate an alpha prototype and test it for its conformity to the design specifications at the beginning of the next academic session

4. After demonstration of the alpha prototype, they proceed to fabricate a beta prototype that is acceptable in the market-place

Course Content

TOPICS COVERED BY LECTURES


PRACTICAL WORK

Interaction with public outside the campus- identifying customer needs- product selection based on customer needs- concept generation- concept testing.

Identifying fabrication requirements- Identifying fabricators for the project- costing- financial model for the product development-finding outside finance for product development if possible and required -patent search for the product.

1. Alpha prototype fabrication and testing-to be submitted at the end of the semester with customer acceptance survey

Course Evaluation

Theoretical and Practical part will be evaluated separately and grades will be awarded. Theoretical component will be evaluated during the semester (50%) and the practical component (50%) will be evaluated at the end of the semester.
Course Outcomes
On completion of this course, the students will be able to,
1. Make market surveys for new product development
2. Select an appropriate product design and development process for a given application
3. Plan the entire cycle of new product design and development.
4. Fabricate prototypes of new products and test them.
6. Choose an appropriate agronomy for the product and adopt methods to minimize the cost

Text Books

References:
1. Journals related to Engineering design.
ICOE 22 – MEDICAL IMAGING SYSTEMS

Course type: Open Elective (OE)  
No. of Credits: 3

Pre-requisites:

Course Objectives

1. To introduce the methods of medical imaging.
2. To impart knowledge in the physics behind the various imaging techniques.
3. To teach the construction and working of various imaging techniques.
4. To study the methods of image reconstruction

Course Content

Introduction to image processing in medical applications, X-Ray tubes, cooling systems, removal of scatters, Fluoroscopy- construction of image Intensifier tubes, angiographic setup, mammography, digital radiology, DSA.

Need for sectional images, Principles of sectional scanning, CT detectors, Methods of reconstruction, Iterative, Back projection, convolution and Back-Projection. Artifacts, Principle of 3D imaging

Alpha, Beta and Gamma radiation, Radiation detectors, Radio isotopic imaging equipments, Radio nuclides for imaging, Gamma ray camera, scanners, Positron Emission tomography, SPECT, PET/CT.

Wave propagation and interaction in Biological tissues, Acoustic radiation fields, continuous and pulsed excitation, Transducers and imaging systems, Scanning methods, Imaging Modes, Principles and theory of image generation.

NMR, Principles of MRI, Relaxation processes and their measurements, Pulse sequencing and MR image acquisition, MRI Instrumentation, Functional MRI.

Text Books

2. Dwight G. Nishimura, Lulu, Principles of Magnetic Resonance Imaging, StanfordUniv,2010

Reference Books


Course Outcomes

On completion of this course, the students will be able to,

1. Acquire basic domain knowledge about the various medical imaging techniques.
2. Understand the construction and working of various medical imaging equipments.
3. Provide a foundational understanding of algorithms used in medical imaging.
4. Analyze the medical images for diagnosis.
**ICOE23 - BUILDING AUTOMATION**

*Course type:* Open Elective (OE)  
*Pre-requisites:* -  
*No. of Credits:* 3

**Course Objectives**

1. To introduce the basic blocks of Building Management System.
2. To impart knowledge in the design of various sub systems (or modular system) of building automation.
3. To provide insight into some of the advanced principles for safety in automation.
4. To Design energy management system.

**Course Content**

Introduction:
Concept and application of Building Management System (BMS) and Automation, requirements and design considerations and its effect on functional efficiency of building automation system, architecture and components of BMS.

HVAC system:
Different components of HVAC system like heating, cooling system, chillers, AHUs, compressors and filter units and their types. Design issues in consideration with respect to efficiency and economics, concept of district cooling and heating.

Access control & security systems:
Concept of automation in access control system for safety, Physical security system with components, Access control components, Computer system access control – DAC, MAC, and RBAC.

Fire & alarm system:
Different fire sensors, smoke detectors and their types and CO2 sensors, Fire control panels, design considerations for the FA system, concept of IP enabled fire & alarm system, design aspects and components of PA system.

CCTV system & energy management system:
Components of CCTV system like cameras, types of lenses, typical types of cables, controlling system, concept of energy management system, occupancy sensors, fans & lighting controller. Introduction to structural health monitoring and methods employed.

**Text Books**

Reference Books


Course Outcomes

On completion of this course, the students will be able to,

1. Understand the concept behind building automation.
3. Design sub systems for building automation and integrate those systems.
4. Learn to design energy efficient system.
MINOR (MI) COURSES
ICMI10 –TRANSDUCER ENGINEERING

Course type: Programme Elective (PE)  Pre-requisites:
No. of Credits: 3

Course Objectives:
1. To expose the students to various sensors and transducers for measuring mechanical quantities.
2. To make the students familiar with the specifications of sensors and transducers.
3. To teach the basic conditioning circuits for various sensors and transducers.
4. To introduce advances in sensor technology.

Course Content:
General concepts and terminology of measurement systems, transducer classification, general input-output configuration, static and dynamic characteristics of a measurement system, Statistical analysis of measurement data.

Resistive transducers: Potentiometers, metal and semiconductor strain gauges and signal conditioning circuits, strain gauge applications: Load and torque measurement, Digital displacement transducer.

Self and mutual inductive transducers- capacitive transducers, eddy current transducers, proximity sensors, tacho-generators and stroboscope.


Introduction to semiconductor sensor, materials, scaling issues and basics of micro fabrication. Smart sensors.

Text Books:

Reference Books:
2. Alok Baura, Fundamentals of Industrial Instrumentation, Wiley India, New Delhi 2011

Course Outcomes:

On completion of this course, the students will be,

1. Familiar with the basics of measurement system and its input, output configuration.
2. Familiar with both static and dynamic characteristics of measurement system.
3. Familiar with the principle and working of various sensors and transducers.
4. Able to design signal conditioning circuit for various transducers.
5. Able to select proper transducer / sensor for a specific measurement application.
ICMI11 – TEST AND MEASURING INSTRUMENTS

Course Type: Minor (MI)  
No. of Credits: 3

Pre-requisites: -

Course Objectives:
1. To give an overview of current, voltage and power measuring electrical, electronics and digital instruments.
2. To expose the students to the design of bridges for the measurement of resistance, capacitance and inductance.
3. To give an overview of test and measuring instruments.

Course Content:
Different methods of measuring low, medium and high resistances, measurement of inductance & capacitance with the help of AC Bridges, Q Meter.

DSO, Function generator, Audio frequency signal generation, Waveform analyzers, Spectrum analyzers.

Text Books:

Reference Books:
Course Outcomes:

On completion of this course, the students will be,

1. Familiar with various measuring instruments (ammeters, voltmeters, wattmeters, energy meters, extension of meters, current and voltage transformers) used to measure electrical quantities.
2. Able to design suitable DC and AC bridges for the measurement of R, L, C and Frequency measurement.
3. Able to suggest the kind of instrument suitable for typical measurements.
4. Able to use the test and measuring instruments effectively.
Course Type: Minor (MI)  
Pre-requisites: -  
No. of Credits: 3

Course Objectives:
1. To expose the students to the importance of process variable measurements.
2. To expose the students to various measurement techniques used for the measurement of temperature, flow, pressure and level in process industries.
3. To make the students knowledgeable in the design, installation and troubleshooting of process instruments.

Course Content:
Temperature measurement: Introduction to temperature measurements, Thermocouple, Resistance Temperature Detector, Thermistor and its measuring circuits, Radiation pyrometers and thermal imaging.
Pressure measurement: Introduction, definition and units, Mechanical, Electro-mechanical pressure measuring instruments. Low pressure measurement, Transmitter definition types, I/P and P/I Converters.
Level measurement: Introduction, Capacitance pickup, Ultrasonic pickup.

Text Books:

Reference Books:

Course outcomes:
On completion of this course, the students will be,
1. Familiar with the different temperature, pressure, flow and level measurement techniques used in process industries.
2. Able to select and make measurements of temperature, flow, pressure and level in any process industry.
3. Able to identify or choose temperature, flow, pressure and level measuring device for specific process.
ICMI13 – ESSENTIALS OF CONTROL ENGINEERING

Course Type: Minor (MI)  
No. of Credits: 3  
Pre-requisites: -

Course Objectives:
1. To expose the students to the fundamentals of feedback control system.
2. To impart the knowledge on different types of control systems representation in pictorial and mathematical forms.
3. To teach the performance characteristics and analysis of control systems in time and frequency domain.

Course Content:
Introduction to control system – Open loop and Closed loop system – Feedback system characteristics – Block diagram reduction techniques – Signal flow graph.

Order and type of system – time domain and frequency domain response of different system characteristics using simulation software – Introduction of stability – Routh Hurwitz stability criteria.

Introduction to bode and Nyquist plot – Plotting of bode and Nyquist plot using simulation software - Gain Margin and Phase margin calculation.

Introduction to different compensator design – the design of different compensator design using simulation software.  PID controller design using simulation software.

Application of control system for different domain with case studies.

Text Books:

Reference Books:

Course Outcomes:
On completion of this course, the students will be able to,
1. Appreciate the importance of feedback control system.
2. Analyze and design the system performance using time domain and frequency domain techniques.
3. Use simulation software for classical control system design and analysis.
ICMI14 – INDUSTRIAL AUTOMATION AND CONTROL

Course Type: Minor (MI)
No. of Credits: 3

Course Objectives:
1. To introduce the importance of process automation techniques.
2. To impart required knowledge in PLC based programming.
3. To introduce to the students to the distributed control system and different communication protocols.

Course Content:
Introduction and overview of Industrial automation – Block diagram of PLC – different types of PLC – Type of input and output – Introduction to relay logic- Application of PLC.

Introduction to Ladder logic programming – Basic instructions – Timer and Counter instruction- Arithmetic and logical instruction – MCR, PID controller and other essential instruction sets - Case studies and examples for each instruction set.

Introduction to high level PLC language – Programming of PLC using simulation software – Real time interface and control of process rig/switches using PLC.

Introduction to DCS and SCADA - Block diagram – function of each component – Security objective – Operation and engineering station interface – Communication requirements.

Development of different control block using DCS simulation software – Real time control of test rigs using DCS. Introduction to HART, Fieldbus and PROFIBUS – Application and case studies of large-scale process control using DCS.

Text Books:
4. Dr. R. Manikandan, Dr. R. Senthil., Logic and Distributed Control System Sai Publishers

Reference Books:
Course Outcomes:

On completion of this course, the students will be familiar with,

1. The process automation technologies.
2. Design and development of PLC ladder programming for simple process applications.
3. The different security design approaches, engineering and operator interface issues for designing distributed control system.
4. The latest communication technologies like HART and Field bus protocol.
ICMI15 - MICROPROCESSORS AND MICROCONTROLLERS

Course type: Minor (MI)  
Pre-requisites: -
No. of Credits : 3

Course Objectives

1. To introduce the architecture of 8, 16 and 32-bit microprocessor and microcontroller.
2. To impart microcontroller programming skills in students.
3. To familiarize the students with data transfer and interrupt services.
4. To Familiarize the students with communication protocols for peripheral interfacing

Course Content

Introduction to computer architecture and organization, Architecture of 8-bit, 16-bit, 32-bit and 64-bit microprocessors, CISC/RISC design philosophy, bus configurations, CPU module. Embedded system overview.

Introduction to embedded C and assembly language, instruction set of a typical 8-bit and 16-bit microprocessor, subroutines and stacks, energy efficient ultra-low power modes, programming exercises.

Timing diagrams, Memory families, Flash Vs FRAM, on-chip peripherals- working with IO ports, ADC, comparators, timers, PWM, Watchdog. Low power modes.

Architectures of 8 and 16-bit Microcontrollers, comparison, programming exercises, applications of energy efficient systems.

Serial and parallel data transfer schemes, interrupts and interrupt service procedure. Internal peripherals of microcontrollers – SPI, I2C UART, USB and DNA. Interfacing with RTC, EEPROM and DAC.

Text Books


Reference Books


Course outcomes:
On completion of this course, the students will be able to,

1. Understand the various functional blocks of microprocessor and microcontrollers.
2. Understand and write the assembly and C language programs.
3. Interface the peripherals with microprocessors and microcontrollers
4. Design and develop microcontroller-based applications
ICMI16- MEDICAL INSTRUMENTATION

Course Type: Minor (MI)  
No. of Credits: 3  
Pre-requisites: -

Course Objectives
The course introduces the human physiological system with respect to medical instrumentation and its design and the instrumentation for measuring and analyzing the physiological parameters.

1. To educate the students on the different medical instruments.
2. To familiarize the students with the analysis and design of instruments to measure bio-signals like ECG, EEG, EMG, etc.
3. To have a basic knowledge in therapeutic devices
4. To introduce about the clinical laboratory instruments and familiar about electrical safety.

Course Content
Electro physiology: Review of physiology and anatomy, action potential, bioelectric potentials, electrode theory, bipolar and uni-polar electrodes, surface electrodes, and needle electrodes, physiological transducers—selection criteria and its application.

Bioelectric potential and cardiovascular measurements: ECG recording system, Heart sound measurement—stethoscope, phonocardiograph (PCG), Foetal monitor—ECG—phonocardiography, cardiac arrhythmia’s monitoring system. EMG, EEG—Evoked potential response, ERG and EOG recording system. Measurement of blood pressure using sphygmanometer instrument based on Korotkoff sound, indirect measurement of blood pressure and direct measurement techniques.


Respiratory and pulmonary measurements: Physiology of respiratory system, respiratory rate measurement—artificial respirator, pulmonary function measurements—spirometer—photo plethysmography, impedance pneumography and Apnea monitor.

Electrical safety: Sources of electrical hazards in medical environment and safety techniques for checking safety parameters of biomedical equipment.

Text Books
3 Leslie Cromwell, Fred J. Weibell and Erich A. Pfeiffer, Biomedical Instrumentation and Measurements, Prentice Hall of India, New Delhi, 2014.
5. Shakti Chatterjee and Aubert Miller, Biomedical Instrumentation Systems, CENGAGE Learning publishing, 2016.

Reference Books

Course Outcomes
On completion of this course the students will be,
1. To understand, design and evaluate systems and devices that can measure, test and/or acquire bio-signal information from the human body.
2. Familiar with patient monitoring equipment used in hospitals.
3. Ability to explain the medical diagnostic and therapeutic techniques
4. Familiar with various clinical laboratory instruments used for diagnosis.
ICMI17 - MICRO ELECTRO MECHANICAL SYSTEMS

Course Type: Programme Elective (PE)  Pre-requisites:
No. of Credits: 3

Course Objectives

1. To introduce the fundamental concepts of MEMS and Micro systems and their relevance to current scientific needs.
2. To introduce the state-of-art micromachining techniques including surface micromachining, bulk micromachining, and related methods.
3. To make the students knowledgeable in the design concepts of micro sensors and micro actuators.
4. To introduce the challenges and limitations in the design of MEMS devices
5. To make the students knowledgeable in computer aided design tools for modeling MEMS device.

Course Content

Introduction, emergence, MEMS application, scaling issues, materials for MEMS, Thin film deposition, lithography and etching.

Bulk micro machining, surface micro machining and LIGA process.


Theory and design: Micro Pressure Sensor, micro accelerometer – capacitive and piezoresistive, micro actuator.

Electronic interfaces, design, simulation and layout of MEMS devices using CAD tools.

Text Books


Reference Books


3. Chang Liu, Foundations of MEMS, Pearson Educational limited, 2nd

Course Outcomes

On completion of this course the students will be,
1. Able to understand the fundamental principles behind the working of micro devices/ systems and their applications.
2. Able to knowledgeable in the standard micro fabrication techniques.
3. Able to identify micro sensors and actuators for a specific application.
4. Able to do acquire skills in computer aided design tools for modeling and simulating MEMS devices.
Essential Programme Laboratory Requirement (ELR) Courses
ICLR10 – THERMODYNAMICS AND FLUID MECHANICS LABORATORY

Course Type: Essential Laboratory Requirement (ELR)
No. of Credits: 2

Course Objectives:

1. To familiarize with the principles of thermal energy and its transformation to mechanical energy.
2. To introduce about thermodynamics - concepts and properties, first and second law.
3. To provide a working knowledge of thermodynamics and fluid mechanics.

List of Experiments:

Thermodynamics

1. Performance test on Petrol and Diesel Engines with Mechanical and Electrical Dynamometers
2. Morse test on multi-cylinder petrol engine
3. Determination of volumetric efficiency on Diesel engine and Two stage reciprocating Air compressor
4. COP in compression refrigerator cycle
5. Test on Air conditioning system
6. Viscosity index of lubricant
7. Study of steam power plant

Fluid Mechanics

1. Determination of pipe friction
2. Calibration of flow meters – Venturi meter and Orifice meter
3. Determination of discharge coefficients for notches
4. Determination of minor losses
5. Centrifugal pump
6. Submersible pump
7. Jet pump
8. Gear pump
9. Screw pump

Reference Books:

Course Outcomes:
On completion of this lab, the students will be able to,
1. Understand heat, work, internal energy, and 1st and 2nd law of thermodynamics.
2. Carry out dimensional analysis, fluid statics and dynamics.
3. Demonstrate fluid mechanics fundamentals, including concepts of mass and momentum conservation.
4. Apply the Bernoulli equation and control volume analysis to solve problems in fluid mechanics.
Course Type: Essential Laboratory Requirement (ELR)
No. of Credits: 2

Course Objectives:
1. To introduce to the design of passive, bilateral electrical circuits.
2. To impart knowledge in network analysis and realization.
3. To impart knowledge in design and verification of combinational and sequential logic circuits.

List of Experiments:
1. Verification of Electrical Circuit laws and network theorems.
4. A.C. circuits and Network realization.
5. Design and verification of combinational logic circuits.
6. Design and verification of sequential logic circuits.

Reference Books:

Course Outcomes:
On completion of this lab, the students will be able to,
1. Design and analyze electrical circuits based on circuit laws and network theorems.
2. Analyze the time response and frequency response of RL, RC and RLC circuits.
3. Design and verify sequential and combinational logic circuits.
ICLR12 – SENSORS AND TRANSDUCERS LABORATORY

Course Type: Essential Laboratory Requirement (ELR)
No. of Credits: 2

Course Objectives:

1. To familiarize the students to the basic principles of various transducers.
2. To impart knowledge in static and dynamic characteristics of sensors.
3. To impart knowledge in the design of signal conditioning circuits for transducers.

List of Experiments:

1. Characteristics of (Resistive and Thermo emf) temperature sensor
2. Characteristics of Piezoelectric measurement system
3. Measurement of displacement using LVDT
4. Characteristics of Hall effect sensor
5. Measurement of strain using strain gauges
6. Measurement of torque using Strain gauges
7. Measurement using proximity sensors
8. Characteristics of capacitive measurement systems
9. Loading effects of Potentiometer
10. Design of Opto-coupler using photoelectric transducers
11. Characteristics of Micro pressure and Micro accelerometer sensing device
12. Study of speed measuring devices and Gyroscope

Reference Books:


Course Outcomes:

On completion of this lab, the students will be able to,

1. Analyze the static characteristics of different measurement systems.
2. Design signal conditioning circuits for transducers.
3. Formulate the design specification of transducer for a given application.
Course type: Essential Laboratory Requirement (ELR)
No. of Credits: 2

Course Objectives:
1. To introduce system level design.
2. To impart knowledge in design and test Op-amp and other ICs based circuits.
3. To familiarize the students in simulation tools and evaluation boards available for analog signal processing.

List of experiments:
1. Design of amplifiers using various modes and its implementation issues
2. Filter design using various methodologies for different set of specifications
3. Sensor linearization and bridge linearization using op-amps
4. Design of waveform generators using op-amp
5. PLL design
6. Regulator design
7. Analog to digital conversion & digital to analog conversion
8. Regenerative feedback circuit design - Schmitt trigger and Multivibrator
9. Transmitter design

Text Books:

Course Outcomes:
On completion of this lab, the students will be able to,
1. Design analog and digital system level circuit.
2. Simulate and validate analog IC circuits using simulation software.
3. Apply this basic IC circuit design concepts for application.
Course Type: Essential Laboratory Requirement (ELR)
No. of Credits: 2

Course Objectives:

1. To familiarize the students with different signal conditioning circuits for temperature and pressure measuring transducer.
2. To familiarize the students to the calibration practices used in industries.
3. To impart knowledge in the transmitter design.

List of Experiments:

1. Design of temperature transmitter using RTD.
2. Design of cold junction compensation circuit for Thermocouple.
3. Design of IC temperature transmitters.
5. Study of zero elevation and suppression in differential pressure transmitter
6. Performance evaluation of pressure gauges using Dead weight tester.
8. Design of alarms and annunciators for process variable measurements.
9. Design of pressure/force transmitter

Reference Books:


Course Outcomes:

On completion of this lab, the students will be able to,

1. Suggest a suitable temperature sensor for an application.
2. Design the required conversion and manipulation circuits for temperature and pressure measurement systems.
3. Evaluate various temperature and pressure measuring sensors.
ICLR15 – MICROPROCESSORS AND MICROCONTROLLERS LABORATORY

Course Type: Essential Laboratory Requirement (ELR)
No. of Credits: 2

Course Objectives:
1. To provide practical experience with 16bit/32bit microcontrollers/microprocessors-based circuits and their interfaces.
2. To enable the students to program, simulate and test various devices using a C language-based compiler.
3. To provide a platform for the students to do multidisciplinary projects.

List of Experiments:
1. Familiarization with the given micro-controller board and its assembler.
2. Basic I/O operations using switches, LEDs and LCD.
3. Programming exercises using interrupts and timers
4. ADC & DAC Interfacing.
5. I/O interfaces- parallel, Serial, SPI, I2C data Transmission.
6. Real time clock and memory interfacing with microcontroller
7. Interfacing microcontroller with stepper motor
8. Building microcontroller-based system for various applications

Reference Books:
2. Andrew N. Sloss, Dominic Symes, and Chris Wright, ARM System Developer’s Guide:

Course Outcomes:
On completion of this lab, the students will be able to,
2. Understand the key concepts of embedded systems like IO, timers, interrupts, interaction with peripheral devices
3. Design and develop embedded system and will be familiar with the debugging techniques.
ICLR16 – CONTROL ENGINEERING LABORATORY

Course Type: Essential Laboratory Requirement (ELR)
No. of Credits: 2

Course Objectives:

1. To impart knowledge on analysis and design of control system in time and frequency domain.
2. To impart knowledge in classical control and state space-based control system design.
3. To familiarize the students with MATLAB Real-time programming to collect and process data.

List of Experiments:

1. Time response characteristics of a second order system.
2. Frequency response characteristics of a second order system.
3. Constant gain compensation in time and frequency domain.
4. Compensating Networks - Characteristics
5. Design of compensation networks - Lead, Lag, Lead-lag
6. Design of state feedback controller.
7. Observer design - full order and reduced order.
8. Real time control of AC/DC servo system
9. Real Time control of 2 DOF Helicopter control
10. Real Time vibration control of cantilever beam at resonance with piezoelectric sensing & actuation
11. Real time control of 3DOF GYRO
12. Real time control of Inverted Pendulum

Reference Books:


Course Outcomes:

On completion of this lab, the students will be able to,
1. Design control systems in both classical and modern techniques.
2. Design and implement controllers to regulate and control various systems.
3. Design full order and reduced order state observer.
Course Type: Essential Laboratory Requirement (ELR)
No. of Credits: 2

Course Objectives:

1. To impart practical knowledge in PC based data acquisition, analysis and control of different process trainers.
2. To teach the industrial automation concept and programming techniques.
3. To familiarize the process modelling and control using simulation tools.

List of Experiments:

1. Identification of FOPDT and SOPDT process using time domain and frequency domain techniques.
2. Design of different PID controller for FOPDT and SOPDT process using different standard technique and evaluate qualitative & quantitative performance.
4. Design and Verification of Combinational & Sequential Circuits Using PLC.
6. Study the effect of different PID Controller Parameters using real time process trainer.
7. Pressure to Current & Current to Pressure Convertor using real time process trainer.
8. Design of Timer and Counter Using PLC.
9. Design of PLC programming for practical applications.
10. Design of Cascade and Feed forward-feedback Controller using simulation software.
11. Verification of Control Valve Characteristics using pneumatic and electronic control value trainer.
12. Development of P&I design using Distributed control system (DCS).

Reference Books:


Course Outcomes:

On completion of this lab, the students will be able to,

1. Design PID controller and tune the same for various process.
2. Implement sequential logic control using PLC for a required application.
3. Use the simulation tools for the design of controller for various process.
ADVANCED LEVEL COURSES FOR B. TECH (HONOURS)
Course Type: Honours (HO)  
Pre-requisites: ICPC13  
No. of Credits: 4  

Course Objectives:

1. To provide fundamentals of various types of diaphragm design.
2. To familiarize with design of strain gauge, capacitive and inductive based transducers and its applications.
3. To furnish the knowledge on design of accelerometer and gyroscope.
4. To provide the basics of various chemical sensors and its design criterion.

Course Content:

Introduction to diaphragm; Diaphragm performance and materials, Design of flat diaphragms, flat diaphragms with rigid centre convex diaphragms, rectangular diaphragms corrugated diaphragms and semiconductor diaphragms through analytical and numerical simulation.

Design of strain gauge-based load cells, torque sensors, force sensors and pressure sensors (Theory and experimentation)

Design of capacitance-based displacement, pressure and level sensors; Design of mutual inductance transducers for measurement of displacement and experimentation. Design of proximity sensors and practical demonstration.

Accelerometer and Gyroscopic design and its applications. Design of Hall Effect sensors, and practical demonstration of few applications.

Introduction to chemical Sensors, characteristics. Design of DO₂ sensor, ChemFETs, PEMFCs.

Text Books:

Reference Books:

8. Alok Baura, Fundamentals of Industrial Instrumentation, Wiley India Pvt. Ltd

Course Outcomes:

On completion of this course, the students will be able to,

1. Select and design diaphragm for different practical applications.
2. Design strain gauge-based torque, force, load and pressure measurement systems.
3. Design capacitance/ inductance transducers for the measurement of displacement, pressure and level.
4. Acquire knowledge in design of accelerometer and gyroscope.
**ICHO11 - INSTRUMENTATION SYSTEM DESIGN**

**Course Type:** Honours (HO)  
**No. of Credits:** 4  
**Pre-requisites:** ICPC17, ICPC20

**Course Learning Objectives:**

1. To impart the design knowledge of flow measurement and temperature measurement devices.
2. To introduce about control valve sizing and section of pumps for practical applications.
3. To introduce the process of Electronic product design
4. To familiarize with the Control Panel design and Control room design details.

**Course Content:**

Flow measurement: Design of Orifice meter, Rotameter, Electromagnetic flow meter, Ultrasonic flow meter, Coriolis flow meter. Temperature measurement: RTD measuring circuit, cold junction compensation circuit for thermocouple, linearization of thermistor characteristics and design of temperature transmitter.


Valves: Control valves - design of actuators and positioners - types of valve bodies - valve characteristics- materials for body and trim - sizing of control valves - selection of body materials and characteristics of control valves for typical applications.

Electronic product design: System Engineering, ergonomics, phases involved in electronic product design. Enclosure Design: Packing and enclosures design guidelines, Grounding and shielding, front panel and cabinet design of an electronic product


**Text Books**

5. Alok Baura, Fundamentals of Industrial Instrumentation, Wiley India Pvt. Ltd (2011)

Reference Books

1. R. W. Zape, Valve selection hand book third edition, Jaico publishing house,
2. Les Driskell, Control valve sizing, ISA.

Course Outcomes:

On completion of this course, the students will be able to,

1. Design temperature and flow measurement system for process application.
2. Design and Analyse CV Sizing
3. Identify various Control panels and Control Room details
4. Design an electronic product.
ICH012 - MICRO SYSTEM DESIGN

Course Type: Honours (HO)  Pre-requisites: ICPE13
No. of Credits: 4

Course Objectives:

1. To provide knowledge on MEMS design and various fabrication process.
2. To impart knowledge on mechanics of membranes and beams in micro scale.
3. To convey the design principles of electrostatic actuation and sensing.
4. To impart design knowledge on micro pressure sensor and micro accelerometer.
5. To provide knowledge on MEMS sensor integration and packaging.

Course Content:

Introduction, An approach to MEMS design, Basic introduction to fabrication, process integration.

Energy conserving transducer, Mechanics of membranes and beams

Electrostatic Actuation and Sensing, Effects of electrical excitation

Design of Micro pressure sensor and Micro accelerometer

Electronic Integration and Packaging

Text Books:


Reference Books:


Course Outcomes:

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

1. Design and fabricate simple micro devices.
2. Design and analyse simple mechanical structures used in sensor actuator.
3. Design electrostatic based actuation and sensing devices, micro pressure sensor and micro accelerometer.
4. Understand sensor integration and packaging techniques.
ICH013 – CONTROL SYSTEM DESIGN

Course Type: Honours (HO)  
No. of Credits: 4  
Pre-requisites: ICPC16, ICPC19

Course Objectives:

1. To impart knowledge in the concepts and techniques of linear and nonlinear control system analysis and synthesis in the modern control (state space) framework.
2. To teach the control design using the classical design principles
3. To teach the controller and observer designs

Course Content

Design of Feedback Control Systems: Introduction; Approaches to System Design; Cascade Compensation Networks; Phase-Lead Design Using the Bode Diagram; Phase-Lead Design Using the Root Locus; System Design Using Integration Networks; Phase-Lag Design Using the Root Locus; Phase-Lag Design Using the Bode Diagram; Design on the Bode Diagram Using Analytical Methods; Systems with a Pre-filter; Design for Deadbeat Response; Design Examples.

Design of State Variable Feedback Systems Introduction, State space representation of physical systems, State space models of some common systems like R-L-C networks, DC motor, inverted pendulum etc., Controllable Canonical Form, Observable Canonical Form, Diagonal Canonical Form, State transition matrix, Solution of state equations, Controllability and Observability, Full-State Feedback Control Design; Observer Design; Integrated Full-State Feedback and Observer; Tracking Reference Inputs; Internal Model Design; Design Examples.

Lyapunov’s stability and optimal control positive/negative definite, positive/negative semi-definite functions, Lyapunov stability criteria, introduction to optimal control, Riccatti Equation, Linear Quadratic Regulator, Design Examples.

Text Books:


Reference Books:


Course Outcomes:

On completing this course, the student would be able to,
1. Develop mathematical models for various physical systems.
2. Design state feedback controllers and observers.
3. Design nonlinear controllers using Lyapunov theory.
4. Analyse the stability of nonlinear system.
ICH014 - ADVANCED PROCESS CONTROL

Course Type: Honours (HO)  Pre-requisites: ICPC16, ICPC22
No. of Credits: 4

Course Objectives:

1. To expose students to the advanced control methods used in industries and research.
2. To teach various system identification and parameter estimation techniques.
3. To prepare the student to take up such challenges in his profession.

Course Content:

Review of System Identification, Parametric and non-parametric methods of system identification, Different family of BJ model; Choice of Input Signals; Least square (LS), Recursive LS, Weighted LS method of system identification.
Introduction to optimal filtering – need for filtering – Noise characteristics- Development of different state estimation techniques such as Kalman filter, Extended Kalman filter, Uncentered Kalman filter and particle Kalman filter. Development and validation of the state estimation/filtering concept with simulated non-linear systems using simulation software.
Development of augmented state space model – GPC – Controller Tuning and Robustness Issues; Extensions to Constrained and Multivariable Cases. Introduction to next generation controller – RTDA controller – Objective function – Derivation of control law – Implementation of above Digital control system using simulation software with case studies.
Case studies of APC estimation/filtering and controller concept with industrial process control applications.

Text Books:

Reference Books


Course Outcomes:

On completion of this course, the student will be able to
1. Design an appropriate advanced controller for specific problems in process industries.
2. Develop suitable filters for linear/non-linear system.
3. Design of SDCS for multivariable systems.
4. Develop the MPC and next generation controller for multivariate system.
ICHO15 – OPTIMAL AND ROBUST CONTROL

Course Type: Honours (HO)  Pre-requisites: ICPC16, ICPC19

No. of Credits: 4

Course Objectives:

1. Introduce analysis and design techniques for multivariable control systems to undergraduate students

Course Content:

Introduction, Linear Algebra, Linear Dynamical Systems (Review of state-space theory)


Model Uncertainty and Robustness – Structured Singular Values, Parameterization of Stabilizing Controllers, Algebraic Riccati Equations.

H-infinity optimal control, linear quadratic optimization, H-infinity loop shaping, Controller order reduction, Fixed order controllers.


Text Books:

4. P J Nahin, When Least is Best, Princeton Univ. Press, 2004,

Reference Books:

Course Outcomes:

Upon completing this course, the students would be able to,

1. Apply Optimization tools to multivariable feedback systems.
2. Use computer software to design MIMO robust controllers.
3. Perform a full design cycle on MIMO models of systems.
**Course Type:** Honours (HO)  
**Course Learning Objectives:**

1. To provide knowledge on the design of signal conditioning circuits for resistive, capacitive and thermal transducers to improve the sensor characteristics.
2. To provide knowledge on the design of transmitters with industrial standard.
3. To impart the knowledge of data acquisition system design, sensor networks and buses.
4. To provide knowledge about the smart sensor design, direct sensor microcontroller interface and universal interfacing circuit.

**Course Content:**


Review of transmitters – design of two wire and four wire transmitters using analog electronic circuits and IC’s. EMI and EMC design consideration for sensor interfacing circuit design.

Introduction to data acquisition system, issues related to interfacing of static and dynamic sensors. Design of data acquisition for a given measurement application through theory and practical approach. Introduction to Sensor buses and sensor network protocols.

Smart sensors and digital sensor system design: Technologies and design methodology, IEEE 1451 standard and frequency sensors.


**Text Books:**

4. Smart Sensors and MEMS, ed. by S.Y. Yurish and M.T. Gomes, Springer
Verlag, 2005


Reference Books


Course Outcomes

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

1. Design signal conditioning circuits for resistive, capacitive and thermal transducers
2. Design transmitters for the required physical parameters using analog circuits and IC.
3. Interface sensors signal with DAQ, Microcontroller and will be familiar with sensor buses and protocols.
4. Design smart sensors systems with standard interfacing circuits.