Micro-Specialization

The Institute proposes to offer Micro-Specializations to UG students from the Spring Semester of the current Academic Session (2014-2015). The salient features are as follows:

1. Each Micro-Specialization has a defined structure in terms of three sequential components:
   a) **Component-I** – One Foundation Course (2-4 credits) that constitutes a Mandatory Requirement and also a Pre-Requisite for subsequent Components.
   b) **Component-II** – One/Two subjects (3-4 credits each) from a Specified list of subjects.
   c) **Component-III** – Project/Design/Term Paper (4 credits) OR one subject (4 credits) from a Specified list.

2. A Student would be required to complete 3-4 subjects (10-14 credits) from the specified list in order to earn a Micro-Specialization.

3. The subjects can be taken through the Breadth/Open Elective component of the curriculum or as Additional Subjects. **Micro credit subjects can also be a part of Micro-specialisation.**

4. A student has to register for a Micro-Specialization. The Registration can be done in the beginning of any Semester beyond first year.

5. In order to register for a Micro-Specialization the student must have completed all curricular requirements up to the previous semester and have a CGPA ≥ 7.0. Thereafter the student must maintain a CGPA or SGPA ≥ 7.5 without any Backlog in the subsequent semesters to keep the Micro-Specialization registration active.

6. GPA for the subjects contributing to the Micro-Specialization will be separately calculated. A minimum GPA of 6.00 is essential to earn the Micro-Specialization.

**All students may please note that all subjects have been approved by Senate at its 311th Meeting held on 22/12/2014, 312th Meeting held on 18/03/2015 and 313th Meeting held on 26/05/2015 and 316th Meeting held on 13/04/2016.**

**In view of the fact that students will have to take the mandatory compulsory pre-requisite subject first before taking other subjects included in the list but may also serve as depth/breadth/HSS elective. Hence students should carefully plan out what do they want to take as micro-specialization right from the start of 2nd year of study and take the compulsory pre-requisite subject first.**

**Students should note that in case they have taken an elective subject of component 2 and 3 before taking the compulsory pre-requisite subject, they cannot re-take that elective subject again to complete the requirements for obtaining micro-specialization in a particular area. They will have to take alternative available elective subject from component 2 & 3. In case no other elective subject is available, they will not be eligible for the micro-specialization in the desired area.**
## INDEX

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of the Micro Specialization and Offering Department / Centre / School</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>Embedded Wireless Systems</strong> - G. S. Sanyal School of Telecommunications</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td><strong>Biomedical Devices and Instrumentation</strong> - School of Medical Science &amp; Technology</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td><strong>Engineering Systems Reliability</strong> - Reliability Engineering Centre</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td><strong>Rubber Engineering</strong> - Rubber Technology Centre</td>
<td>12</td>
</tr>
<tr>
<td>5</td>
<td><strong>Electronic Materials &amp; Applications</strong> - Material Science Centre</td>
<td>13</td>
</tr>
<tr>
<td>6</td>
<td><strong>BIOENERGY</strong> - School of Energy Science &amp; Engineering</td>
<td>15</td>
</tr>
<tr>
<td>7</td>
<td><strong>Entrepreneurship &amp; Innovation</strong> - Rajendra Mishra School of Engineering Entrepreneurship</td>
<td>19</td>
</tr>
<tr>
<td>8</td>
<td><strong>Drug Discovery</strong> - Chemistry &amp; Bioscience</td>
<td>20</td>
</tr>
<tr>
<td>9</td>
<td><strong>Micro Fluidics and Nano Patterning</strong> - Chemical Engineering/ Mechanical Engineering/ School of Nano Science &amp; Nano Technology</td>
<td>21</td>
</tr>
<tr>
<td>10</td>
<td><strong>PHOTONICS</strong> - Physics</td>
<td>22</td>
</tr>
<tr>
<td>11</td>
<td><strong>Industrial Safety Engineering</strong> - Industrial &amp; Systems Engineering</td>
<td>25</td>
</tr>
<tr>
<td>12</td>
<td><strong>Intelligent Learning System Design</strong> - Centre for Educational Technology</td>
<td>28</td>
</tr>
<tr>
<td>13</td>
<td><strong>Intellectual Property Rights</strong> - Rajiv Gandhi School of Intellectual Property Law</td>
<td>37</td>
</tr>
<tr>
<td>14</td>
<td><strong>Optimization Theory and Applications</strong> - Mathematics</td>
<td>38</td>
</tr>
<tr>
<td>15</td>
<td><strong>Rural Innovation and Management</strong> - Rural Development Centre</td>
<td>39</td>
</tr>
<tr>
<td>16</td>
<td><strong>Simulation Methods And Applications</strong> - Centre for Theoretical Studies</td>
<td>42</td>
</tr>
<tr>
<td>17</td>
<td><strong>Quality Engineering</strong> - Reliability Engineering Centre</td>
<td>43</td>
</tr>
<tr>
<td>18</td>
<td><strong>Science of Happiness</strong> - Rekhi Centre of Excellence for the Science of Happiness</td>
<td>51</td>
</tr>
<tr>
<td>19</td>
<td><strong>Business Analytics</strong> - Vinod Gupta School of Management</td>
<td>59</td>
</tr>
<tr>
<td>20</td>
<td><strong>Embedded Control and Software: Modeling and Design</strong> - Advanced Technology Development Centre</td>
<td>64</td>
</tr>
<tr>
<td>21</td>
<td><strong>Artificial Intelligence and Applications</strong> - Centre of Excellence in Artificial Intelligence</td>
<td>72</td>
</tr>
</tbody>
</table>
**Name of the Micro-Specialization:** Embedded Wireless Systems

1. **School/Center:** G. S. Sanyal School of Telecommunications

2. **Brief Description:**
   This course aims to disseminate necessary knowledge base on signal processing methodology, algorithms and protocols for design and development of embedded wireless communication systems.

3. **Number of Subjects needed to earn the Micro-Specialization:** 4 Subjects or 3 Subjects + 1 Project

4. **Credits needed to earn the Micro-Specialization:** 12-14 credits

5. **Structure:**
   - Component I: One Subject (2-0-0)
   - Component II: Two Subjects (3-1-0/ 3-0-0)
   - Component III: One Project (0-0-6) or One Subject (3-0-0)

   **A. COMPONENT- I:** MANDATORY REQUIREMENT: (2 credit FOUNDATION COURSE) for those students who have not studied Digital Communications (EC31002) and passed successfully.

   **TABLE-I**
<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TE30002</td>
<td>Introduction to Wireless Communications</td>
<td>2-0-0</td>
<td>2</td>
<td>Both Semesters</td>
<td>NA</td>
</tr>
</tbody>
</table>

   **B. COMPONENT- II ANY TWO SUBJECTS (3/4 credits each) FROM TABLE-II**

   **TABLE-II**
<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TE61002</td>
<td>MIMO Communications</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>TE30002</td>
</tr>
<tr>
<td>TE61003</td>
<td>Communications Signal Processing and Algorithms</td>
<td>3-1-0</td>
<td>4</td>
<td>Autumn</td>
<td>TE30002</td>
</tr>
<tr>
<td>TE60003</td>
<td>Spread Spectrum Communications and Jamming</td>
<td>3-0-0</td>
<td>3</td>
<td>Autumn</td>
<td>TE30002</td>
</tr>
<tr>
<td>TE60114</td>
<td>Broadband Access Networks</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>TE30002</td>
</tr>
</tbody>
</table>
C. COMPONENT- III: PROJECT (4 credits) OR ANY ONE (3 credits) SUBJECT FROM TABLE-III

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TE60006</td>
<td>Communication Services and Applications</td>
<td>3-0</td>
<td>3</td>
<td>Spring</td>
<td>TE30002</td>
</tr>
<tr>
<td>TE60004</td>
<td>Telecommunications Network Security</td>
<td>3-0</td>
<td>3</td>
<td>Spring</td>
<td>TE30002</td>
</tr>
<tr>
<td>TE67001</td>
<td>Project on Embedded Wireless Systems</td>
<td>0-6</td>
<td>4</td>
<td>Both Semesters</td>
<td>TE30002</td>
</tr>
</tbody>
</table>

Subject Details

**TE30002: Introduction to Wireless Communications (L-T-P: 2-0-0; Credit: 02)**

A. Syllabus:
- Introduction to wireless technology (1 Lecture Hr.);
- Bandpass signals and systems (3 Lecture Hr.);
- Baseband equivalent of narrow band signals and systems (5 Lecture Hr.);
- Noise in wireless receivers (3 Lecture Hr.);
- Wireless transceiver structures – link budget, RF stage, antenna (6 Lecture Hr.);
- Digital signal processing and digital design of wireless transceivers (4 Lecture Hr.);
- System level examples – Physical Layer and Medium Access Layer (6 Lecture Hr.);

B. Total Lecture Hours: 28

**TE67001: Project on Embedded Wireless Systems (L-T-P: 0-0-6; Credit: 04)**

A suitable executable project from any one of the following areas:

(a) Spread Spectrum transceiver with variable spreading gain over AWGN channel;
(b) Power control for multiuser interference mitigation;
(c) Design and implementation of cognitive transceivers;
(d) Design and implementation of codecs in DSP / FPGA;
(e) Wireless transceivers for body area network;
(f) Embedded sensing systems;
(g) Implementation of synchronization algorithms for cellular communications;
(h) Implementation of equalization algorithms;
(i) Machine to machine wireless communications;
(j) Embedded security procedures;
(k) Embedded components of software radio;
(l) Any other area, related to digital wireless systems, as may be offered by the School.
Name of the Micro-Specialization: Biomedical Devices and Instrumentation

1. School/Center: School of Medical Science & Technology

2. Brief Description:
This program is designed to provide the knowledge and skills needed for the development of medical devices and diagnostic techniques, including aspects of medical instrument/product regulation and also product development.

It is a rapidly advancing, inter-disciplinary research field for creation and development of new methods/systems to effectively process or manipulate biological materials with electronic devices and components. An interdisciplinary R&D work at SMST has been initiated to promote MEMS and Biosensor activity that encompasses design, fabrication and engineering of biomedical & micro-fluidic devices for its electro-physiological characterization, sensing various biological signals, Electrical mechanical and physical properties of bio molecules and cells. The research also involves development of different transducers and related technologies for sensing various biomedical signals for precise and appropriate diagnostics and therapeutics. Micro-fabrication technology is also being explored to develop various devices for deployment of in-vivo and in-vitro detection of biomedical signals and its characterization. One of the course of this program is designed to teach the fundamental background of state-of-the-art technologies for micro-sensor and micro-actuator system applications.

The course titled “Biomedical Instrumentation” will deal with fundamentals of medical instrumentation systems, sensors, and biomedical signal processing. For example instruments for cardiovascular and respiratory assessment. Biomedical transducers for measurements of bio-potentials, pressure, flow, concentrations, movement and temperature are discussed. Clinical laboratory measurements, therapeutic and prosthetic devices, and electrical safety requirements.

Engineered materials are increasingly used in medical applications, bone and dental implants, scaffolds for tissue engineering, replacement body parts, and biomedical and surgical devices. Biomaterials, as a subject, require a understanding of the properties of materials in general, and the interactions of materials with the biological environment in particular. Therefore biomaterials engineering is an important subject that needs to be learned for in-vivo applications of biomedical devices.

3. Number of Subjects needed to earn the Micro-Specialization: Two Subjects + One Project

4. Credits needed to earn the Micro-Specialization: 12 credits

5. Structure: Component I: One Subject (3-1-0)
Component II: One Subject (3-1-0)
Component III: One Project (0-0-6)

A. COMPONENT- I: MANDATORY REQUIREMENT: (4 credit FOUNDATION COURSE)

| TABLE-I |
|---|---|---|---|---|---|
| Sub no. | Sub Name | LTP | Credits | Offering Semester | Pre-Requisite (if any) |
| MM61501 | Basic Human Anatomy Physiology and Pathology | 3-1-0 | 4 | Autumn | NA |
B. COMPONENT- II ANY ONE SUBJECT (4 credits each) FROM TABLE-II

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MM61509</td>
<td>MEMS and Biosensor</td>
<td>3-1-0</td>
<td>4</td>
<td>Autumn</td>
<td>MM61501</td>
</tr>
<tr>
<td>MM61502</td>
<td>Biomedical Instrumentation</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>MM61501</td>
</tr>
<tr>
<td>MM61316</td>
<td>Biomaterials</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>MM61501</td>
</tr>
</tbody>
</table>

C. COMPONENT- III: ONE PROJECT (4 credits) FROM TABLE-III

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MM77319</td>
<td>Minor Project-I</td>
<td>0-0-6</td>
<td>4</td>
<td>Autumn</td>
<td>MM61501</td>
</tr>
<tr>
<td>MM77320</td>
<td>Minor Project-II</td>
<td>0-0-6</td>
<td>4</td>
<td>Spring</td>
<td>MM61501</td>
</tr>
</tbody>
</table>

MM61501: BASIC HUMAN ANATOMY, PHYSIOLOGY AND PATHOLOGY (LTP: 3-1-0, CRD: 4)

SYLLABUS:

Introduction to Human Anatomy, Physiology, Pathology and Medical Technology. Introduction to Cellular-sub-cellular structure and function, extra cellular matrix, tissues, organs and systems from an integrated viewpoint. Introduction to genetics- proteomics metabolomics bio-regulatory pathways feedbacks-biorhythms, physiology of Membrane transport, RMP, neuromuscular transmission and muscle contraction (including Skeletal, cardiac and smooth muscle characteristics). Integumentary system: Basic structure function, circulation and interrelation with other systems. Musculoskeletal system: basic structure function, circulation and interrelation with other systems.

Blood, Lymphatics and other body-fluids: Basic structure function, own circulation and interrelation with other systems. Cardiovascular system: Basic structure function, own circulation and interrelation with other systems, Cardiac cycle, heart sounds and electrical activity of heart with basic ECG interpretation. Respiratory system: Basic structure function, own circulation and interrelation with other systems. Nervous system: Basic overview of structures and functions of neuron, Basic structure function, own circulation and interrelation with other systems, ANS, Motor and Sensory system), central regulation of visceral function, sensation, sleep and EEG, hunger, thirst, Control of posture and movement, joint mechanics and Gait Analysis. Special senses (vision, hearing, equilibrium, smell, taste), own circulation and interrelation with other systems. Endocrine system: Basic structure function, own circulation and interrelation with other systems.

Gastrointestinal system: Basic structure function, own circulation and interrelation with other systems. Reproductive system: Basic structure function, own circulation and interrelation with other systems (Basics of Reproductive physiology, sex differentiation, menstruations, pregnancy and lactation. Hypothalamic-pituitary axis, calcium metabolism and its regulation).

Renal system: Basic structure function, own circulation and interrelation with other systems (Nephron hemodynamics, clearance and regional transport, basics of acid-base disturbance). Bio-implants: Different implants and their interfaces as well as interaction with human systems. Introduction to necessity medical imaging and image analysis: A journey towards integrated

**MM61502: BIOMEDICAL INSTRUMENTATION (LTP: 3-1-0, CRD: 4)**

**SYLLABUS:**

Introduction to the physiology of cardiac, nervous and muscular and respiratory systems. Transducers and Electrodes: Different types of transducers and their selection for Biomedical applications, Electrode theory, Different types of electrodes Hydrogen Calomel, Ag-AgCl, pH, PCO2 electrodes, selection criteria of electrodes.

Cardiovascular measurement: The cardio vascular system, Measurement of Blood Pressure, Blood flow, Cardiac output and Cardiac rate, Electrocardiography, Photocardiograph, balloistocardiography, Plethysmography, Magneta Cardiography, Cardiac pace-maker, computer applications. Measurement of Electrical Activities in Muscles and Brain: Electrimyography, Electroencephalograph and their interpretation.


**MM61509: MEMS & BIOSENSORS (LTP: 3-1-0, CRD: 4)**

**SYLLABUS:**

Fundamental of MEMS: Introduction to MEMS principles and fabrication technologies, fundamental MEMS structures, MEMS materials, MEMS design, fabrication, packaging, Fundamental mechanical, electrical optical, biochemical and fluidic characteristics of the basic microstructures.

Bio- MEMS for clinical detection: Fundamentals of micro and nano fabrication of biochips and lab-on-a-chips, molecular recognition and bio-immobilization principles and procedures, on-chip biochemical detection methods, introduction to micro/nano fluidics, basic components of lab-on-a-chips and its integration.

Biosensors and Biochips: Fundamentals of biosensors, fundamentals of electrochemistry and electrochemical biosensors, micro-fluidic devices and systems, MEMS sensors and actuators for medical instrumentation and fundamental of bioelectronics for bio-signal conditioning and processing.
MM61316: BIOMATERIALS (LTP: 3-1-0, CRD – 4)

SYLLABUS:-


Name of the Micro-Specialization: Engineering Systems Reliability

1. School/Center: Reliability Engineering Centre

2. Brief Description: UG students with various engineering backgrounds need to design, manufacture, operate and maintain engineering systems/services. Reliability engineering focuses on identification of weaker components/processes in a system and the methods of improvement so that the system becomes more reliable, safer and easily maintainable. Reliability engineering tools are structured, systematic, and objective approaches for quantitative and qualitative performance analysis. This specialization will help students to understand these tools, life testing, field failure data collection and analysis methods. This micro-specialization is designed with generic approach so that students from all disciplines get benefited.

3. Number of Subjects needed to earn the Micro-Specialization: 4 Subjects or 3 Subjects + 1 Project

4. Credits needed to earn the Micro-Specialization: 12-14 credits

5. Structure: Component I: One Subject (2-0-0)  
   Component II: Two Subjects (3-1-0/ 3-0-0)  
   Component III: Project (0-0-6) or One subject taken from Component II

A. COMPONENT- I: MANDATORY REQUIREMENT: (2 credit FOUNDATION COURSE)

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RE20001</td>
<td>Introduction to Reliability Engineering</td>
<td>2-0-0</td>
<td>2</td>
<td>Both</td>
<td>NA</td>
</tr>
</tbody>
</table>

B. COMPONENT- II ANY TWO SUBJECTS (3/4 credits each) FROM TABLE-II

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RE60021</td>
<td>Reliability Estimation and Life Testing</td>
<td>3-1-0</td>
<td>4</td>
<td>Autumn</td>
<td>RE20001</td>
</tr>
<tr>
<td>RE60011</td>
<td>Probabilistic Risk Assessment</td>
<td>3-1-0</td>
<td>4</td>
<td>Autumn</td>
<td>RE20001</td>
</tr>
<tr>
<td>RE60024</td>
<td>Software Reliability</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>RE20001</td>
</tr>
<tr>
<td>RE60018</td>
<td>Fault Diagnosis and Predictive Maintenance</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>RE20001</td>
</tr>
<tr>
<td>RE60002</td>
<td>Reliability Design</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>RE20001</td>
</tr>
<tr>
<td>RE60005</td>
<td>Quality of Service Analyses in Cloud Computing</td>
<td>4-0-0</td>
<td>4</td>
<td>Spring</td>
<td>RE20001</td>
</tr>
<tr>
<td>RE60015</td>
<td>Statistical Process Control</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>RE20001</td>
</tr>
<tr>
<td>CE60112</td>
<td>Risk and Reliability of Civil Infrastructure Systems</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>RE20001</td>
</tr>
</tbody>
</table>

C. COMPONENT- III: PROJECT (4 credits) FROM TABLE-III OR ANY ONE (4 credits) SUBJECT FROM TABLE-II

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RE67006</td>
<td>Project on System Reliability/Risk Analysis</td>
<td>0-0-6</td>
<td>4</td>
<td>Both</td>
<td>RE20001</td>
</tr>
</tbody>
</table>


**Syllabus**

**RE20001: SUBJECT NAME - INTRODUCTION TO RELIABILITY ENGINEERING**  
LTP- 2-0-0, CRD- 2

**SYLLABUS:-**  
Basic Definitions of reliability and maintainability terms. Failure rates such as constant, increasing and decreasing hazard rates. Reliability Block Diagram, Series, parallel, series-parallel, standby and k-out-of-modeling. Reliability prediction and estimation, Life Testing. The concepts of availability, maintainability, safety, and probabilistic risk of engineering products. Basic concepts of software reliability.

**RE60003: SUBJECT NAME - RELIABILITY ESTIMATION & LIFE TESTING**  
LTP- 3-1-0, CRD- 4

**SYLLABUS:-**  

**RE60011: SUBJECT NAME - PROBABILISTIC RISK ASSESSMENT**  
LTP- 3-1-0, CRD- 4

**SYLLABUS:-**  

**RE60024: SUBJECT NAME - SOFTWARE RELIABILITY**  
LTP- 3-0-0, CRD- 3

**SYLLABUS :-**  
Definition, errors-their cause and consequence, basic design principle of reliable software, requirements, objectives, and specifications, system architecture, program structure design, design practices, module design and coding, programming style. Software testing principles, module testing, functions and system testing, debugging, programming languages and reliability, computer architecture and reliability, proving program correctness, reliability models, software support systems.

**RE60018: SUBJECT NAME - FAULT DIAGNOSIS & PREDICTIVE MAINTENANCE**  
LTP- 3-0-0, CRD- 3

**SYLLABUS:-**  
Determining health of machines through parameter monitoring. Performance and auxiliary variables, vibration parameters, time and frequency domain signals, vibration identification and diagnostic tables, vibration standards, vibration monitoring instruments. Temperature monitoring, thermography, tem-plugs, thermo-paints. Lubrication monitoring, SOAP, wear particles analysis, ferrography, ferrographical analyzer. Noise-sound monitoring sound measurement, magnetic tape recorders, sound level meters and analyzers, sound level data processing.
RE60002: SUBJECT NAME- RELIABILITY DESIGN  
LTP- 3-1-0, CRD- 4

SYLLABUS :-


RE67006: SUBJECT NAME- MICRO SPECIALIZATION PROJECT  
LTP- 0-0-6, CRD - 4

Possible areas:

1. Accelerated Life Testing on components and products
2. Fault Diagnosis of Engineering Systems
3. Reliability Prediction of products
4. Failure data analysis and reliability estimation
5. Software reliability and quality
6. Risk analysis of engineering systems
Name of the Micro-Specialization: **Rubber Engineering**

1. **School/Center:** Rubber Technology Centre (RTC)

3. **Brief Description:** Rubbers and Elastomers are very special class of Polymers that occupy a pivotal position in the materials field today. In performance characteristics, application prospects and diversity, they offer novelty and versatility not found in other kind of materials. This Micro-specialization course will primarily focus on the basic understanding of the science, technology and engineering of rubbers, fundamentals concepts behind engineering design with rubbers and various routes of processing of rubbers and rubber like materials for various applications like tyres, automotives, cables, hoses, belts etc. The course has been designed to have an interdisciplinary relevance for mechanical engineering, chemical engineering etc.

4. **Number of Subjects needed to earn the Micro-Specialization:** Three Subjects

5. **Credits needed to earn the Micro-Specialization** 10 credits

6. **Structure:**

   **Component I:** One Subject (2-0-0)
   **Component II:** One Subject (3-1-0)
   **Component III:** One subject (3-1-0)

   **A. COMPONENT- I: MANDATORY REQUIREMENT (2 credit FOUNDATION COURSE)**

   **TABLE-I**

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT30001</td>
<td>Basic Science and Technology of Rubbers</td>
<td>2-0-0</td>
<td>2</td>
<td>Autumn</td>
<td>NA</td>
</tr>
</tbody>
</table>

   **B. COMPONENT- II ONE SUBJECT (4 credits) FROM TABLE-II**

   **TABLE-II**

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT60016</td>
<td>Engineering Design with Rubbers</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>RT30001</td>
</tr>
</tbody>
</table>

   **C. COMPONENT- III: ONE SUBJECT (4 credits) FROM TABLE-III**

   **TABLE-III**

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT30003</td>
<td>Processing of Rubbers and Rubber like Materials</td>
<td>3-1-0</td>
<td>4</td>
<td>Autumn</td>
<td>RT30001</td>
</tr>
</tbody>
</table>
Name of the Micro-Specialization: **Electronic Materials & Applications**

1. **School/Centre:** MATERIALS SCIENCE CENTRE

2. **Brief Description:** Nano-electronics have enjoyed explosive growth in the past few years. In particular, nanofabrication techniques have advanced tremendously in recent years. Obviously revolutionary changes in the ability to measure, organize, and manipulate matter on the nanoscale are highly beneficial for electronics with its persistent trend of downscaling devices, components, and integrated systems. In turn, the miniaturization required by electronics is one of the major driving forces for nanomaterials. Thus for the basic ideas needed to understand recent developments in materials & processes, as applied to nanoelectronics, are the focal theme of this Micro-specialization.

3. **Number of Subjects needed to earn the Micro-Specialization:** 3 Subjects or 2 Subjects +1 Project

4. **Credits needed to earn the Micro-Specialization:** 10 - 11 credits

5. **Structure:**
   - **Component I:** One Subject (3-0-0)
   - **Component II:** One Subject (3-1-0/3-0-0) or Project (0-0-6)
   - **Component III:** Project (0-0-6) or One subject (3-1-0)

   **A. COMPONENT-I: MANDATORY REQUIREMENT: (3 credit FOUNDATION COURSE)**

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS60009</td>
<td>Fundamentals of Electronic Materials</td>
<td>3-0-0</td>
<td>3</td>
<td>Both</td>
<td>NA</td>
</tr>
</tbody>
</table>

   **B. COMPONENT-II ANY ONE SUBJECTS (3/4 credits) OR PROJECT FROM TABLE-II**

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS61015</td>
<td>Materials for High Frequency Applications</td>
<td>3-1-0</td>
<td>4</td>
<td>Autumn</td>
<td>MS60009</td>
</tr>
<tr>
<td>MS31001</td>
<td>Photonic Materials &amp; Applications</td>
<td>3-0-0</td>
<td>3</td>
<td>Autumn</td>
<td>MS60009</td>
</tr>
<tr>
<td>MS60032</td>
<td>Optoelectronic Materials and Devices</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>MS60009</td>
</tr>
<tr>
<td>MS67103</td>
<td>PROJECT*</td>
<td>0-0-6</td>
<td>4</td>
<td>Both</td>
<td>MS60009</td>
</tr>
<tr>
<td>MS61015</td>
<td>Materials for High Frequency Applications</td>
<td>3-1-0</td>
<td>4</td>
<td>Autumn</td>
<td>MS60009</td>
</tr>
</tbody>
</table>
C. COMPONENT- III:  PROJECT (4 credits) OR ANY ONE (4 credits) SUBJECT FROM TABLE-II

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS60023</td>
<td>Epitaxy of Compound Semiconductors</td>
<td>3-1-0</td>
<td>4</td>
<td>Autumn</td>
<td>MS60009</td>
</tr>
<tr>
<td>MS60044</td>
<td>Technology of Ceramics for Electronic Applications</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>MS60009</td>
</tr>
<tr>
<td>MS60052</td>
<td>Introduction to Nanotechnology and Nanostructured Materials</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>MS60009</td>
</tr>
<tr>
<td>MS60038</td>
<td>Polymers for Electronic and Photonic Applications</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>MS60009</td>
</tr>
<tr>
<td>MS67104</td>
<td>PROJECT*</td>
<td>0-0-6</td>
<td>4</td>
<td>Both</td>
<td>MS60009</td>
</tr>
</tbody>
</table>

*PROJECT - A student is allowed to take PROJECT only in one semester. Project would be offered on following major disciplines (i) Polymer materials, (ii) Ceramic Materials, (iii) Semiconducting Materials, (iv) Nanostructured Materials
Name of the Micro-Specialization: **BIOENERGY**

1. **School**: School of Energy Science & Engineering (SESE)

2. **Brief description**: Opening with an introductory foundation course on Bioenergy, this micro-specialization shall provide the students with a wide-angle view of Bioenergy, ranging from its fundamentals through bioresource management, biofuels technology and bioreactor design to biopollution control. The student shall also get an opportunity to engage in Bioenergy research through mini-projects on Biohydrogen, Biomethane, Bioethanol, Biodiesel, Microbial Fuel Cell, etc.

3. **Number of Subjects needed to earn the Micro-Specialization**: 4 Subjects or 3 Subjects+1 Project

4. **Credits needed to earn the Micro-Specialization**: 12 - 13 credits

5. **Structure**: Component I: One Subject (2-0-0)

   Component II: Two Subjects (3-1-0/ 3-0-0)

   Component III: One subject (3-1-0) or Project (0-0-6)

   **A. COMPONENT-I: MANDATORY REQUIREMENT: (2 credit FOUNDATION COURSE)**

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES30001</td>
<td>Introduction to Bioenergy</td>
<td>2-0-0</td>
<td>2</td>
<td>Autumn</td>
<td>NA</td>
</tr>
</tbody>
</table>

   **B. COMPONENT-II ANY TWO SUBJECTS (3/4 credits) FROM TABLE-II**

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BT41002</td>
<td>Bioresource Technology</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>ES30001</td>
</tr>
<tr>
<td>CH60016</td>
<td>Fundamentals Of Bioenergy</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>ES30001</td>
</tr>
<tr>
<td>BT41013</td>
<td>Bioreactor Analysis And Design</td>
<td>3-0-0</td>
<td>3</td>
<td>Autumn</td>
<td>ES30001</td>
</tr>
<tr>
<td>ES60002</td>
<td>Waste To Wealth: Microbial Intervention</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>ES30001</td>
</tr>
</tbody>
</table>

   **C. COMPONENT-III: PROJECT (4 credits) OR ANY ONE (4 credits) SUBJECT FROM TABLE-III**

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ES67001</td>
<td>Innovative Student Project On Renewable Energy</td>
<td>0-0-6</td>
<td>4</td>
<td>Both</td>
<td>ES30001</td>
</tr>
<tr>
<td>CE60028</td>
<td>Industrial Water Pollution Control</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>ES30001</td>
</tr>
<tr>
<td>ES61001</td>
<td>Characterization And Analysis Of Biomass And Biofuel</td>
<td>3-1-0</td>
<td>4</td>
<td>Autumn</td>
<td>ES30001</td>
</tr>
</tbody>
</table>

   **if any**: The “Innovative Student Project on Renewable Energy” listed in Table III shall be a student-driven project that will be conceived by the student and mentored by the faculty members of PK Sinha Center for Bioenergy.
**ES30001: Introduction to Bioenergy (2-0-0; 2 credits)**

**Objective:** The aim of this course is to provide the undergraduate students with an overview of the contemporary global narratives of Bioenergy, and familiarize them with the fundamentals of the engineering science of Bioenergy. As an introductory course to the Micro-specialization on Bioenergy, this foundation course would prime the students with the necessary pre-requisites needed for them to credit the elective courses in the Bioenergy Micro-specialization.

**Syllabus:**

Definition of Bioenergy, Sources of Bioenergy, Classification of Bioenergy: Solid, Liquid, gaseous, Bioenergetic pathways, Microorganisms for Bioenergy production, Stoichiometry of Bioprocesses, Bioreactor analysis, Process design and scale-up

**Reference Books:**


**ES60002: Waste to Wealth: Microbial Intervention (3-1-0; 4 credits)**

**Objective:**

Aim of this course is to expose the students to the recent frontier areas of Bioenergy studies and its importance. The main objective of this course is to familiarize the graduate and undergraduate students to the different types of organic pollutants and their control through microbiological intervention. By opting for this course, students will find an opportunity to learn the advance techniques adopted presently for conversion of the organic solids as well as liquid wastes to wealth.

**Syllabus:**

Introduction: Glimpses of microbial world towards biofuel/bioenergy production from biomass; Biomass characterization (Biophysical, Biochemical, Physicochemical, thermal, etc.); Microbial Growth kinetics of pure and mixed culture; Mechanisms of Reactions: Pathways involved in waste to energy production; Metabolic and media engineering in biomass conversion; Microbiology of aerobes and anaerobes; Mechanism of bioconversion process; Trends in biofuel production: First, second, third and fourth generation biofuel; Biohydrogen; Oleaginous biodiesel production; Microbial fuel cells; Bioremediation of heavy metals, xenobiotics and hazardous wastes; Biofertilizers; Value added product development and its cost effective recovery; Conventional and nonconventional techniques adopted for product
Reference Books:


ES61001: Characterization And Analysis Of Biomass And Biofuel (3-1-0; 4 credits)

Analysis of biomass and biofuel quality plays an important role in biofuel research. This course will help PG students/Research scholars to acquire state of the art knowledge of analysis, characterization techniques and their interpretations with regards to biofuels production.


Analysis of liquid bio-fuel such as bio-ethanol, bio-butanol, bio-alkane, bioalkenes, biodiesel etc.

Analysis of different constituents and contaminants present in the targeted product. Analysis of recovered biomass: Microscopic and spectroscopic studies for structural analysis and its interpretation, pore size determination, 3D microstructure analysis Analysis of gaseous bio-fuel: Determination of CH₄, CO₂, CO, H₂S, H₂ in biogas Determination of volatile fatty acid (VFA) and its constituents, alkalinity (Total and partial), biological oxygen demand (BOD), Chemical oxygen demand (COD) and conversion efficiency Analysis of syngas and compressed gas.

Analysis of fuel qualities/properties: Bomb calorimeter, Junker’s calorimeter, Flash point, pour point, viscosity, kinematic viscosity, acid value, saponification, fatty acid composition, iodine value, cetane index, octane value, oxidative stability and shelf life determination.

Objective:

Aim of this course is to expose the students to the recent techniques used in Energy Research. The main objective of this course is to familiarize the students with the latest sophisticated analytical tools used for the characterization of biomass and biofuel which play a crucial role in bioenergy production. This elective course can be taken by the graduate and undergraduate students.

<table>
<thead>
<tr>
<th>Module No.</th>
<th>Course Content</th>
<th>Class Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction: Biomass, diversity, sources, availability etc. Constitutional analysis of biomass: Qualitative and quantitative Proximate and ultimate analysis of biomass.</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Biochemical analysis using analytical tools: Total carbon, total organic carbon, protein, nitrogen content Carbohydrate (Starch, cellulose, hemicellulose), lipid, pectin and fibre estimation Estimation of total sugar, reducing sugar, non-reducing sugar Determination of lignin and its derivatives Determination of organic and inorganic elements which include C, H, N, S, P, K, macro and micronutrient analysis Toxicity test of the biomass.</td>
<td>5</td>
</tr>
<tr>
<td>3</td>
<td>Analysis of liquid bio-fuel such as Bio-ethanol, Bio-butanol, Bio-alkanes, Bioalkenes, Biodiesel</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Analysis of different constituents and contaminants present in the targeted product. Analysis of recovered biomass: Microscopic and spectroscopic studies for structural analysis and its interpretation, pore size determination, 3D microstructure analysis</td>
<td>10</td>
</tr>
<tr>
<td>5</td>
<td>Analysis of gaseous bio-fuel: Determination of CH$_4$, CO$_2$, CO, H$_2$S, H$_2$ in biogas Determination of volatile fatty acid (VFA) and its constituents, alkalinity (Total and partial), biological oxygen demand (BOD), Chemical oxygen demand (COD) and conversion efficiency Analysis of syngas and compressed gas</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>Analysis of fuel qualities/properties: Bomb calorimeter, Junker’s calorimeter, Flash point, pour point, viscosity, kinematic viscosity, acid value, saponification, fatty acid composition, iodine value, cetane index, octane value, oxidative stability and shelf life determination.</td>
<td>7</td>
</tr>
<tr>
<td>7</td>
<td>Advanced tools and techniques for bio-fuel research</td>
<td>6</td>
</tr>
</tbody>
</table>

Reference Books:


Teachers: Prof Rintu Banerjee & Prof. Tapas K. Bandopadhyay
Name of the Micro-Specialization: Entrepreneurship & Innovation

1. **School**: Rajendra Mishra School of Engineering Entrepreneurship

2. **Brief Description**: Innovation, entrepreneurship, and enterprise are inextricably related. An executive is expected to possess entrepreneurial qualities for effective decision making that call for innovative thinking about enterprise resources. The proposed micro specialization has been structured to impart knowledge in a balanced way so as to equip the future executives with the necessary inputs to effectively use innovative thinking for maximizing value creation for the enterprise.

3. **Number of Subjects needed to earn the Micro-Specialization**: Four

4. **Credit needed to earn the Micro-Specialization**: 11 - 12 credits

5. **Structure**:
   - **Component I**: One Subject (3-0-0)
   - **Component II**: Two Subjects (3-0-0) / (2-1-0) / (0-0-3)
   - **Component III**: One subject (3-0-0)

A. **COMPONENT- I: MANDATORY REQUIREMENT**: (3 credit FOUNDATION COURSE)

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EP60020</td>
<td>Foundations of Entrepreneurship</td>
<td>3-0-0</td>
<td>3</td>
<td>Both</td>
<td>NA</td>
</tr>
</tbody>
</table>

B. **COMPONENT- II ANY TWO SUBJECTS FROM TABLE-II**

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EP60021</td>
<td>Engineering B-Plan Development – I</td>
<td>2-1-0</td>
<td>3</td>
<td>Autumn</td>
<td>EP60020</td>
</tr>
<tr>
<td>EP60042</td>
<td>Engineering Design Process</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>EP60020</td>
</tr>
<tr>
<td>EP60003</td>
<td>Product Development</td>
<td>3-0-0</td>
<td>3</td>
<td>Autumn</td>
<td>EP60020</td>
</tr>
<tr>
<td>EP60031</td>
<td>Entrepreneurial Exit Strategies</td>
<td>3-0-0</td>
<td>3</td>
<td>Autumn</td>
<td>EP60020</td>
</tr>
<tr>
<td>EP60005</td>
<td>Financial and Legal aspects of business</td>
<td>3-0-0</td>
<td>3</td>
<td>Autumn</td>
<td>EP60020</td>
</tr>
<tr>
<td>EP60010</td>
<td>Financing New Venture</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>EP60020</td>
</tr>
<tr>
<td>BM49002</td>
<td>Financial Analytics Lab</td>
<td>0-0-3</td>
<td>2</td>
<td>Spring</td>
<td>EP60020</td>
</tr>
<tr>
<td>EP60006</td>
<td>Management of Growth Ventures</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>EP60020</td>
</tr>
</tbody>
</table>

C. **COMPONENT- III: ONE SUBJECT FROM TABLE-III**

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EP60007</td>
<td>Techno – Entrepreneurial Leadership</td>
<td>3-0-0</td>
<td>3</td>
<td>Autumn</td>
<td>EP60020</td>
</tr>
<tr>
<td>EP60018</td>
<td>Innovation Management</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>EP60020</td>
</tr>
<tr>
<td>EP60008</td>
<td>Economics of Entrepreneurship</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>EP60020</td>
</tr>
</tbody>
</table>
Name of the Micro-Specialization: Drug Discovery

1. **School**: Chemistry & Bioscience
2. **Brief Description**: this course aims to disseminate necessary knowledge base on the use of chemical and biological principles for the development of drugs.

3. **Number of Subjects needed to earn the Micro-Specialization**: Four

4. **Credit needed to earn the Micro-Specialization**: 11 - 15 credits

5. **Structure**: Component I: Two Subjects (2-0-0/3-1-0)  
   Component II: Two Subjects (3-1-0/3-0-0)  
   Component III: One subject (3-0-0/3-1-0)

   A. **COMPONENT-I: MANDATORY REQUIREMENT**: (Any ONE FOUNDATION COURSES)

<table>
<thead>
<tr>
<th>Table I</th>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CY20103</td>
<td>Organic Chemistry-I</td>
<td>2-0-0</td>
<td>2</td>
<td>Autumn</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>BT21101</td>
<td>Biochemistry</td>
<td>3-1-0</td>
<td>4</td>
<td>Autumn</td>
<td>NA</td>
</tr>
</tbody>
</table>

   B. **COMPONENT-II ANY TWO SUBJECTS (3/4 credits) FROM TABLE-II**

<table>
<thead>
<tr>
<th>Table II</th>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CY41018</td>
<td>Structure and Function of Biomolecules</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>CY20103 or BT21101</td>
</tr>
<tr>
<td></td>
<td>CY60004</td>
<td>Biophysical Chemistry</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>CY20103 or BT21101</td>
</tr>
<tr>
<td></td>
<td>BT60007</td>
<td>Computation Structural Biology</td>
<td>3-1-0</td>
<td>4</td>
<td>Autumn</td>
<td>CY20103 or BT21101</td>
</tr>
<tr>
<td></td>
<td>BT61030</td>
<td>Protein Engineering</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>CY20103 or BT21101</td>
</tr>
<tr>
<td></td>
<td>BS60001</td>
<td>Pharmacokinetics and Pharmacogenomics</td>
<td>3-0-0</td>
<td>3</td>
<td>Autumn</td>
<td>CY20103 or BT21101</td>
</tr>
<tr>
<td></td>
<td>BS41004</td>
<td>Advances in Protein Structure &amp; Function</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>CY20103 or BT21101</td>
</tr>
<tr>
<td></td>
<td>BS41002</td>
<td>Structure Determination of Biomolecules</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>CY20103 or BT21101</td>
</tr>
</tbody>
</table>

   C. **COMPONENT-III: ONE SUBJECT FROM TABLE-III**

<table>
<thead>
<tr>
<th>Table III</th>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CY60005</td>
<td>Drug design and development</td>
<td>3-0-0</td>
<td>3</td>
<td>Autumn</td>
<td>CY20103 or BT21101</td>
</tr>
<tr>
<td></td>
<td>CY61030</td>
<td>Medicinal Chemistry</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>CY20103 or BT21101</td>
</tr>
<tr>
<td></td>
<td>BS67001</td>
<td>Project/Term Paper</td>
<td>0-0-6</td>
<td>4</td>
<td>Both</td>
<td>CY20103 or BT21101</td>
</tr>
</tbody>
</table>
Name of the Micro-Specialization: Micro Fluidics and Nano Patterning

1. Department/School/Center: Chemical Engineering/ Mechanical Engineering/ School of Nano Science & Nano Technology

2. Brief Description: This micro specialization will allow the students to understand how the nature of fluid flow changes under severely confined conditions. The specialization will focus on how the effect of different forces change/get altered in the meso scale, due to enhanced effect of surface tension, capillary forces as well as dispersion forces. The course will introduce to a student how scaling relations influence the transport properties at this length scale. Further, experimental investigation at this length scale also requires significant knowledge on micro and nano scale fabrications. The specialization thus aims at covering the essential concepts of fluidics and micro fabrication techniques, providing the students advanced expertise and knowledge in this cutting edge area of research.

3. Number of Subjects needed to earn the Micro-Specialization: Four

4. Credits needed to earn the Micro-Specialization 15-16 credits

5. Structure: Component I: One Subject (3-1-0)
   Component II: Two Subjects (3-1-0/3-0-0)
   Component III: One subject (3-1-0)

   A. COMPONENT- I: MANDATORY REQUIREMENT: (Any ONE 4 credit FOUNDATION COURSE)

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH61011</td>
<td>Adv. Fluid Mechanics</td>
<td>3-1-0</td>
<td>4</td>
<td>Autumn</td>
<td>NA</td>
</tr>
<tr>
<td>ME60011</td>
<td>Fluid Mechanics</td>
<td>3-1-0</td>
<td>4</td>
<td>Autumn</td>
<td>NA</td>
</tr>
</tbody>
</table>

   B. COMPONENT- II ANY TWO SUBJECTS (3/4 credits) FROM TABLE-II

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH62039</td>
<td>Micro Scale Transport Process</td>
<td>3-0-0</td>
<td>3</td>
<td>Autumn</td>
<td>CH61011 or ME60011</td>
</tr>
<tr>
<td>CH30012</td>
<td>Transport Phenomena</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>CH61011 or ME60011</td>
</tr>
<tr>
<td>NT70002</td>
<td>Introduction to Nano Technology</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>CH61011 or ME60011</td>
</tr>
<tr>
<td>ME60310</td>
<td>Micro Fluidics</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>CH61011 or ME60011</td>
</tr>
</tbody>
</table>

   C. COMPONENT- III: ONE SUBJECT FROM TABLE-III

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CH62052</td>
<td>Instability and patterning of thin polymer films</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>CH61011 or ME60011</td>
</tr>
</tbody>
</table>
Name of the Micro-Specialization: **PHOTONICS**

1. **Department/School/Center:** Physics
2. **Brief Description:** Photonics is a growth area, and is strongly dependent on the science underpinning the topics. The course aims to teach this underlying science, leading to an appreciation of how this science can be used in the development of devices and systems. The program has been designed to prepare students for an exciting career in industries or pursue research and development work. The graduates with this micro-specialization will find opportunities in the industries or venture out for entrepreneurship. Consistent with the Institute’s mission “dedicated to the service of the nation”, the program aims to transform students into learned men and women who are capable of fulfilling the need of the nation’s Photonics community, business and industry. A broader mission is to enable undergraduates to acquire knowledge and experiences to prepare them to pursue lifelong learning, advanced study, leadership roles in business and community.

3. **Number of Subjects needed to earn the Micro-Specialization:** 4 Subjects or 3 Subjects + 1 Projects
4. **Minimum Credits needed to earn the Micro-Specialization:** 11-13 credits
5. **Structure:**
   - **Component I:** One Subject (3-0-0)
   - **Component II:** Two Subjects (3-1-0/3-0-0)
   - **Component III:** One subject (0-0-3) or Project (0-0-3)

A. **COMPONENT-I: MANDATORY REQUIREMENT:** (3 credit FOUNDATION COURSE)

| Table-I |
|------------------|-----------------|-----------------|-----------------|-----------------|
| Sub no. | Sub Name | LTP | Credits | Offering Semester | Pre-Requisite (if any) |
| PH41004 | OPTICS | 3-0-0 | 3 | Autumn | NA |

B. **COMPONENT-II ANY TWO SUBJECTS (3/4 credits) FROM TABLE-II**

| Table-II |
|------------------|-----------------|-----------------|-----------------|-----------------|
| Sub no. | Sub Name | LTP | Credits | Offering Semester | Pre-Requisite (if any) |
| PH58038 | NON LINEAR OPTICS | 3-0-0 | 3 | Spring | PH41004 |
| PH60032 | LASER SPECTROSCOPY | 3-1-0 | 4 | Spring | PH41004 |
| PH60201 | PHYSICS OF PHOTONIC DEVICES | 3-0-0 | 3 | Autumn | PH41004 |
| PH60202 | ATOMIC, MOLECULAR AND OPTICAL PHYSICS | 3-0-0 | 3 | Autumn | PH41004 |
| PH60203 | OPTICAL FIBER TECHNOLOGY | 3-0-0 | 3 | Spring | PH41004 |
| PH60204 | PHYSICS AND TECHNOLOGY OF LASERS | 3-0-0 | 3 | Spring | PH41004 |
| PH60408 | BIOPHOTONICS | 3-0-0 | 3 | Autumn | PH41004 |
| PH60037 | OPTO-ELECTRONIC MATERIALS AND DEVICES | 3-1-0 | 4 | Autumn | PH41004 |

C. **COMPONENT-III: One SUBJECT / PROJECT FROM TABLE-III**

| Table-III |
|------------------|-----------------|-----------------|-----------------|-----------------|
| Sub no. | Sub Name | LTP | Credits | Offering Semester | Pre-Requisite (if any) |
| PH59008 | Laboratory on Modern Optics | 0-0-3 | 2 | Spring | PH41004 |
| PH67002 | Project | 0-0-3 | 2 | Spring | NA |
PH59008: Laboratory on Modern Optics (0-0-3; 2 credits)

Laboratory- Experiments:

1. GaAlAs Diode laser
   Characteristics of current threshold, temperature behaviour and beam geometries of a visible
   diode laser. Investigate modulation behavior.
2. Introduction to Optical Fibers
   Introduction to splicing and cleaving fibers. Efficient launching of light into a single mode fiber,
   and measurement of splice losses.
3. Fiber Interferometry
   Employment of Mach-Zehnder interferometer as a sensitive temperature sensor.
4. Fiber Optic Communications
   The investigation of the properties of optical fibers that are relevant to long-distance
   communications.
5. Birefringent Fiber Experiment
   Analysis of the temperature response of the output of a hi-bi fiber in order to locate the fiber axes.
6. Acousto-optic Modulator
   Alignment and investigation RF-strained crystal to produce variable diffraction efficiencies.
   Characterization in terms of beam-size and modulation limit.
7. Erbium –Doped Fiber Amplifier
   The study of noise and gain characteristics of Erbium –Doped Fiber Amplifier.
8. Fourier Optics Experiment
   Alignment of 4F optical system. Use of this system as a spatial filter to remove noise from a
   signal.
9. Holographic Interferometry
   Use of real time Holographic Interferometry to perform simple strain measurements.
10. Laser Mode Structures and resonator Optics
    Alignment of He-Ne laser cavity. Characterization of transverse modes Use of a confocal Febry-
    perot interferometer to detect the longitudinal modes.
11. Optical Design
    Examine the some of the practical aspects of optical design, and to compare the experimental
    results with the predictions of a ray tracing program.
12. Phase Sensitive Detection
    Introduction to the PSD as a device for recovering signal from noise. Use in improving the
    convenience and accuracy of optical measurements.
13. Twyman-Green interferometer
    Use of a computer package to analyze aberrations in optical components. Compare theoretical
    behavior with interferometrically – derived experimental patterns.
14. Q-switched Diode-pumped Nd:Yag Laser
    Alignment of laser cavity containing acoust0-optic Q-switch. Characterization of Q-switched laser.
15. Fiber Micro-bending
    Investigation of the effect of periodic small bends on fiber transmission. Use of the effect as an
    environmental sensor.
16. Optical Network Analysis
    Investigation of the losses in the optical network using optical time domain reflectometry.
17. The Atomic force Microscope
   Use of an AFM to investigate the surface tomography of a number of optical and optoelectronic components including diffractive optical elements.

18. Laser Diode coherence properties
   Alignment and use of a Michelson-Morley interferometer with a spectrally modulated source to characterize the coherence length of a semiconductor diode laser.

19. White-Light Fourier Transform Spectrometry
   This experiment shows how the common technique of Fourier Transform spectrometry can be used to obtain information about the optical phase and absorption properties of a sample.

20. Principles of optical wave guiding
   Investigations of principles and design rules of optical wave guides.

21. Thin-Film Optical Design
   Design and analysis of thin film optical coatings.

22. Computer aided Optical Design
   Introduction to optical design using the code V-package

23. Surface relief gratings
   Study of surface relief gratings of varying periodicity on polymers.

24. Optical Tweezers
   Introduction to technique with which small particles can be moved using a tightly focused laser beam.

25. Fiber Bragg Grating
   The basic principles of Fiber Bragg Grating for sensors

26. Computer controlled of scientific instruments
   The study of Computer controlled of scientific instruments using Labview.

27. Principles of Lasers
   Introductions and characteristics of Er-doped fiber laser

28. Three dimensional imaging with diffractive optics
   Demonstrate and validate three dimensional imaging using a Lens and a diffractive optical elements.

29. ZEMAX-based computer aided optical design
   Introduction to optical design using the ZEMAX

30. WDM components, WDM systems and Bragg Grating
   Introduction of areas relevant to WDM component, DWDM systems 1310/1550nm WDM systems & Bragg Gratings.
Name of the Micro-Specialization: **Industrial Safety Engineering**

1. **Dept/School/Center:** Industrial & Systems Engineering
2. **Brief Description:**

Today industries and organizations, particularly in India, are facing stiff challenges in meeting the safety and health requirements of the stakeholders and there are reasons for it. These are, for example, (i) abysmally poor preparedness, (ii) absence of trained personnel, (iii) lack of scientific research, and (iv) weak industry academic institution partnership. Although attempts have been made to improve safety at the industry and organization levels, there is no visible improvement at the national level. For example, in Indian manufacturing sector, the fatal accident rate is close to 100 fatalities per million employees against the range from 10 to 30 in advanced countries. In mines, the statistic is abysmally poor with more than 200 fatalities per year. This increasing trend of fatal and serious accidents in industries, causing huge loss of property and people, calls for immediate attention towards improving overall safety scenario across industries in India. In line with these requirements, Ministry of Labour and Employment (Government of India) has stated the following in the national safety policy:

(i) Continuous reduction in the incidence of the work related injuries, fatalities, diseases, disasters, and loss of national assets.
(ii) Improved coverage of work related injuries, fatalities and diseases and provide a more comprehensive data base for facilitating better performance and monitoring.
(iii) Continuous enhancement of community awareness regarding safety, health and environment at workplace related areas.
(iv) Continually increasing community expectation of workplace health and safety standards.
(v) Improving safety, health and environment at workplace by creation of “green jobs” contributing to sustainable development.

Upon assessing the present status on safety engineering in relation to the objectives of the national policy, it is observed that there is a large gap which needs to be bridged. Salient loopholes against each of the above objectives are given below.

- Objective-1: Scattered work in progress & lack of any knowledge inference engine
- Objective-2: No national database, at present
- Objective-3: Lack of safety culture - requires continuous effort
- Objective-4: Lack of safety knowledge among people
- Objective-5: Possible, only if the earlier objectives are realised

IIT Kharagpur, being an internationally recognized technical institution of India having a number of experts with proven knowledge, expertise, and research experiences in industrial safety engineering, systems safety design and control, and risk management, should take a lead in educating and producing fresh engineering graduates capable in design, installation, operation, maintenance, management, and improvement of safety of products, processes, and work systems across industries in India and the globe.

### 2.1 Relevance of the courses offered

Industrial work systems are an integrated whole of people, material, information, equipment, and energy for production of goods and services, the key ingredients of a nation's growth. Design of integrated worksystem is a critical but important component that every engineer must know. When people are integrated into a system, their safety is of utmost important. As industries vary from mining, chemical,
construction, etc. to IT and services on one hand and from manual to mechanised on the other, the hazards involved are of different kinds. From energy perspective, these can be chemical, mechanical and electrical to potential energy. So, people at work are exposed to different kinds of hazards and whose quantity (risk) varies between industries and also within industrial activities. To protect people at work, several standards and guidelines have been framed by regulatory and government agencies (e.g., OSHAS 18001) which need to be implemented and followed by every organization. In addition, organization must develop, implement and monitor effective safety management system for surveillance, prevention of accidents and mitigation of impacts. Upon undergoing the subject “Introduction to industrial safety” (Table I), the students will learn the different facets and aspects of industrial safety, the stakeholders with roles and responsibilities, standards and guidelines, safety management principles, and hazard control hierarchy. In addition, the four dimensions of safety namely engineering safety, organizational safety, behavioural safety, and laws and enforcements will be taught. It’s the basic course and every students doing thin specialization in ISE must take this. The different dimensions of this basic course will be discussed under eight electives (see Table II) and depending on the choice a student can take 3 such electives. The need for these electives is given below:

The first step to ensure safety to people at work is engineering out hazards from work system. The key concept here is “safety by design”. The subject “Engineering systems safety design and control” (IM60045) will cover this. Engineering systems safety evolves around socio-technical system theory keeping technology at the core and aligning hazard control mechanisms around the core. It also integrates quality management principles with system safety tools. Upon completion of the course, the students will be equipped with concepts of engineering systems safety, dimensions of engineering systems safety, safety design and analysis mathematics, design for engineering systems safety and control for safety, and integrating safety with other operational goals such as quality.

To engineer out hazards, the students must know what is a hazard, how to quantify its potential, how do these hazards occur, etc. Other way, some critical questions that must be answered by every safety manager are: (i) What can go wrong?, (ii) How can it go wrong?, (iii) How likely is its occurrence?, (iv) What would be the consequences?, (v) What is the risk level?, (vi) How to prioritize risk?, (vii) What is the uncertainty in risk values?, and (viii) Where to put resources for improvement? Two electives are proposed in this regard; one from general risk assessment point of view (RE60011 – probabilistic risk assessment) and another one from chemical industry point of view (CH62038: Hazard analysis and risk management in chemical industry).

No matter how good a system is from engineering safety point of view, it is obvious that the system components will deteriorate over time. Maintenance of system components is a must. The subject “Fault diagnosis and predictive maintenance” (RE60018) will cover this. The reliability and safety issues of maintained systems will be explored in light of maintenance policy selection such as preventive, predictive and corrective maintenance. Another important aspect to be considered is maintainability design. Upon going through the subject the students also will learn how to measure and monitor the health of machines for maintenance related decision making to improve both safety and reliability.

Another two important issues of industrial safety are fire safety, and rescue and disaster management. There are a large number of fire sources in every industrial organization. Statistics shows that one of the disastrous events is fire which spread across all industries around the globe. Students must be prepared to design out fire from industrial activities and in case it occurs, its mitigation as well as emergency preparedness is a must. The subject “Fire safety engineering” will cover all these. The subject “Rescue and disaster management” (MI50003) covers emergency prepared for disastrous events like fire,
explosion, inundation etc. It also covers pre- and post-disaster emergency planning for preparedness and evacuation.

Every industry spends substantially to improve safety. But the world statistics says that much more is needed to do. The key question is there that with such a large number of accidents occurring every year across the industries worldwide, are we learning from our mistakes? Similarly, are we using data and information inter alia generated from different functions of an organization? The answer is “no”. This is because of lack of knowledge of data analytics. The subject “safety analytics” will cover this.

No knowledge is complete unless it is transferred and implemented to those for which it is developed. The students after going through the core and elective subjects must take a real-life-problem solving project, or a design project, or a term paper. This is highlighted in Table III.

3. **Number of Subjects needed to earn the Micro-Specialization**: 3 Subject + 1 Project/Design/ Term Paper

4. **Credits needed to earn the Micro-Specialization 12-14 credits**

5. **Structure**: Component I: One Subject (2-0-0)
   Component II: Two Subjects (3-1-0/3-0-0)
   Component III: Project/Design/Term Paper (0-0-6)

A. **COMPONENT- I: MANDATORY REQUIREMENT**: (2 credit FOUNDATION COURSE)

   **TABLE-I**

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IM40001</td>
<td>Introduction to industrial safety</td>
<td>2-0-0</td>
<td>2</td>
<td>Both</td>
<td>NA</td>
</tr>
</tbody>
</table>

B. **COMPONENT- II ANY TWO SUBJECTS (3/4 credits) FROM TABLE-II**

   **TABLE-II**

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IM60045</td>
<td>Engineering Systems Safety Design And Control</td>
<td>3-1-0</td>
<td>4</td>
<td>Autumn</td>
<td>IM40001</td>
</tr>
<tr>
<td>IM61020</td>
<td>Safety Analytics</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>IM40001</td>
</tr>
<tr>
<td>RE60018</td>
<td>Fault Diagnosis And Predictive Maintenance</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>IM40001</td>
</tr>
<tr>
<td>RE60011</td>
<td>Probabilistic Risk Assessment</td>
<td>3-1-0</td>
<td>4</td>
<td>Autumn</td>
<td>IM40001</td>
</tr>
<tr>
<td>CH62038</td>
<td>Hazard Analysis And Risk Management In Chemical Industry</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>IM40001</td>
</tr>
<tr>
<td>MI60058</td>
<td>Fire Safety Engineering</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>IM40001</td>
</tr>
<tr>
<td>MI50003</td>
<td>Rescue And Disaster Management</td>
<td>3-0-0</td>
<td>3</td>
<td>Autumn</td>
<td>IM40001</td>
</tr>
<tr>
<td>MI45008</td>
<td>Safety Engineering</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>IM40001</td>
</tr>
</tbody>
</table>

C. **COMPONENT- III: PROJECT/DESIGN/TERM PAPER (4 credits)**

   **TABLE-III**

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IM67003</td>
<td>Project/design/term paper</td>
<td>0-0-6</td>
<td>4</td>
<td>Both</td>
<td>IM40001</td>
</tr>
</tbody>
</table>
Name of the Micro-Specialization: **Intelligent Learning System Design**

1. **School/Centre:** Centre for Educational Technology

2. **Brief Description:**
   To cope up with growing needs and cost, education sector is undergoing a rapid change with the adoption of Information and Communication Technology. Smart Education Technology applies and integrates intelligent techniques towards the goal of imparting personalized and engaging education. As Intelligent Tutoring System (ITS) is a first step towards individualized education, it has been kept as a foundational subject in this specialization. Notion of stand-alone educational systems has been replaced by web-based education. To make smart web-based education systems, semantics of educational entities on the web is needed to be modelled in the form of Semantic Web. This specialization will provide an introduction to semantic web technologies and their relations to educational technology and digital library. Textual discourse plays important role in instruction delivery, assessment and social feedback. Language processing for eLearning deals with smart techniques towards automation of different educational processes through analysis of textual discourses. Serious games have been proved to be very effective in engaged and inquiry based learning. Intelligent game design provides foundations on application of Artificial Intelligent techniques in designing intelligent games.

Specific objectives of this specialization are as follows:
- To analyze different modules involved in design of ITS
- To provide in depth analysis of textual discourses in eLearning through language processing techniques
- To provide foundation on semantic web technologies, related programming paradigms and their relevance to smart educational systems.
- To provide pedagogic implications of game-based learning paradigm.
- To apply AI algorithms in designing serious games.
- To implement project ideas integrating smart techniques like language processing, semantic web and intelligent game design.

3. **Number of subjects needed to earn the Thin Specialization:** 3 Subjects + 1 Project

4. **Number of credits needed to earn the Thin Specialization:** 12-13

5. **Structure:**
   - **Component I:** One Subject (2-0-0)
   - **Component II:** Two Subjects (3-1-0/3-0-0)
   - **Component III:** One Project (0-0-6)

A. **COMPONENT- I: MANDATORY REQUIREMENT:** (2 credit FOUNDATION COURSE)

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ET30002</td>
<td>Intelligent Tutoring system</td>
<td>2-0-0</td>
<td>2</td>
<td>Spring</td>
<td>NA</td>
</tr>
</tbody>
</table>
B. COMPONENT- II ANY TWO SUBJECTS (3/4 credits) FROM TABLE-II

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ET61002</td>
<td>Language Processing for e-learning</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>ET30002</td>
</tr>
<tr>
<td>ET60019</td>
<td>Knowledge Modelling and Semantic Technology</td>
<td>3-0-0</td>
<td>3</td>
<td>Autumn</td>
<td>ET30002</td>
</tr>
<tr>
<td>ET60021</td>
<td>Intelligent Game Design</td>
<td>3-0-0</td>
<td>3</td>
<td>Autumn</td>
<td>ET30002</td>
</tr>
</tbody>
</table>

C. COMPONENT- III: PROJECT (4 credits)

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ET67003</td>
<td>Learning System Design Project</td>
<td>0-0-6</td>
<td>4</td>
<td>Autumn</td>
<td>ET30002</td>
</tr>
</tbody>
</table>

ET30002: Intelligent Tutoring System (2-0-0; 2)

Course Description

Intelligent Tutoring System (ITS) is focused towards providing individualized learning experience to the students through application of artificial intelligence techniques. This course covers different topics that relate to student and teacher modelling, development of adaptive systems using core AI techniques like knowledge representation, Bayesian belief networks, cognitive modelling.

Course Objective

Upon completion of the course the students will be able to

- identify and describe different components in ITS architecture
- identify parameters and strategies to evaluate ITSs
- describe and compare different approaches to student modeling
- describe and compare different approaches to teaching knowledge modeling
- explain and compare different cognitive modeling approaches towards ITS development
- classify different types of ITSs
- analyze the features and working principles of different types of ITSs

Course Content

- **Introduction (4):** Foundation of the field, computers in education, ITS architecture and design principles, evaluation.
- **Knowledge Representation (5):** Student model (modeling skill, procedure, affect, complex problems, bug library, planning and plan recognition), Features of teaching knowledge, learning theory based teaching model (Socratic learning theory, cognitive learning theory, constructivist theory, situated learning), animated pedagogical agent
- **Cognitive Modelling and ITS (9):** ACT-R and Cognitive tutor, Constraint-based modelling, Knowledge tracing, Example-tracing
- **Analysis of ITS systems (8):** Cognitive Tutor (Carnegie learning), Model tracing tutor (ANDES), Constraint-based Tutor (SQL-Tutor), Inquiry-based Tutor (Rashi, Crystal Island), Dialog-based Tutor (AutoTutor, Why2-Atlas)
Books

1. Building Intelligent Interactive Tutors: Student-centered strategies for revolutionizing e-learning, Beverly Park Woolf
2. Student Modeling: The Key to Individualized Knowledge-Based Instruction, Jim E. Greer and Gordon I. McCalla, Springer

References

3. (1990), 42(1), 7-49
8. Fifteen years of constraint-based tutors: what we have achieved and where we are going, User Modelling and User-Adapted Interaction, 2012, 22(1-2), 39-72,

ET61002: Language Processing for e-learning(3-1-0; 4)

Course Description

Text is an important media for delivering education. Thus innovative use of text processing techniques has drawn interest of many researchers in text processing domain in developing effective and interesting e-learning applications. The course will explore text processing techniques like syntactic and semantic analysis, entity extraction, discourse processing, question answering, computational affect analysis etc. and their applications to e-learning domains. As e-learning has got enormous research and business opportunities, aspiring entrepreneurs and researchers will get acquainted with recent challenges and advances in developing text processing-based e-learning applications.

Course Objective

Upon completion of the course the students will be able to

a) Identify different text processing techniques for developing an e-learning applications
b) Design e-learning systems through text analysis

c) Experiment with benchmark datasets available for different e-learning tasks

d) Assemble different text processing techniques to develop an e-learning application

e) Analyze architectures of different text-based e-learning applications

Course Content

- **Introduction (3):** e-learning, text processing relevant to e-learning
- **Text Processing Fundamentals (4):** Morphological analysis, POS tagging, parsing, lexical resources, ontology, machine learning tools.
- **Computer Assisted Language Learning (CALL) (5):** Categorization, Pedagogical perspective, Vocabulary learning, Grammar learning and error correction, Semantic analysis and discourse processing for intelligent CALL, second language acquisition.
- **Readability Level Assessment (5):** mental lexicon, cognitive models of text comprehension, visual word recognition, Language dependence of readability measures, Lexical and grammatical feature based readability assessment, Statistical approaches towards readability assessment, text cohesion, Coh-Metrix.
- **Text Adaptation (5):** Encyclopedic annotations of text, Lexical and morphology-based simplification, paraphrasing, text entailment, syntactic and discourse level simplification
- **Automatic Question Generation (5):** Pedagogy driven question categorization, vocabulary assessment, MCQ generation, factual question generation, Evaluation metrics.
- **Automatic essay/answer grading (5):** Writing dimensions and evaluation features, Lexical, syntactic and discourse processing for automatic grading, Research prototypes: e-Rater, C-Rater, BETSY, reliability and validity, norming and scaling, Bayesian analysis.
- **E-learning and Web 2.0 (4):** Educational metadata standards, ontology and semantic web, Pedagogic and topical metadata annotation of learning materials, ontology learning, Issues in collaborative learning
- **Dialogue-based Tutoring (4):** Natural language intelligent tutoring system, mixed initiative dialogues, mixed mode dialogues, AutoTutor, ITSPoke, BEETLE, CIRCSIM-Tutor, learner affect analysis.

Books

1. Speech and Language Processing, Daniel Jurafsky, James H. Martin
2. Handbook of Natural Language Processing, Nitin Indurkhya, Fred J. Damerau
4. Automated Essay Scoring: A cross disciplinary perspective, MD Shermis, J Burstein

References

1. Educational Natural Language Processing, Tutorial at COLING 2008 and AIED 2009, Delphine Bernhard
2. Opportunities for Natural Language Processing Research in Education, Computational Linguistics and Intelligent Text Processing (2009), pp. 6-27, Jill Burstein


13. A monolingual tree-based translation model for sentence simplification, Zhemin Zhu, Delphine Bernhard, and Iryna Gurevych, COLING’10

**ET60019: Knowledge Modelling and Semantic Technologies (3-0-0; 3)**

**Course Description**

Knowledge modelling is a process of formalizing the knowledge of a domain through formal knowledge representation frameworks. Apart from many other knowledge driven systems, knowledge modelling through ontology has helped in realization of embedding semantics to current hypertext-based web. The semantic web vision has shown enormous promise to revolutionize current World Wide Web dramatically. This envisionment rides on the idea of embedding semantics of web data so that the contents become machine processible. Driving technologies in semantic web vision include explicit metadata, ontologies, formal logic, inferencing and intelligent agents. Huge potential and advantages of semantic web have sparked significant interest in industry and government. Semantic web has shown great promise in eLearning domain.

This course aims at developing foundations in semantic web technology addressing web scale semantic knowledge modelling techniques and related programming paradigms and applications.

**Course Objective**

Upon completion of the course the students will be able to
Course Content

Semantic Web Concepts

- **Introduction to Knowledge Modelling (3):** Knowledge-based systems, Knowledge representation formalisms, fundamentals of reasoning.
- **Semantic Web Vision (3):** Current web, current web to semantic web, semantic web technologies, standardization, semantic web layer cake
- **Foundations of Semantic Web (8):** Extensible Markup Language, Resource Description Framework (RDF), RDF Schema (RDFS), Semantics for RDF and RDFS, Inference system for RDF and RDFS, Querying RDF
- **Ontology for Semantic Web (10):** Semantic modelling through ontology, evolution of ontology languages, Web Ontology Language (OWL), OWL semantics with Description Logic, OWL reasoning, ontology engineering.
- **Sources of Semantic Data (3):** Friend of a Friend (FOAF) ontology, Simple Knowledge Organization System (SKOS), Dublin Core (DC), Linked Data Cloud

Semantic Web Programming

- **Programming with RDF (5):** RDF serialization, RDF querying with SPARQL, RDF inference with Jena and/or sesame, programming with DBpedia
- **Ontology engineering (5):** Ontology development with Protégé, Ontology visualization, OWL API

Semantic Web Applications

- **Applications (5):** Semantic web services, Social semantic web, Semantic search, e-learning, digital library

Books

1. Semantic Web for the Working Ontologist, Dean Allemang and James Hendler, Morgan Kaufmann
2. Programming the Semantic Web, Toby Segaran, Colin Evans and Jamie Taylor, O’Reilly
3. A Semantic Web Primer, Grigoris Antoniou and Frank van Harmelen, MIT Press

References


**ET60021: Intelligent Game Design(3-0-0; 3)**

**Course Description**

Game-based instruction is a very effective pedagogic approach in increasing learner engagement motivation. This course provides a foundation on application of artificial intelligence techniques in development of intelligent games. Topics covered in this course are oriented towards game design primitives like movement, path-finding, waypoint tactics, strategic moves. Interactive storytelling is an essential technique in designing immersive games and is very effective in educational games. Topics covered in this part are narratology, computational storytelling, interaction design and narrative-based educational games.

**Course Objective**

Upon completion of the course the students will be able to

- identify the role of serious games in education
- explain rational and advantages of game-based pedagogy and the role game AI in this
- analyse and apply AI algorithms in intelligent game design primitives like movement, path-finding, decision making, tactical analysis
- explain and analyse algorithms relevant to game execution environment
- explain design choices relevant to graphics level of detail
- explain and analyse algorithms for sense management
- describe the roles of story and plot in interactive storytelling
- explain, analyze and compare computational models of storytelling
- analyze narrative-based educational games (e.g., Crystal Island)

**Course Content**

- **Introduction (3):** Serious games in education, game-based learning pedagogy, issues in designing intelligent games, game AI
- **Basic Techniques (18):** Movement (Kinematic movement algorithms, Steering behaviors, Predicting physics, Jumping, Co-ordinated movement, Motor control, ), Path-finding (Path-finding graph, Dijkstra algorithm, A* algorithm, Hierarchical path-finding, Continuous time path-finding, Movement planning), Decision making (Decision tree, state machines, fuzzy decision making, Goal oriented behaviour, Blackboard architectures, Scripting, Action execution), Tactical and strategic AI (Waypoint tactics, Tactical analyses, Tactical path-finding, coordinated action),
Learning (learning basics, action prediction), Board games (Mini-maxing, Transposition tables, Memory-enhanced test algorithms, Turn-based strategy games)

- **Supporting Technologies (8):** Execution management (Scheduling, Anytime algorithms, level of details, ), World interfacing (Event managers, Polling stations, Sense Management), Tools and content creation (Knowledge for waypoint and path-finding, Knowledge for movement, Knowledge for decision making)

- **Interactive Storytelling Games (10):** Story, narratology, Textual and cinematic discourse, Interaction, Computational storytelling, World and character modeling, Narrative-based educational games

**Books**

1. Artificial Intelligence for Games, Ian Millington, Morgan Kaufmann
2. Programming Game AI by Example, Mat Buckland, Wordware Publishing Inc.
3. Al for Game Developers, David Bourg and Glenn Seemann, O’Reilly

**References**

ET67003: Learning System Design Projects (0-0-6; 4)

List of projects:

Project proposals centered around the following themes will be sought of student groups and assigned subjected to approval from course instructor.

- Design of cognitive tutor for teaching algebra
- Design of adaptive courseware generation based on different student modeling parameters (learning style, learner category etc.)
- Automatic generation of assessment items from text documents.
- Design of automated short answer grading system
- Design of ontology-based MCQ generation system
- Design of semantic search functionality using linked data cloud.
- Design of semantic web technology based digital library
- Strategic educational games for teaching mathematics
- Interactive storytelling games for teaching conceptual and informative subjects.

The design project workflow is as follows:
1. Formation of group
2. Submission of informal proposal
3. Initial review and approval by course instructors
4. A formal project proposal
5. Final Technical report
6. Final demonstration and presentation
Name of the Micro-Specialization: Intellectual Property Rights

1. Department/School/Center: Rajiv Gandhi School of Intellectual Property Law

2. Brief Description: There is a greater need to protect intellectual property rights in today’s often challenging dynamic environment. Solutions need to be contextual with an international dimension. The art of solving client problems in this area requires practical understanding into the aspect of IPR. The objective of the micro-specialization course is to equip
   ➢ Practical skills into IP search, analysis and drafting
   ➢ Practical understanding of IP licensing
   ➢ Understanding IP portfolio and strategy to devise effective protection mechanisms

   The student shall get an opportunity to engage in projects relevant to industry and practice in this area (practical drafting/search and analysis of IP in relevant domain area).

3. Number of Subjects needed to earn the Micro-Specialization: Four

4. Credits needed to earn the Micro-Specialization: 14 credits

5. Structure: Component I: One Subject (2-0-1)
   Component II: Two Subjects (3-1-0)
   Component III: One subject (2-1-0)

A. COMPONENT-I: MANDATORY REQUIREMENT: (3 credit FOUNDATION COURSE) from Table - I

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IP60133</td>
<td>General Principles of Law for Engineers</td>
<td>2-0-1</td>
<td>3</td>
<td>Autumn</td>
<td>NA</td>
</tr>
</tbody>
</table>

B. COMPONENT- II ANY TWO SUBJECTS (4 credits) FROM TABLE-II

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IP60102</td>
<td>Copyright</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>IP60133</td>
</tr>
<tr>
<td>IP60119</td>
<td>Law Of Patent-I</td>
<td>3-1-0</td>
<td>4</td>
<td>Autumn</td>
<td>IP60133</td>
</tr>
<tr>
<td>IP60123</td>
<td>Trademark And Design</td>
<td>3-1-0</td>
<td>4</td>
<td>Autumn</td>
<td>IP60133</td>
</tr>
<tr>
<td>IP60129</td>
<td>IP Management And Technology Transfer</td>
<td>3-1-0</td>
<td>4</td>
<td>Autumn</td>
<td>IP60133</td>
</tr>
</tbody>
</table>

C. COMPONENT- III: ONE SUBJECT FROM TABLE-III

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>IP60174</td>
<td>Intellectual Property and Competition law</td>
<td>2-1-0</td>
<td>3</td>
<td>Spring</td>
<td>IP60133</td>
</tr>
<tr>
<td>IP60158</td>
<td>Competition law</td>
<td>2-1-0</td>
<td>3</td>
<td></td>
<td>IP60133</td>
</tr>
<tr>
<td>IP60164</td>
<td>Music and entertainment Industry law</td>
<td>2-1-0</td>
<td>3</td>
<td></td>
<td>IP60133</td>
</tr>
</tbody>
</table>
Name of the Micro-Specialization: **Optimization Theory and Applications**

1. **Department/School/Center:** Mathematics

2. **Brief Description:** Theory of optimization plays an important role in Engineering management and mathematics and is closely related to several other field in the decision science. The objective of this micro specialization framework is to provide a solid foundation of various optimization techniques and their applications.

3. **Number of Subjects needed to earn the Micro-Specialization:** Four

4. **Credits needed to earn the Micro-Specialization** 12-13 credits

5. **Structure:**
   - **Component I:** Two Subjects
   - **Component II:** One Subject (3-1-0)
   - **Component III:** One subject (3-1-0/3-0-0)

   **A. COMPONENT- I: MANDATORY REQUIREMENT: (TWO FOUNDATION COURSES )**

   **Table-I**
<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA30014</td>
<td>Operations Research</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>NA</td>
</tr>
<tr>
<td>MA39014</td>
<td>Operations Research Lab</td>
<td>0-0-3</td>
<td>2</td>
<td>Spring</td>
<td>MA30014</td>
</tr>
</tbody>
</table>

   **B. COMPONENT- II ANY ONE SUBJECTS (4 credits) FROM TABLE-II**

   **Table-II**
<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA41010</td>
<td>Non linear Programming</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>MA30014 and MA39014</td>
</tr>
<tr>
<td>MA41109</td>
<td>Optimization by Vector Space Method</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>MA30014 and MA39014</td>
</tr>
</tbody>
</table>

   **C. COMPONENT- III: ONE SUBJECT FROM TABLE-III**

   **Table-III**
<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MA61061</td>
<td>Optimization Methods in Finance</td>
<td>3-0-0</td>
<td>3</td>
<td>Autumn</td>
<td>MA30014 and MA39014</td>
</tr>
<tr>
<td>MA60044</td>
<td>Multi Objective Programming</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>MA30014 and MA39014</td>
</tr>
<tr>
<td>MA61053</td>
<td>Numerical Optimization</td>
<td>3-1-0</td>
<td>4</td>
<td>Autumn</td>
<td>MA30014 and MA39014</td>
</tr>
</tbody>
</table>
Name of the Micro-Specialization: Rural Innovation and Management

1. Department/School/Center: Rural Development Centre

2. Brief Description: Improving the quality of life and liveliness in rural India is of significant importance as 64% Indians live in rural areas. Accordingly, the primary focus of the Ministry of Rural Development (India) is on the “sustainable and inclusive growth of rural India through a multipronged strategy for eradication of poverty by increasing livelihoods opportunities, providing social safety net and developing infrastructure for growth”. IIT Kharagpur, being within the rural belt in West Bengal has its well established Rural Development Centre, serving for the purpose since 1975. Today’s young generation is keen to contribute to the development of rural people. Collectively the contribution could be in providing food, safety, security and health infrastructure and effectively managing them. This is possible only when effective knowledge and skills are imparted to the meritorious youth who are motivated and committed to the development of rural sectors in India. In light of this perspective, the Rural Development Centre of IIT Kharagpur aims to offer a “Micro-Specialization in Rural Innovation and Management” (RIM) for the UG students from all engineering and science disciplines.

We all know that the people residing in the rural areas are lagging behind their urban counterparts in respect of certain key indicators of development such as poverty ratio, literacy rate, nutritional status, housing situation and access to basic amenities. Several developmental schemes are being taken up during various planned phases in our country. However, the rate of improvement is still not to the mark since the first 5-year Plan was introduced. The students will require to know why do so happen and how to overcome these. Nevertheless, it is pertinent to understand (i) the issues related to rural development such as poverty, equity, health, education, infrastructure, social barriers, safety and security, (ii) strategies and policies of rural development, and (iii) management and implementation approaches. All these things among others will be taught in the subject named “Fundamentals of Rural Innovation and Management” (see Table I). It’s the basic course giving an idea of Innovative Actions of Rural Development and every students doing micro specialization in RIM must take this. The different dimensions of this basic course will be discussed under six electives in two groups like Technology component and Management component (see Table II) and depending on the choice a student can take one such electives from each group. The need for these electives is given below:

The students must understand the main differences between rural and urban communities as this is important for understanding the distinguishing characteristics of the rural life. As such in the rural development context no single description or analysis is applicable throughout the country – there are variations between regions, sub-regions, and also between religious, castes and various ethnic groups. Such variations due to the extent or degree of differential responses explain the diversity as well as the unity that characterises Indian rural society. In line with this, the issues related to rural economics and marketing, and rural infrastructure development and management are extremely important. Promoting sustainable and inclusive rural development requires deeper understanding of the factors that constrain or promote rural development and addressing them through appropriate policies and institutions. Peculiarities of rural development lead to imperfections in input and output markets resulting in distortions to efficient functioning of market mechanisms and hence social welfare. In addition, lack of capabilities and adequate
access to markets limit inclusiveness of the development process. Accordingly, two more electives namely “Economics of Rural Sectors” and “Rural Infrastructure Development and Management” are introduced. In addition, one more subject “Foundation of Entrepreneurship” has been included in the course to provide basic knowledge on rural enterprise development and employment generation in rural sector. These subjects are grouped as Elective subjects under management subcomponent. (see Table II).

Rural economy is primarily dependent on agricultural products. The pertinent issues are agri-land utilization, enhanced crop production, storage and distribution in addition to farm supplies, agro processing, agricultural marketing, and agricultural finance. In the current development paradigm, adequate knowledge of issues relating to structural adjustment of agriculture and rural industries, generation of agricultural surplus, enhancement of productivity, development of markets, technological and institutional innovations, international trade, natural resource conservation and management, etc. are very important. Innovation and technological approach towards any developmental activity includes the three major interrelated components like, development of innovative and appropriate technologies, proper transfer and successful adoption of those. Since a technological innovation is not applicable or transferable to all situations, it needs to be made an appropriate one that is suited to the economic and social conditions and level of civilization of a given population in a specific zone or area. On the other hand, follow of proper technique for transferring a technological innovation leads to a successful and effective adoption of the same. Three electives namely “Transfer and Adoption of Rural Technology” and “Food Processing and Agri-value Chain” and “Alternative Energy sources” are introduced under Technology subcomponent of electives (see Table II).

No knowledge is complete unless it is transferred and implemented to those for which it is developed. The students after going through the core and elective subjects must take a real-life-problem solving project, or a design project, or a term paper. This is highlighted in Table III.

3. **Number of Subjects needed to earn the Micro-Specialization:** Four

4. **Credits needed to earn the Micro-Specialization:** 13 - 14 credits

5. **Structure:**
   - **Component I:** One Subject
   - **Component II:** Two Subjects (3-0-0/3-1-0)
   - **Component III:** One Subject

**A. COMPONENT- I: MANDATORY REQUIREMENT: (ONE FOUNDATION COURSE )**

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RD30005</td>
<td>Fundamentals of Rural Innovation and Management</td>
<td>3-0-0</td>
<td>3</td>
<td>Both</td>
<td>NA</td>
</tr>
</tbody>
</table>
B. COMPONENT- II ANY TWO SUBJECTS (3/4 credits) FROM TABLE-II (One each from 2 Elective groups)

<table>
<thead>
<tr>
<th>Sub No.</th>
<th>Name</th>
<th>L-T-P</th>
<th>Credit</th>
<th>Offering Semester</th>
<th>Pre-requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RD30007</td>
<td>Transfer and Adoption of Rural Technology</td>
<td>3-0-0</td>
<td>3</td>
<td>Both</td>
<td>RD30005</td>
</tr>
<tr>
<td>RD30006</td>
<td>Food Processing and Agri-value Chain</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>RD30005</td>
</tr>
<tr>
<td>RD30009</td>
<td>Economics of Rural sectors</td>
<td>3-0-0</td>
<td>3</td>
<td>Autumn</td>
<td>RD30005</td>
</tr>
</tbody>
</table>

Elective II (Management component)

<table>
<thead>
<tr>
<th>Sub No.</th>
<th>Name</th>
<th>L-T-P</th>
<th>Credit</th>
<th>Offering Semester</th>
<th>Pre-requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AG60002</td>
<td>Alternative energy sources</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>RD30005</td>
</tr>
<tr>
<td>RD30011</td>
<td>Rural Infrastructure Development and Management</td>
<td>3-0-0</td>
<td>3</td>
<td>Both</td>
<td>RD30005</td>
</tr>
<tr>
<td>EP60020</td>
<td>Foundations of Entrepreneurship</td>
<td>3-0-0</td>
<td>3</td>
<td>Both</td>
<td>RD30005</td>
</tr>
</tbody>
</table>

C. COMPONENT- III: ONE SUBJECT FROM TABLE-III

<table>
<thead>
<tr>
<th>Sub No.</th>
<th>Name</th>
<th>L-T-P</th>
<th>Credit</th>
<th>Offering Semester</th>
<th>Pre-requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RD67001</td>
<td>Project/design/term paper</td>
<td>0-0-0</td>
<td>4</td>
<td>Both</td>
<td>Subjects of Table I and Table II</td>
</tr>
</tbody>
</table>
Name of the Micro-Specialization: Simulation Methods and Applications

1. Department/School/Center: Centre For Theoretical Studies

2. Brief Description: The aim of this micro specialization is to introduce students to some methods in simulations and also provide them with adequate exposure on how such methods are applied in diverse problems in the science and engineering. As is clear from the structure of the micro specialization, the foundation (base) course provides the background and the electives involve applications ranging across disciplines in science and engineering.

3. Number of Subjects needed to earn the Micro-Specialization: Three

4. Credits needed to earn the Micro-Specialization: 11 - 12 credits

5. Structure: Component I: One Subject  
   Component II: One Subject (3-0-0/2-0-3)  
   Component III: One Subject

A. COMPONENT- I: MANDATORY REQUIREMENT: (ONE FOUNDATION COURSE )

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Sub Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS70009</td>
<td>Methods In Molecular Simulations</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>NA</td>
</tr>
</tbody>
</table>

B. COMPONENT- II ANY ONE SUBJECT (3/4 credits) FROM TABLE-II

<table>
<thead>
<tr>
<th>Sub No.</th>
<th>Name</th>
<th>L-T-P</th>
<th>Credit</th>
<th>Offering Semester</th>
<th>Pre-requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CE60103</td>
<td>Monte Carlo Simulations in Engineering</td>
<td>3-0-0</td>
<td>3</td>
<td>Autumn</td>
<td>TS70009</td>
</tr>
<tr>
<td>TS62001</td>
<td>Simulations In Collider Physics And Cosmology</td>
<td>2-0-3</td>
<td>4</td>
<td>Autumn</td>
<td>TS70009</td>
</tr>
<tr>
<td>TS62002</td>
<td>Quantum Methods In Molecular Simulations</td>
<td>2-0-3</td>
<td>4</td>
<td>Spring</td>
<td>TS70009</td>
</tr>
</tbody>
</table>

C. COMPONENT- III: ONE SUBJECT FROM TABLE-III

<table>
<thead>
<tr>
<th>Sub No.</th>
<th>Name</th>
<th>L-T-P</th>
<th>Credit</th>
<th>Offering Semester</th>
<th>Pre-requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TS67001</td>
<td>Project/ term paper</td>
<td>0-0-0</td>
<td>4</td>
<td>Both</td>
<td>TS70009</td>
</tr>
</tbody>
</table>
Name of the Micro-Specialization: Quality Engineering

1. **School/Center:** SubirChowdhury School of Quality and Reliability (Former Reliability Engineering Centre)

2. **Name of the Micro Specialization:** Quality Engineering

3. **Brief Description:** This micro-specialization is open to the UG students with various engineering backgrounds. This specialization will help them understand the concepts of quality and expose to the ways and means to assess, improve, implement and manage the same in every sphere of activities. The specialization provides courses on general quality concepts, quality engineering, off-line and on-line quality control techniques. Further, the specialization also offers courses on quality of services, power, water, air, and food products which have become very important in the present industrial and globalization scenario in India. This specialization will help students to understand various quality problems and use of appropriate tools and techniques for addressing the same. This micro specialization is designed with generic approach so that students from all disciplines get benefited.

4. **Number of Subjects needed to earn the Micro Specialization (3-4 subjects):** 4

5. **Minimum Credits needed to earn the Micro Specialization (10-14 credits):** 11

6. **Structure:**

   A. **COMPONENT- I: MANDATORY REQUIREMENT (2 credit FOUNDATION COURSE)**

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RE30003</td>
<td>Introduction to Quality</td>
<td>2-0-0</td>
<td>2</td>
<td>Both</td>
<td>Uploaded in ERP and Approved by Senate</td>
</tr>
</tbody>
</table>

   B. **COMPONENT- II: TWO SUBJECTS (3/4 credits each) FROM TABLE-II**

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RE60015 (OR) IM 31005</td>
<td>Statistical Process Control (OR) Quality Design and Control</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>RE30003</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td></td>
</tr>
<tr>
<td>RE60005</td>
<td>Quality of Services Analysis in Cloud Computing</td>
<td>4-0-0</td>
<td>4</td>
<td>Spring</td>
<td>RE30003</td>
</tr>
<tr>
<td>RE60025</td>
<td>Software Quality Assurance</td>
<td>3-0-0</td>
<td>3</td>
<td>Autumn</td>
<td>RE30003</td>
</tr>
<tr>
<td>IM 31002 (OR) IM 60062</td>
<td>Quality Engineering (OR) Six Sigma Fundamentals &amp; Applications</td>
<td>3-1-0</td>
<td>4</td>
<td>Autumn</td>
<td>RE30003</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td></td>
</tr>
<tr>
<td>IM 60057</td>
<td>Total Quality Management</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>RE30003</td>
</tr>
</tbody>
</table>
C. COMPONENT - III PROJECT/DESIGN/TERM PAPER (4 credits) OR ONE (3/4 credit) SUBJECT

TABLE-III

<table>
<thead>
<tr>
<th>Sub no.</th>
<th>Name</th>
<th>LTP</th>
<th>Credits</th>
<th>Offering Semester</th>
<th>Pre-Requisite (if any)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RE47001</td>
<td>Project/Term Paper on Quality</td>
<td>0-0-6</td>
<td>4</td>
<td>Both</td>
<td>RE30003</td>
</tr>
<tr>
<td>CE 31304</td>
<td>Air Quality Management</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>RE30003</td>
</tr>
<tr>
<td>EE 60025</td>
<td>Power Quality</td>
<td>3-0-0</td>
<td>3</td>
<td>Autumn</td>
<td>RE30003</td>
</tr>
<tr>
<td>AG 31032</td>
<td>Water Quality Management</td>
<td>3-1-0</td>
<td>4</td>
<td>Spring</td>
<td>RE30003</td>
</tr>
<tr>
<td>AG 60127</td>
<td>Food Quality and Safety Standards</td>
<td>3-0-0</td>
<td>3</td>
<td>Autumn</td>
<td>RE30003</td>
</tr>
</tbody>
</table>

5. Additional Remarks, if any:

The component – I will provide the necessary background to the concepts of quality specialization. Component-II will cover the three important traditional quality areas, viz., Statistical Quality Control and Acceptance Sampling, Quality through Design and Experimentation, and Quality Management. As some courses in this component are similar in contents, an OR logic needs to be applied to avoid taking them by the same students (See Table – II). The component – III will help the student to apply the quality concepts to real problems. The Component – III also gives options for the students to understand quality problems in important functional areas (which directly affect the day to day life) and to address them adequately.

HOC/HOS/Chairman
Detailed Syllabi of Courses

**RE30003  Introduction to Quality LTP- 2-0-0,CRD- 2**


Text Books:
J.M. Juran and Frank M. Gryna, Jr., “Quality Planning and Analysis”, McGraw-Hill.

**SUBJECT NO-RE60015, SUBJECT NAME- STATISTICAL PROCESS CONTROL LTP- 3-0-0,CRD- 3**

**SYLLABUS:-**
Process variation and causes, statistical basis for quality control, concept of rational sub-grouping. Quality characteristics-variables and attributes, Pattern on control charts, control charts for mean and range mean and standard deviation, individual units, cumulative sum, moving average, trend and acceptance, control charts for variables: O.C. curves control charts for fraction nonconforming (p-charts), number of nonconforming items (np-chart), number of non-conformities (c-charts), number of non-conformities per unit (u-chart), demerits per unit (U-chart). Process capability analysis.

Text Books:
AmitavaMitra, “Fundamentals of Quality Control and Improvement”

**SUBJECT NO RE 60005 Quality of Services Analysis in Cloud Computing LTP - 4-0-0, CRD (4)**

**SYLLABUS :-**
**History of Cloud Computing:** Paradigms in Computing, Parallel Computing, Distributed Computing, Grid Computing, Service Computing; Service Oriented Architecture (SOA), Web Services. **(1 Lectures)**  
**Cloud performance:** Real time monitoring, Scheduling, admission control, traffic control, dynamic resource provisioning. **(5 Lectures)**  
Protocol; Translation of SLAs into Monitoring Specifications, Dynamic Creation of Monitoring Infrastructures, Penalty Management, Runtime Prediction (4 Lectures)

**Managing Big Data: Cloud File Systems:** GFS and HDFS, Big Table, HBase and Dynamo; Map Reduce Programming Model, Hadoop: Hadoop Fundamentals, Hama and other Hadoop Related Services, Security Threats and attacks to Big Data, authentication protocols to secure Big Data, Hardware solutions to Big Data Security. (8 Lectures)

**Some Case Studies:** Xen Hypervisor, Amazon Web Service, Windows Azure, Google App Engine, Eucalyptus, Open Stack, Open Nebula (3 Lectures)

**RE60025 Software Quality Assurance** LTP - 3-0-0, CRD (3)

**SYLLABUS :-**
Basics of software quality: Introduction, Definition, needs and objectives, Software quality models, McCall’s model, Boehm’s model, ISO 9126 model, Software quality metrics, Metrics, their classification, implementation and limitations, Quality assurance and certification, Quality management system, quality management standards, ISO, IEEE, CMM/CMMI, Software quality assurance management: Software development, Software processes and different development life cycles, 3S development, Software quality management, SRS template and development, customer management, security management and risk mitigation and management, Resources and organization management, Software quality issues with different team structures. Software quality assurance techniques: Planning and analysis, Cost analysis, budget analysis, time analysis, Verification and validation, Errors, bugs and failure, Defect prevention and reduction, root cause analysis, Software testing, Different testing strategies: graph-based, model-based. Software reliability for QoS: Fundamental reliability metrics, Time interval, failure interval, failure intensity, Factors influencing software reliability, First and second definitions, Models for reliability prediction, Classic model, failure model, architecture-based model, Statistical models, advanced models

**Text and reference books:**

**SUBJECT NO-IM31002, SUBJECT NAME- QUALITY ENGINEERING** LTP- 3-1-0,CRD- 4

**SYLLABUS :-**
Prerequisites: IM31005 Quality Design and Control Experimental design fundamentals; Statistical concepts; Features of experimentation; Analysis ofvariance (ANOVA): no-way, one-way, two-way, and three-way ANOVA, Critique of Ftest;Some experimental designs: Factorial experiments (2k), role of contrasts,confounding, fractional replication, and other aspects; 2k-p fractionalfactorial experiments; Response Surface Methodology (RSM),Taguchi philosophy;Loss function; Orthogonal arrays: Steps in designing, conducting, and analyzing an experiment; Parameter and tolerance design concepts: control and noisefactors; Analysis of inner/outer array experiments: signal-to-noise ratio andperformance measures; Applications to attribute data.

SUBJECT NO-IM31005, SUBJECT NAME- QUALITY DESIGN AND CONTROL LTP- 3-1-0,CRD- 4

SYLLABUS :-
Prerequisites: IM21003 Operations Research-1


Textbook:

References:

SUBJECT NO-IM60057, SUBJECT NAME- TOTAL QUALITY MANAGEMENT LTP- 3-0-0,CRD- 3

SYLLABUS :-
Fundamentals of TQM; Some important philosophies and their impact on quality (Deming, Juran, Crossby), Features of Malcom Balridge quality award; Identification and measurement of quality costs; Issues related to products, processes, organization, leadership, and commitment for total quality achievement; Tools and techniques used in TQM: seven tools, new seven, essential features of QCC, ZD, Kaizen, and JIT programmes; Fundamental concepts about Quality Function Deployment (QFD); Components of Total Quality System (TQS) in organizations, Quality Auditing: Introduction to ISO 9000 and 14000 standards. Case studies.

Books
1. Total Quality Management – Dr B Janakiraman, Prof R K Gopal – PHI, 2005
SUBJECT NO-IM60062, SUBJECT NAME- SIX SIGMA FUNDAMENTALS & APPLICATIONS LTP- 3-0-0, CRD- 3
SYLLABUS :
Introduction to Six Sigma: Definitions and success stories, six sigma framework, DMAIC – the six sigma improvement process, statistics and six sigma, difference between six sigma and TQM.
Preparing for Deployment: Elements of successful deployment, personal requirements – champions, black belts, and green belts, and focusing on deployment – customer focus, project selection, and QFD.
Six Sigma Tools: Exploratory tools – Charts, diagrams, and metrics, Data collection and monitoring tools – primary and secondary data, instrument design and sample survey, gage R&R, and attribute measurement systems, and SPC, Analysis tools – Diagrams, Hypothesis testing, ANOVA, correlation and regression (linear and logistic), and FMECA.
Six Sigma Methodology (DMAIC): Define – objectives, process thinking, process mapping, balanced scorecard, project selection and tracking, Measure – objectives, measurements (discrete vs continuous), measurement as a process, baseline estimation, performance metrics, and measurement system analysis, Analysis – objectives, value stream analysis, analyzing sources of variations, and determining process drivers, Improve – objectives, defining new process, benchmarking, prioritizing and selecting a solution, and corrective action matrix, Control – objectives, more on SPC, visual control, best practices and lessons learned, and documenting process changes.
Case studies: Selective cases with hands on exercises.
Textbooks and References:

SUBJECT NO-RE47001
SUBJECT NAME: Project/Term Paper on Quality LTP- 0-0-6, CRD – 4
Objectives: The objective of the project to enable the student to apply the concepts of quality in real situations or industrial problems. Instead, the student can write a Term Paper or research paper on a selected recent topic. Term paper is intended to describe an event, a concept, or argue a point with adequate supporting documents or literature in the domain of Quality. The term paper must be a written original work discussing a topic in detail with latest relevant literature, usually several typed pages in length and is due at the end of the semester.
Possible areas:
1. Statistical Process Control
2. Quality Engineering
3. Quality Management
4. Quality Standards
5. Software Quality

SUBJECT NO-CE60022, SUBJECT NAME- AIR QUALITY MANAGEMENT LTP- 3-1-0, CRD - 4
SYLLABUS :
Air pollutants- Sources, classification, Combustion processes and pollutant emission, Effect on Health, vegetation, materials and atmosphere, Reactions of pollutants in the atmosphere and their effects- Smoke, smog and ozone layer disturbance, Atmospheric diffusion of pollutants and their analysis, Transport,
transformation and deposition of air contaminants on a global scale. Air sampling and pollutant measurement methods, principles and instruments, ambient air quality and emission standards, control. Removal of gaseous pollutants by adsorption, absorption, reaction and other methods, Particulate emission control, settling chambers, cyclone separation, Wet collectors, fabric filters, electrostatic precipitators and other removal methods.

**SUBJECT NO- EE 60025 POWER QUALITY LTP - 3-0-0, CRD 3**

Introduction: Definition of power quality, its impacts and evaluation procedure with emphasis on deregulated environment; General classes of power quality problems; Transients: impulsive transient, oscillatory transient; Long-duration voltage variations: overvoltage, undervoltage, sustained interruptions; Short-duration voltage variations: interruption, sags, swells; Voltage imbalance; Waveform distortion; Voltage fluctuations; Power frequency variations.

Voltage Sags and Interruptions: Sources of sags and interruptions; Voltage sag performance estimation; Principles of protection; Solutions at end-user level: ferroresonant transformers, magnetic synthesizers, active series compensators, on-line and standby UPS, SMES devices; Cost estimation for voltage sag events.

Transient Overvoltages: Sources of transient overvoltages: capacitor switching, lightning, ferroresonance; Principles of protection: surge arrestors, isolation transformers, low-pass filters, low-impedance power conditioners.

Harmonics: Harmonic sources: fluorescent lighting, adjustable speed drive, industrial load, cyclic load, power converter; Harmonic distortion evaluation; Harmonic control: reduction of harmonic load current, filtering, modification of system frequency response; Harmonic control on utility feeders and at end-user facility; Devices for harmonic distortion control: in-line reactors, zigzag transformers, passive and active filters.

Long-Duration Voltage Variations: Voltage regulation principles; Regulating devices: tap-changing transformers, isolation devices with separate voltage regulators, capacitors, SVC, STATCOM, DVR, active power line conditioner; Flicker: sources, calculation and mitigation techniques.

Power Quality Benchmarking: RMS voltage variation indices; Harmonics indices; Power quality contracts; Power quality insurance; Inclusion of power quality in distribution planning; Power quality state estimation.

Distributed Generation (DG) and Power Quality: Resurgence of DG; DG technologies; Interface to the utility system; Power quality issues; Operating conflicts; DG in low-voltage distribution systems.

Power Quality Monitoring: Basic concepts and monitoring considerations; Power quality measuring instruments: wiring and grounding test devices, multimeters, oscilloscopes, disturbance analyzers, harmonic and spectrum analyzers, flicker meters, energy monitors; Power quality data assessment techniques: time-frequency analysis of signals (Fourier and Wavelet transforms), Kalman filtering, disturbance/event classification.

**SUBJECT NO-AG31032, SUBJECT NAME- WATER QUALITY MANAGEMENT LTP- 3-0-0, CRD - 3**

SYLLABUS :-


Water Quality Modeling: Use of modeling technique, Study of the available models for water quality modeling.

SUBJECT NO-AG60127, SUBJECT NAME- FOOD QUALITY AND SAFETY STANDARDS
LTP- 3-0-0, CRD - 3
SYLLABUS :-
Statutory meaning of food, essential commodity, food quality, safety & sanitations; changing nature of food quality and standards; food policy in India; regulations and methods for prevention of food adulteration; food safety and sanitations standards and methods; statutory grading of agricultural produce; regulations for supply, distribution, trade and commerce of essential commodities. Food standards authority – Indian & International; Bureau of Indian Standards (BIS); quality control and inspection in export and import of food items; international agreements on sanitary and phyto-sanitary measures; harmonization of food regulations; emerging methods, trends and issues; case studies. Plant safety, hygienic process design, HACCP, GMP, ISO and CIP
Name of the Micro-Specialization: Science of Happiness

1. School/Center: Rekhi Centre of Excellence for the Science of Happiness

2. Name of the Micro Specialization: Science of Happiness

3. Brief Description: This course aims to provide a scientifically grounded understanding of ‘Happiness and Wellbeing’. It would emphasize both the science as well as the practice of happiness and wellbeing from individual, social and organizational perspectives. The course will introduce the students to the science of happiness and wellbeing along with options to focus on diverse personal, social and cultural and organizational aspects of happiness and wellbeing through a number of elective courses focusing on workplace, holistic country level approach, Indic traditions, communication strategies, measurement approaches, and physical focus.

This micro-specialization in Science of Happiness and Wellbeing is proposed for all UG students of the Institute.

4. Number of Subjects needed to earn the Micro Specialization: 3 Subjects + One Project/Term paper

5. Minimum Credits needed to earn the Micro Specialization (10-14 credits): 13

6. Structure:

A. COMPONENT- I: FOUNDATION COURSE (MANDATORY REQUIREMENT)

<table>
<thead>
<tr>
<th>Subject No</th>
<th>Subject name</th>
<th>L-T-P</th>
<th>Credit</th>
<th>Semester</th>
<th>Prerequisite(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS62002</td>
<td>Science of Happiness and Wellbeing</td>
<td>3-0-0</td>
<td>3</td>
<td>Both</td>
<td>None</td>
</tr>
</tbody>
</table>

B. COMPONENT- II: Two subjects (Electives)

<table>
<thead>
<tr>
<th>Subject No</th>
<th>Subject name</th>
<th>L-T-P</th>
<th>Credit</th>
<th>Semester</th>
<th>Prerequisite(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HS60042</td>
<td>Introduction to Gross National Happiness</td>
<td>3-0-0</td>
<td>3</td>
<td>Both</td>
<td>None</td>
</tr>
<tr>
<td>HS62004</td>
<td>Measurement of Happiness</td>
<td>3-0-1</td>
<td>3</td>
<td>Both</td>
<td>None</td>
</tr>
<tr>
<td>RX60015</td>
<td>Communication, Happiness and Wellbeing</td>
<td>3-0-0</td>
<td>3</td>
<td>Both</td>
<td>None</td>
</tr>
<tr>
<td>RX60019</td>
<td>Happiness at Work</td>
<td>3-0-0</td>
<td>3</td>
<td>Both</td>
<td>None</td>
</tr>
<tr>
<td>RX60013</td>
<td>Happiness: Indic Perspectives</td>
<td>3-0-0</td>
<td>3</td>
<td>Both</td>
<td>None</td>
</tr>
<tr>
<td>RX60017</td>
<td>Sports and Wellbeing</td>
<td>2-0-0</td>
<td>2</td>
<td>Both</td>
<td>None</td>
</tr>
</tbody>
</table>

C. COMPONENT- III: Project/Term Paper

<table>
<thead>
<tr>
<th>Subject no</th>
<th>Subject name</th>
<th>L-T-P</th>
<th>Credit</th>
<th>Semester</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>RX67001</td>
<td>Project/Term Paper</td>
<td>0-0-6</td>
<td>4</td>
<td>Autumn/Spring</td>
<td>None</td>
</tr>
</tbody>
</table>
The proposed courses are outlined below:

**Subject No. - RX60015, Communication, Happiness and Wellbeing** (L-T-P = 3-0-0) = 3 credit

**Faculty:** Prof V N Giri, Prof P Patnaik, Prof M K Mandal

**Overview**

This course aims at understanding how communication behaviors relate to constructing happiness and wellbeing. We are living in an age which is full of challenges and competitions. To the best of our capabilities, we try to meet these challenges. Effective communication (a) helps ease our access to people and develop effective interpersonal communication, (b) provides us with strategies that help us communicate our positivity and (c) gives us specific communicative tools that can enhance happiness.

The course will enable students to develop skills in communication to deal with various situations and resolve the conflicts, as well as develop specific communication styles and games that enhance wellbeing and happiness. Communication strategies that lead to self-discovery, discovery of relationship with others, and thus lead to happiness and wellbeing will also be explored. Thus, the talks and interactions will equip students to properly understand the complex nature and behaviour of human being which are necessary to avoid possible pitfalls and lead a happy life.

**Aim of the course:**

Upon successful completion of this course the students will be able to

- Develop an in-depth understanding on how happiness is created through communication behaviour, and interaction.
- Will determine, track, and analyze their happiness through communication skills.
- Will learn best communication practices associated with happiness (i.e., gratitude, kindness, optimism, politeness, affection, generous communication and listening.
- Learn not to blame others by default.
- **Understand the importance of face-to-face communication.**
- Understand the role of communication in workplace happiness
- Recognize different communication styles used in different situations with different types of people.
- Understand the importance of intrapersonal communication.
- Identify the importance of nonverbal communication.

**Course Contents:**

- **Communication basics: The Different Channels and models:** This will introduce the students to the diverse ways we communicate, encode, decode, and also how multiple channels work. (6 hours)
- **Multimodality, intermediality and affective communication:** This will introduce the students to how multiple channels of communication work, how they are linked to one another, and how they manage to communicate both positive and negative emotions. (6 hours)
- **Intrapersonal communication:** Communication is a two way process, where feedback plays a key role in how perception evolves and changes. Different principles, strategies and implications of communicating in close quarters will be explored (6 hours)
- **Communicative practices: Generosity, Gratitude and Forgiveness:** How communication strategies can be used to both give and generate these altruistic practices will be explored. (6 hours)
- **Communication styles for generating congenial environment:** Different ways of communicating impact how people react to us. Their relationship and implications in the context of happiness will be explored. (6 hours)
- **Nonverbal communication skills**: These play a key role in interpersonal communication and in generating warmth and happiness. Strategies and implications will be explored. (6 hours)
- **Communicating for workplace happiness**: Both verbal and non-verbal strategies for effective workplace communication will be explored. (4 hours)
- Communication for self-discovery and discovery of others: Certain unique strategies based on both ancient traditions and modern knowledge will be explored for students to start on the path of positive self-discovery. (4 hours)
- **Happiness Games**: Diverse communicative games that would include communicating with self, with others, using interpersonal strategies, of using multiple channels, etc., will be used through the course.

References:

**Recommended Books:**

1. Maximizing Happiness Through Intimate Communication by Marshall L Shearer
2. Language and the Pursuit of Happiness: A New Foundation for Designing..... by Chalmers Brothers
3. If You're So Smart, Why Aren't You Happy? by Raghunathan Raj
5. Being Happy: You Don't Have to Be Perfect to Lead a Richer, Happier Life by Ben-Shahar, Tal

**Subject No. - RX60019, Happiness at Work, Credits: 3-0-0**

**Faculty** Prof. D. Suar, Rekhi Centre &HSS, Prof. K B L Srivastava, Rekhi Centre & HSS, Prof. Susmita Mukhopadhyay, Rekhi Centre & VGSOM, Dr. Saamdu Chetri, Rekhi Centre

**Objective**

Happiness at work improves the organizational productivity by increasing employees’ performance, engagement, innovation, and retention. It explores the key factors that link to workplace happiness, such as psychological capital, gratitude, a sense of purpose and meaning in life, social skills, kindness, and authentic behaviour.

The course contains topics to learn and practice at personal, interpersonal, and enterprise levels. The pedagogy includes lectures, cases, structured exercises, and class presentations. Research papers from journals and internet will be provided for reading on specific topics.

**Contents**

**Individual level:** (20 hours)

- Happiness and subjective well-being (SWB)
- Theories, Correlates, and Outcomes of SWB
- Interventions for SWB
- Psychological capital: Hope, optimism, self-efficacy, resilience
- Meaning and Renewal in Life: Meaning and purpose in life, Professional, social, physical and spiritual renewal
• Health, fitness, and dieting; Virtues and values, Western and eastern perspectives
• Emotional intelligence: Concepts, theories, and practices; Employees’ commitment, job satisfaction, innovation, engagement, flow at work; Job crafting

**Interpersonal level:** (10 hours +10 hours)
• Empathy, gratitude, kindness, humour, altruism, humility; Building relationships
• Social capital; Ethical, authentic, and servant leadership
• Group decision-making; Conflict handling

**Organizational level:** (10 hours+5 hours)
• Organizational culture
• Organizational change
• Nudge
• Stress and burnout management
• Relaxation, yoga, meditation—mindfulness, heartful meditation

**References**


**Subject No. - RX60013, Happiness: Indic Perspectives** (L-T-P: 3-0-0, CRD: 3)

**Proposed Course Instructors:** Prof. P. Patnaik, Rekhi Centre and HSS, Dr. Anuradha Choudry, Rekhi Centre and HSS, Dr. Saamdu Chetri, Rekhi Centre, Dr. Jenia Mukherjee, Rekhi Centre and HSS

**Semester in which Course will be offered**
Spring and Autumn Semester

**Justification for Introducing the New Course**

In today’s world, which is defined by various levels of individual and collective stressors, Happiness and Well-being, as opposed to Success, has become a central area of study. Two approaches are taken – to understand causes of happiness, from neurological to psychological, social and economic. Secondly, to explore traditional practices, and create new practices that lead to happiness. This course attempts to examine the Indian traditions where understanding and achieving happiness has been a key focus, and to examine the link between the theory and practice of happiness in these traditions and their modern relevance. It is with this backdrop that this course seeks to explore the Indian perspectives of happiness that emerge from five traditions in India, namely, the Vedic, Buddhist, Jain, Sikh and the Charvaka which have not been studied in much depth thus far.

**Description**

The course seeks to introduce the students, in the context of Hindu, Buddhist, Jain, Sikh and Charvaka frameworks, to the philosophical and theoretical underpinnings as well as specific practices that emerged
from them which related to happiness. It will first present them with the fundamental concepts of each of these schools of thoughts followed by an understanding of their salient characteristics related to happiness and wellbeing. It will then offer them the scope to study certain typical practices of each tradition that are believed to create happiness in order to encourage dialogue and discussion on the different perspectives of this most sought after experience. Furthermore, besides giving students a theoretical understanding of the subject, this course will highlight the applicational aspects in one’s daily life and lay emphasis on the scope for research in these areas.

Course Syllabus (Total 38 hours)

1. Leading global studies on Happiness (4 hours)
   1.1 Mainstream Psychological concepts of happiness
   1.2 The scientific approach to decoding happiness

2. Hindu Traditions on Happiness (6 hours)
   2.1 Major Philosophies and their definitions
   2.2 Social Practices that lead to Happiness
   2.3 Individual practices to cultivate happiness
   2.4 Identification of causes of pain and sorrow
   2.5 Specific tools that enhance happiness

3. Buddhist Traditions on Happiness (6 hours)
   3.1 Philosophical Principles
   3.2 Key practices that foster Happiness at collective and individual levels
   3.3 Four noble Truths
   3.3 Systematic approaches to create Happiness

4. Jaina Perspective on Happiness (6 hours)
   4.1 Philosophical concepts
   4.2 Implication in practice at societal and personal levels
   4.3 Causes of sorrow and suffering
   4.4 Pathways to happiness

5. Charvaka and the quest for Happiness (6 hours)
   5.1 Philosophical underpinings
   5.2 Charvaka and the approach of Materialism
5.3 Obstacles to happiness

5.4 Means of Happiness

6. Sikh Approach to Happiness (6 hours)

6.1 Philosophical rationale

6.2 Collective and individual practices

6.3 Challenges to experiencing Happiness

6.4 Customs that generate happiness

7. Summary of conclusions (4 hours)

7.1 Identification of common features in the various Indic perspectives of happiness

7.2 Scope and Challenges of Implementing them in IIT Kharagpur: a practical approach

References


Subject No. - RX60017, Sports and Well Being (2-credit course), Credit: 2-0-0

Faculty: Prof. R. Guha, Prof. M. K. Mandal, Prof. S. Bhattacharya
Description and scope:
Well-Being and its various parameters have been a point of recent research and explored globally. The relationship of well-being and sports has been fairly well established. Engaging in Sports activities impacts psychological preparedness for high-end competitions and also enables the individual physically to combat stress. This course explores the different psychological variables that impact athletic participation and performance and vis-a-vis affects well-being. Topics studied will include the personality differences between athletes and non-athletes, attributions for performance, the impact of equity in providing motivation, strategies for successful performance (such as imagery, arousal, and goal setting), address the biochemical changes resulting from sports activities and its relationship to mood and well-being. The course would also attempt would be to decipher the source of unhappiness like stress, anxiety, perceived sense of isolation, and help develop psychological ‘edge’ beyond physical skill & biological endurance. Thus, along with coping with success, the other key focus of the course would be on the ability to bounce back after failure.

COURSE INTRODUCTION

1. WELL BEING AND SPORTS – A study of interdependence

2. PHYSIOLOGICAL PARAMETERS OF WELL-BEING
   - Role of Neurotransmitters in well-being
   - Neurotransmitters and sports

3. INDIVIDUAL DIFFERENCES IN WELL BEING: Personality, Motivation and Cognition
   - Goal setting
   - Focus – Attention and concentration
   - Self-confidence and boosting
   - Mental toughness and mindfulness training
   - Role of sports in self-grooming

Discussion: In These Girls, Hope is a Muscle; Jerry McGuire

4. SPORTS AND PSYCHOLOGICAL SKILLS:
   - Introduction to mental skills training – Flow
   - Arousal regulation and coping
   - Arousal regulation workshop
   - Relaxation training
   - Visualisation and mental imagery

Discussion: Boys of Winter; Bull Durham

5. SPORTS SOCIAL SKILLS AND WELL BEING:
   - Aggression and mood
   - Uprooting stereotypes about self and others
   - Communication - breaking the ice berg
• Role of Sports in building social skills

Discussion: Friday Night Lights; Hoosiers

6. A HEALTHY DOSE OF SPORTS AND WELL BEING

• Energy management
• Burnout
• Stress Management
• Sports as a paired career option

<table>
<thead>
<tr>
<th>S. N.</th>
<th>Classes</th>
<th>No. of Sessions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Wellbeing and sports – interdependence</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>Physiological parameters of wellbeing</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>Individual difference in wellbeing</td>
<td>4</td>
</tr>
<tr>
<td>4</td>
<td>Sports and psychological skills</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>Sports skills and wellbeing</td>
<td>6</td>
</tr>
<tr>
<td>6</td>
<td>Bouncing back – special focus</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td><strong>30</strong></td>
</tr>
</tbody>
</table>

References


Book

Ram Nayaar, The Sport of Life: Reaching True Happiness & Success Through Fearless Living, CreateSpace Independent Publishing Platform (October 13, 2016)
Name of the Micro-Specialization: **Business Analytics**

1. **School/Center:** Vinod Gupta School of Management
2. **Name of the Micro Specialization:** Business Analytics
3. **Brief Description:** In the age of digitization and huge data generation, business analytics has penetrated all domains and verticals of business. This specialization is aimed to equip MBA students with the required skills and techniques associated with applied statistics and machine learning.
4. **Number of Subjects needed to earn the Micro Specialization:** 4 (2 Core + 2 Electives)
5. **Minimum Credits needed to earn the Micro Specialization:** 12
6. **Structure:**

   **A. COMPONENT- I: (MANDATORY REQUIREMENT)**

<table>
<thead>
<tr>
<th>Subject No</th>
<th>Subject name</th>
<th>L-T-P</th>
<th>Credit</th>
<th>Semester</th>
<th>Prerequisite(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BM63026</td>
<td>Advanced Business Analytics</td>
<td>2-0-0</td>
<td>2</td>
<td>2</td>
<td>None</td>
</tr>
<tr>
<td>BM63083</td>
<td>Time Series Econometrics</td>
<td>2-0-0</td>
<td>2</td>
<td>3</td>
<td>None</td>
</tr>
</tbody>
</table>

   **B. COMPONENT- II: Two subjects (Electives)**

<table>
<thead>
<tr>
<th>Subject No</th>
<th>Subject name</th>
<th>L-T-P</th>
<th>Credit</th>
<th>Semester</th>
<th>Prerequisite(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BM63043</td>
<td>Supply Chain Analytics</td>
<td>2-0-0</td>
<td>2</td>
<td>3</td>
<td>None</td>
</tr>
<tr>
<td>BM63092</td>
<td>Marketing Analytics</td>
<td>2-0-0</td>
<td>2</td>
<td>3</td>
<td>None</td>
</tr>
<tr>
<td>BM63045</td>
<td>Product Analytics</td>
<td>2-0-0</td>
<td>2</td>
<td>4</td>
<td>None</td>
</tr>
<tr>
<td>BM63079</td>
<td>People Analytics</td>
<td>2-0-0</td>
<td>2</td>
<td>4</td>
<td>None</td>
</tr>
<tr>
<td>BM63076</td>
<td>Advanced Marketing Analytics</td>
<td>2-0-0</td>
<td>2</td>
<td>4</td>
<td>None</td>
</tr>
</tbody>
</table>

   **C. COMPONENT- III: Project/Term Paper**

<table>
<thead>
<tr>
<th>Subject No</th>
<th>Subject name</th>
<th>L-T-P</th>
<th>Credit</th>
<th>Semester</th>
<th>Prerequisites</th>
</tr>
</thead>
<tbody>
<tr>
<td>BM67011</td>
<td>Project I</td>
<td>0-0-0</td>
<td>2</td>
<td>Autumn</td>
<td>None</td>
</tr>
<tr>
<td>BM67012</td>
<td>Project II</td>
<td>0-0-0</td>
<td>2</td>
<td>Spring</td>
<td>None</td>
</tr>
</tbody>
</table>
Detailed Syllabi of Courses

1. Advanced Business Analytics; (2-0-0: 2 Credit)

Prerequisite: Introduction to Business Analytics

Course Objective: This course builds upon the Introduction to Business Analytics course through theory sessions, hands on sessions and relevant managerial case studies. After undergoing this course the students should be able to handle business problems and take managerial decisions using Advanced Analytics techniques.

Course Contents:

- Spline Based Prediction: Piecewise Polynomials and Splines, Filtering and Feature Extraction, Smoothing Splines, Selection of smoothing parameters, Case on smoothing Spline (with PROACT Data set)
- Support Vector Machines and Model Performance Evaluation: Computing the SVM for Classification, The SVM as a Penalization Method, Function Estimation and Reproducing Kernels, SVMs and the Curse of Dimensionality, Support Vector Machines for Regression, Hands-on Exercises on SVM with R, Measure of Performance, Confusion Matrix, Risk Charts; ROC Charts; Other Charts, Scoring, Hands-on With Data sets
- Case study with data set: IMDB data from 2006 to 2016
- Boosting: Forward Stagewise Additive Modeling, Exponential Loss and AdaBoost, Loss Functions and Robustness, "Off-the-Shelf" Procedures for Data Mining, Boosting Trees, Regularization & Interpretation, Hands on R Exercises on Boosting
- Case with data set: Human Resources Analytics [Why are our best and most experienced employees leaving prematurely?]
- Case with data set: Default of Credit Card [Clients Dataset Default Payments of Credit Card Clients in Taiwan from 2005]
- Case with data set: Bitcoin Historical Data [Bitcoin data at 1-min intervals from select exchanges, Jan 2012 to May 2017]
- Penalized Regression: Ridge Regression, LASSO, Feature Engineering
- Introduction to Ensembles
- Case on LASSO with data set: House Prices: Advanced Regression Techniques [Kaggle]
- Strategic uses of Business Analytics in Decision Making
- Case on Strategic uses of Business Analytics: Armacord Incorporated: Combatting Money-laundering Using Data Analytics, Davit Khachatryan, Harvard Business School Case, Product #: BAB260-PDF-ENG

Suggested Text Books & Reference:

1. Data Mining and Business Analytics with R, Johannes Ledolter, Wiley
2. Data science for Business, Foster Provost, O’Reilly Press

2. Time Series Econometrics (2-0-0: 2 Credit)

Course Objective: Today, forecasting is key to business; and based on analytics. If you are wondering about how to take advantage of inferential analytics, predictive analytics, data science, and big data, this is the course can help you! This course covers topics in regression analysis and time series analysis and other statistical techniques on forecasting. These are time series regression, decomposition methods, and the Box-Jenkins forecasting methodology to name a few. Forecasting is not an armchair activity, nor is it an exercise in mathematical
formalism, a one-click-and your done computer project, or an uncritical appeal to past experience. Rather, the modern forecaster must be a creative thinker who is able to use available information wisely, draw on the experience of others, use technical arguments when needed and, finally create a computer-based forecasting system that allows management to plan effectively. Probably no such paragon exists, but we should at least aim for an appreciation of all these skills and the ability to work in a team to achieve success. Virtually every area of business makes use of some type of forecast. This course is intended for students working in the _field of economics, business, marketing, production, operations research, international trade, accounting, etc., who want a non-technical introduction to applied time series econometrics and forecasting.

Course Contents:

- Basics of business econometrics: Linear regression modelling and forecasting
- Non-linear regression modelling
- Count data and discrete data modelling
- Time series modelling: ARIMA, volatility modelling, VAR modeling
- Panel data modelling: Fixed effect, random effect, GMM
- Structural equation modelling
- Simultaneous equation modelling: ILS, 2SLS, 3SLS, IV
- Business forecasting with soft computing

Suggested Text & Reference Books:

1. Econometric Models and Business Forecasts, R. S. Pindyck and D. L. Rubinfeld, McGraw Hill

Component II, Elective Courses

1. Supply Chain Analytics, (2-0-0: 2 Credit)
   Prerequisite: Supply Chain Management

   Course Objective: This course focuses on the applications of analytical techniques for optimizing the different objectives connected with the effectiveness of a supply network considering the constraints of demand and supply.

   Course Contents:

   - Introduction to Supply Chain Analytics: Descriptive, Predictive , and Prescriptive analysis in Supply Network
   - Role of analytics in building traditional, agile, responsive and rapid responsive networks
   - Review of Performance Measures for Efficiency and Effectiveness (SCOR Model)
   - Design & optimization of Global Supply Networks
   - Demand Forecasting Techniques in Supply Networks, Selection of Best Forecast Model & Optimum Parameters, Importance & Relevance of Demand Data - Concept of Outliers & Filtering Techniques
   - Managing Economies of Scale in Supply Chain: Cycle Inventory & Related Analytic Models for Optimization
   - Optimum Level of Product Availability : Analytic Models
   - Transportation Models : Route, Shipment Schedule and Flow Path Optimization
Analytics for Sourcing Decisions in Supply Network, Supplier selection and comparison
- Analytical techniques for contract management and collaboration in SC.

**Suggested Text & Reference Books:**


**2. Marketing Analytics, (2-0-0: 2 Credit)**

**Prerequisite:** Marketing I, Marketing II, Business Analytics

**Course Objective:** The main objective of this course is to utilize analytics techniques in solving marketing problems. The marketing problems which will be solved using analytics tools and techniques will cover decisions on product, price, promotion and place. It will also focus on the changing business scenario with technological advancement thus helping the students tackling new age marketing problems in a data driven way.

**Course Contents:**

- Demand Forecasting
- Pricing Decisions with Analytics
- Customer Utility and Product Design
- Customer Lifetime Value
- Customer Segmentation and Targeting
- Advertising Effectiveness Models
- Retail Analytics
- Social Network Analysis

**Suggested Text & Reference Books:**


**3. Product Analytics, (2-0-0: 2 Credit)**

**Prerequisite:** Production and Operations Management, Quantitative Techniques-I

**Course objective:** The objective of this course is to familiarize the students with the applications of analytical techniques for product ideation, design, development, and launch. The course also deals with performance evaluation and field failure analysis of new products.
Course contents:

- Relevance of Product Analytics (PA) in Today’s Context
- Introduction to Product Lifecycle Management (PLM) and its role in product development, market life cycle and product life cycle, tracker’s model for forecasting of new products, Gartner magic quadrant: positioning technology players within a specific market and market scope
- Product and service metrics, product visualization tools, enterprise product data management
- Data science fundamentals and role of big data in PA
- Evolution of digital tools for product design, capabilities of smart connected products, internet-of-things (IoT) based product
- Supervised and unsupervised learning algorithms for product development and launch
- Dimension reduction techniques in PA
- Artificial Neural Network and Recurrent Neural Network in PA
- Product analytics through soft computing (Particle Swarm Optimization (PSO), Genetic Algorithm (GA), Ant Colony Optimization (ACO))
- Success factors and organizational competencies for new products
- Idealism and realism in product analytics, cultural interplay, reluctance and trust on analytics
- Limitations of current approaches and future directions of research in PA

Suggested Texts & References:


4. Advanced Marketing Analytics, (2-0-0: 2 Credit)

Prerequisite: Marketing I, Marketing II, Business Analytics, Marketing Analytics

Course Objective: The course builds upon the Marketing Analytics course and deals with complex problems which marketers face and which may be solved using Advanced Analytics. The course has cases mapped on to the Models which have been used to create various contexts which the marketers have to deal with in their decision making.

Course Contents:

- Structural Econometric Modelling for marketing decisions
- Latent Class Choice Models
- Hidden Markov Models
- Text Mining and Sentiment Analytics
- Advanced Bass Model
- Media Planning Models
- Stochastic RFM Model
- Simulation Based Decision Making

Suggested Text & Reference Books: Cutting Edge Marketing Analytics Real World Cases and Data Sets for Hands on Learning, Rajkumar Venkatesan, Paul Farris, Ronald T. Wilcox, Pearson
Name of the Micro-Specialization: **Embedded Control, Software, Modeling and Design**

1. **School/Center:** Advanced Technology Development Centre

2. **Name of the Micro Specialization:** Embedded Control, Software, Modeling and Design

3. **Brief Description:** Our world is increasingly becoming automated, through the ubiquitous presence and coordinated involvement of embedded systems, controls and software. From medical devices to transportation (ships, railways, cars, aerospace, etc) or security systems to process industries, which affect our daily lives, rapid automation of these systems is taking place thanks to the incorporation and advancement of embedded systems, controls and software. For example, in an automated chemical process plant, the right amount of flow rates at the right time (achieved through control commands) are essential for its operation and are realized based on the calculations of required mixtures of various chemicals, computed by an embedded systems’ software which also gives control commands and senses the actual condition through sensors. Hence, it is evident that the requirements of the global industry are clearly shifting towards a large demand in advanced and skilled workforce who have the combined expertise in these areas, resulting in a more complex and multidisciplinary field. The present curriculum of relevant individual B.Tech courses such as CSE, EE, ECE, QEDM, ME, CH, AE, CE, AG though might contain related subjects but they do not teach all three in a combined and coordinated manner as per the present industrial requirements. For example, the EE’s B.Tech course of IIT KGP has the courses of “Control System Engineering” “Measurements and Electronic Instruments” and “Embedded Systems”. However, in real world’s (usually complex) practical and industrial systems, the operational control logic is mostly incorporated in an embedded systems which further operates through interfaces with sensors and actuators, which have associated design and development challenges due to this integration and require detailed simultaneous understanding of multi-disciplinary concepts, generally not covered in the existing courses. Hence by studying in details about the integrated embedded systems with controls and software one will be equipped to tackle the real industrial world by solving the software challenges along with the embedded design to execute the control algorithm, prevalent in the practical systems such as automated medical devices and automotive systems. Moreover, in practical systems the complexities are such that several embedded systems of similar or different types might interact with each other (e.g.in Aerospace, Automotive) in a well-coordinated manner to perform several tasks, requiring the study of their architectural designs, communications and synchronizations among them towards meeting the objective. This kind of multi-disciplinary course having the integrated essential aspects of all the three fields of embedded systems, software and controls is expected to create competencies for the new generations of B.Tech students particularly in the streams of EE, ECE, CSE, QEDM, ME, CH, AE, CE, AG who can actively contribute to the design, development and testing of automated embedded products in various disciplines of the industry.

4. **Number of Subjects needed to earn the Micro Specialization:** 4 (3 Subjects + 1 Project OR 4 Subjects)

5. **Minimum Credits needed to earn the Micro Specialization:** 13-14
6. Structure:

**A. COMPONENT I: MANDATORY REQUIREMENT: (3 credit FOUNDATION COURSE)**

<table>
<thead>
<tr>
<th>Subject No</th>
<th>Subject name</th>
<th>L-T-P</th>
<th>Credit</th>
<th>Semester</th>
<th>Prerequisite(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT30001</td>
<td>Fundamentals of Embedded Control and Software</td>
<td>3-0-0</td>
<td>3</td>
<td>Autumn</td>
<td>None</td>
</tr>
</tbody>
</table>

**B. COMPONENT II: ANY TWO SUBJECTS (3/4 credits each) FROM TABLE - II**

<table>
<thead>
<tr>
<th>Subject No</th>
<th>Subject name</th>
<th>L-T-P</th>
<th>Credit</th>
<th>Semester</th>
<th>Prerequisite(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT60001</td>
<td>Embedded Control System</td>
<td>4-0-0</td>
<td>4</td>
<td>Autumn</td>
<td>None</td>
</tr>
<tr>
<td>AT60002</td>
<td>Principles of Automotive Dynamics &amp; Control</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>None</td>
</tr>
<tr>
<td>AT60003</td>
<td>Embedded Software Design and Validation</td>
<td>4-0-0</td>
<td>4</td>
<td>Autumn</td>
<td>None</td>
</tr>
<tr>
<td>AT60004</td>
<td>Security Aware IoT and CPS Design</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>None</td>
</tr>
<tr>
<td>AT60006</td>
<td>Embedded Sensing, Actuation and Interfacing System</td>
<td>4-0-0</td>
<td>4</td>
<td>Spring</td>
<td>None</td>
</tr>
<tr>
<td>AT60008</td>
<td>Embedded Communication Networks</td>
<td>3-0-0</td>
<td>3</td>
<td>Spring</td>
<td>None</td>
</tr>
<tr>
<td>CS61063</td>
<td>Computational Foundations of Cyber Physical Systems</td>
<td>3-1-0</td>
<td>4</td>
<td>Autumn</td>
<td>None</td>
</tr>
</tbody>
</table>

**COMPONENT III: PROJECT (4 credits) OR ANY ONE (4 credits) SUBJECT FROM TABLE - II**

<table>
<thead>
<tr>
<th>Subject No</th>
<th>Subject name</th>
<th>L-T-P</th>
<th>Credit</th>
<th>Semester</th>
<th>Prerequisite(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT67005</td>
<td>Project</td>
<td>0-0-6</td>
<td>4</td>
<td>Both</td>
<td>None</td>
</tr>
</tbody>
</table>
Detailed syllabus of the subjects:

1. AT30001: Fundamentals of Embedded Control and Software (Core)

Objective: The purpose of this course is to provide an overview of the fundamental knowledge required to understand and explore the design and development of an embedded control system considering its hardware, software and control aspects. Using this knowledge the students are expected to gain interest for expanding their depth by taking up more courses relevant to embedded control systems and software which will further enhance their skills and expertise towards development of more elaborate and customized embedded control systems in different applications of interest.

Syllabus: The overall syllabus is of 33 lectures

<table>
<thead>
<tr>
<th>Module</th>
<th>Description</th>
<th>Lecture Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction to Embedded Systems and Embedded Control Systems</td>
<td>[2]</td>
</tr>
<tr>
<td></td>
<td>a. What is an embedded system and real examples</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. Characteristics/ architecture of an Embedded system</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. Block Diagram(s), components and operations of embedded Control System</td>
<td></td>
</tr>
<tr>
<td></td>
<td>d. Real time requirements and its issues</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Basics of Microcontroller</td>
<td>[5]</td>
</tr>
<tr>
<td></td>
<td>a. Architecture</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. Functionalities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. Programming (Timers, I/Os, interrupts, etc) and examples</td>
<td></td>
</tr>
<tr>
<td></td>
<td>d. Serial and parallel interfaces for communications</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Real world systems and their state space plant model &amp; MATLAB modeling</td>
<td>[5]</td>
</tr>
<tr>
<td></td>
<td>a. Controller Basics and implementation, PID and its applications &amp; issues</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. Mass spring damper</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. Two tank interacting system (plant and controller)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>d. Automotive Systems (Plant and controller)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Modeling to Implementation</td>
<td>[4]</td>
</tr>
<tr>
<td></td>
<td>a. Introduction to different modeling techniques</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. MATLAB modeling to software implementation</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Analysis of Embedded Software</td>
<td>[4]</td>
</tr>
<tr>
<td></td>
<td>a. Embedded Software Testing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. Optimization techniques of software</td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. Performance Analysis: WCET calculation</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Embedded System Task Scheduling</td>
<td>[3]</td>
</tr>
<tr>
<td></td>
<td>a. General scheduling and embedded requirements</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. Basic features of RTOS</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Basics of Embedded Communication</td>
<td>[3]</td>
</tr>
<tr>
<td></td>
<td>a. ECU communication protocols</td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. Case Study: CAN overview</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Sensors, actuators, their interfacing in Embedded Control Systems and numerical considerations</td>
<td>[5]</td>
</tr>
<tr>
<td></td>
<td>a. Types of sensors and as per application, e.g., LVDT, Hall effect, pressure, temperature</td>
<td></td>
</tr>
</tbody>
</table>
Text Books/ References:

Course Teachers:
1. Somnath Sengupta
2. Ayantika Chatterjee
3. Banibrata Mukherjee
4. Arnab Sarkar

Overlap: Overlap % with Embedded Control System (AT60001): 40 %
Overlap % with Embedded Software Design and Validation (AT60003): 40 %

This proposed course will be primarily offered as a foundation course for Micro specialization. This course has a good amount of overlap with two core courses of ATDC namely, (1) Embedded Control System (AT60001) and (2) Embedded Software Design and Validation (AT60003). The reasons for introducing this course in spite of good overlap with the existing core courses are as follows: As per the structure of micro specialization, only one core/foundation course is allowed. However, the objectives and requirements of proposed micro specialization cannot be fulfilled by choosing any one of the core existing courses because the spectrum of this microspecialization essentially should cover both embedded control aspects as well as embedded programming and software design aspects. Therefore, it necessitates the overviews and partial combination of both the core courses. However, during formulating the syllabus it has been ensured that the difficulty level is as per the targeted UG students’ capability and requirements for earning the microspecialization degree.
Detailed Syllabus of the elective subjects:

AT60001: Embedded Control System (L-T-P: -4-0-0, CRD-4)

1: Introduction: Mathematical modeling of physical systems: Review of differential equation, transfer function and state variable representations; Examples of modeling different types of systems.

2: Control System Design: Closed loop control: Analysis of simple control loops; Stability; Time and Frequency domain specifications of control system performance. Simple approaches for controller design; Discretization. Practical realization of a control loop

3: Controller Implementation: Architecture of embedded controllers and description of various components; Design and implementation of control loops: Choice of embedded computing platforms, i/o and communication

4: Real-time Issues: Real-time issues in controller implementation: Scheduling algorithms and their performance analysis; Constraints of the operating systems; Real-time operating systems; Validation techniques for control systems. Performance assessment of control algorithms on the target implementation architecture for the given application.

5: Applications: Case studies from automotive, aerospace, process control and other application domains.

AT60002: Principles of Automotive Dynamics & Control (L-T-P: -3-0-0, CRD-3)

1: Introduction to Automotive Systems
   Overall Architecture, operation, Overall process, Driving Cycles, Challenges.
   Brief overview of Powertrain Architecture, Embedded Systems Architecture, Communication Networks (CAN, LIN, Flexray, etc)

2: Automotive Components and Their Models, Powertrain Components, Transmission, Drives, Battery, Auxiliary and their effects in dynamics

3: Engine Basics and its control

4: Types of IC engines, Construction, Operation, Dynamics, Control, OBD-II Engine controls - Fuel Injection, λ Closed loop, EGR, Throttle, Knock.

5: Vehicle Dynamics Kinematic Models, Motion Analysis, electronic Stability Control, Control of Semi active and active suspension

6: Revision of Control Basics Closed Loop system, transfer functions, poles and zeros, bode plots, stability, Common control schemes like PID control and its application to vehicle dynamics

7: Control loops in various ECUs (Overview)
   Engine Management System, Transmission Control Unit, Electric Power Assist System, Supervisory Control Unit,
   Battery Management Systems

8: Automotive Sensors and Actuators
   Sensors and actuators for significant components, their characteristics and basic modeling

9: Electric and Hybrid Vehicle System
   Basics of EV and HEV system, types, modeling and energy management based supervisory control.

10: Introduction to Autonomous Vehicles
   Control requirements of AV, AV sensors and actuators, Case study: L1-L2 level of AV.


AT60003: Embedded Software Design and Validation (L-T-P: -4-0-0, CRD-4)

1. Introductory Lecture

3. Model/Implementation Validation: Temporal Logic, Model Checking, Program verification (using CBMC)
5. HW basics: Basics of Computer Architecture (ISA, Pipeline, Cache), Bus protocols: CAN, Flexray, Sensors, ADC/DAC
6. Realtime Operating System Basics: Real time scheduling, Modern RTOS examples and case studies
7. Embedded Software Testing and Software Engineering Aspects
8. Hardware-software Codesign, Task Mapping, Task Scheduling
9. Performance Validation: Timing Analysis of Embedded Software: WCET Analysis of C Programs, Real Time Calculus (RTC) — extra topic (if time permits)
10. Tools and related assignments: Simulink/Stateflow (in ESDV lab), Uppaal (in ESDV lab), Spin/CBMC (in ESDV lab)

**AT60004: Security Aware CPS and IoT Design (L-T-P: -3-0-0 CRD-3)**

2. FSM based and Graph based Security Aware CPS design
4. ICS/SCADA System and Embedded Systems Security for CPS
5. Security Requirements for Internet Of Things: Introduction to IoT, Relationship Between CPS and IoT, Threats to Internet Of Things (IOT) Architectures.
6. IoT threats specific to Access Control and Privacy: Insufficient Authentication/Authorization, Threats to Access Control, Privacy, and Availability.
8. IOT Node Authentication: Public-Key-Based Authentication, Identify-Based Authentication, Lightweight Cryptography.

**AT60006: Embedded Sensing, Actuation and Interfacing System (L-T-P: -4-0-0 CRD-4)**

1. Introduction: Overview of Embedded System, Architecture; Importance of advanced sensors, actuators and interfacing circuits: Applications.
2. Embedded Sensors and Actuators: Various types of sensors, actuators, their descriptions and applications: Thermal, Electrical, Magnetic, Mechanical, Pneumatic etc.
4. Advanced Techniques for Direct Interfacing of Resistive Sensors to Embedded controller: Embedded Processor Based Excitation System; Direct interfacing Resistive Sensors and its array to Microcontrollers

5. Advanced Interfacing Techniques for the Capacitive Sensors to Embedded controller: Microcontroller Compatible Oscillator Based Active Bridge Circuit for wide range measurement, Auto balancing bridge for Lossy Capacitive Sensor.


9. Case studies and Applications: Automotives applications: Smart remote pressure and temperature sensor in vehicle tires, Integrated Hall Sensors, Accelerometers, Gyroscopes; Biomedical: Wearable/implantable Integrated Biomedical Sensors; Smart Home for Elder-People based on Wireless Sensors; Tutorials and assignments on design of signal conditioning circuit, interfacing circuits, and complete embedded system for various application.

AT60008 : Embedded Communication Networks (L-T-P: -3-0-0, CRD-3)

1. Introduction: Key Concepts, Event vs. State Based Communication, Finding the Best Real-Time Protocol

   3. Error Detection and Correction: Key Concepts, Shannon’s Theorem, Liner Block Codes, CRC Codes, Convolutional Codes, Data Error Detection and Recovery, Control Flow Error Detection, Detecting and correcting I/O and memory errors.

4. Uncertainty in I/O: Robust Control Theory, Effects of Uncertainty


CS61063: Computational Foundations of Cyber Physical Systems (L-T-P: 3-1-0, CRD-4)

1. What are Cyber-Physical Systems?
   i. Cyber-Physical Systems (CPS) in the real world
   ii. What are the special design considerations for CPS?
   iii. Basic principles of design and validation of CPS

2. Principles of Automated Control Design (basic control theory)
   i. ODEs, Lipschitz continuity: existence of solutions, equilibria, Stability criteria
   ii. Eigenvalues, pole placement, introduction to PID control
   iii. Stability Analysis: Lyapunov Functions (CLFs, MLFs), stability under slow switching
   iv. Tutorial: Control Design using Simulink

3. Engineering Challenges in Implementing a CPS
   i. From continuous control laws to software based control systems [1 hour]
   ii. Architectural Platforms for implementing CPS [6 hours]
      A. ECU Architectures and Real Time Operating Systems
      B. Network (e.g. WirelessHart) and Bus Protocols (e.g. Flexray)
      C. Sense and Actuation (fault tolerant algorithms for sense and actuation)
   iii. Principles of CPS Implementation [6 hours]
      A. From features to software components
      B. Mapping software components to ECUs: Real Time Scheduling strategies
      C. Performance Analysis - effect of scheduling, bus latency, sense and actuation faults on control performance
   iv. Tutorial: Control, Bus and Network Scheduling using Truetime

4. Safety and Security Assurance of Cyber-Physical Systems
   i. Advanced Automata based modeling and analysis: [4]
      A. Basic introduction and examples
      B. Timed and Hybrid Automata
      C. Definition of trajectories, zenoness
      D. Formal Analysis: Flowpipe construction, reachability analysis
   ii. Analysis of CPS Software: [4]
      A. Weakest Pre-conditions
      B. Bounded Model checking
   iii. Tutorials [4]
      A. Control Verification using Matlab Toolbox S-Talib
      B. Hybris Automata Modeling: Flowpipe construction using Flowstar, SpaceX and Phaver tools
      C. CPS SW Verification: Frama-C, CBMC
      A. Attack models
      B. Secure Task mapping and Partitioning
      C. State estimation for attack detection

5. CPS Case studies and Tutorials
   i. Automotive and Avionics: SW controllers for ABS, ACC, Lane Departure Warning, Suspension Control etc.
   ii. Flight (pitch, yaw, roll) Control Systems
   iii. Heathcare: Artificial Pancreas
   iv. Mass Transportation: European Train Control Systems (ETCS)

Component III. Project

For this project, one guide should be from the parent department of the student and other can be from ATDC.

Possible area project/topic:

1) Embedded control for electrical and electronic devices
2) Developing plant models and controller logic for automotive systems
3) Evaluating performance of a developed algorithm in an actual real time environment with various constraints, resource management and performance metrics
4) Developing xEV diagnostic algorithms for onboard application
5) Embedded Sensing System
6) Energy harvesting applications
7) Embedded applications in biomedical
8) Secure CPS framework design
9) Secure analytics on IoT sensor data
   10) Encrypted computation on IoT sensor data
**Name of the Micro-Specialization:** Artificial Intelligence and Applications

1. **School/Center:** Centre of Excellence in Artificial Intelligence

2. **Brief Description:**
   This micro-specialization comprises of two foundation courses, one on Artificial Intelligence and the other on Machine Learning along with two elective courses related to Artificial Intelligence and Applications. The foundation course on AI introduces fundamental techniques of AI along with a gamut of real-life problems where AI techniques can be successfully applied. This course spans across different layers – knowledge representation and logic; search and reasoning frameworks; planning, learning, and communication and interaction. The foundation course on Machine Learning introduces the foundational topics in Machine Learning along with several applications. The course includes a laboratory for hands-on implementation. There is a diverse elective list that includes courses on mathematical foundations and various aspects of AI and Machine Learning and their applications. A student needs to take 2 electives.

3. **Number of Subjects needed to earn the Micro-Specialization:** 4

4. **Credits needed to earn the Micro-Specialization:** 15 credits

5. **Structure:**
   
   **A. COMPONENT- I: (MANDATORY REQUIREMENT) FROM TABLE-I**

<table>
<thead>
<tr>
<th>Subject No</th>
<th>Subject name</th>
<th>L-T-P</th>
<th>Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI42001</td>
<td>Machine Learning Foundations And Applications</td>
<td>3-0-3</td>
<td>5</td>
</tr>
<tr>
<td>AI61005</td>
<td>Artificial Intelligence Foundations And Applications</td>
<td>3-1-0</td>
<td>4</td>
</tr>
</tbody>
</table>

   **B. COMPONENT-II: ANY TWO SUBJECTS (3/4 credits each) FROM TABLE-II**

<table>
<thead>
<tr>
<th>Subject No</th>
<th>Subject name</th>
<th>L-T-P</th>
<th>Credit</th>
</tr>
</thead>
<tbody>
<tr>
<td>AI61002</td>
<td>Deep Learning Foundations And Applications</td>
<td>3-1-0</td>
<td>4</td>
</tr>
<tr>
<td>AI61003</td>
<td>Linear Algebra For AI And ML</td>
<td>3-1-0</td>
<td>4</td>
</tr>
<tr>
<td>AI60002</td>
<td>Machine Learning For Earth System Sciences</td>
<td>3-0-0</td>
<td>3</td>
</tr>
<tr>
<td>AI61004</td>
<td>Statistical Foundation For Artificial Intelligence And Machine Learning</td>
<td>3-1-0</td>
<td>4</td>
</tr>
</tbody>
</table>

   More elective courses may be added to this list from time to time.

**NOTE:** Students opting for Dual Degree program at COEAI will not be eligible for getting this Micro-specialization