Micro-Specialization

The Institute proposes to offer Micro-Specializations to UG students. 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 upto 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.

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.

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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 (3/1-0-0)

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

TABLE-I

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
TE30002	Introduction to Wireless Communications	2-0-0	2	**Both Semesters**	NA

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

TABLE-II

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
TE61002	MIMO Communications	3-1-0	4	Spring	**TE30002**
TE61003	Communications Signal Processing and Algorithms	3-1-0	4	Autumn	**TE30002**
TE60003	Spread Spectrum Communications and Jamming	3-0-0	3	Autumn	**TE30002**
TE60114	Broadband Access Networks	3-1-0	4	Spring	**TE30002**
TE60008	Network Information Theory and Coding	3-0-0	3	Spring	**TE30002**

C. COMPONENT- III: PROJECT (4 credits) OR ANY ONE (3 or 4 credits) SUBJECT FROM TABLE-III

TABLE-III

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
TE60006	Communication Services and Applications	3-0-0	3	Spring	TE30002
TE60004	Telecommunications Network Security	3-0-0	3	Spring	TE30002
TE67001	Project on Embedded Wireless Systems	0-0-6	4	Both Semesters	TE30002
TE61004	Telecommunications Network Planning And Management	3-1-0	4	Spring	TE30002
TE60001	Teletraffic Engineering	3-0-0	3	Autumn	TE30002
TE61001	Telecommunication Networks and Optimizations	3-1-0	4	Spring	TE30002

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-II

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
MM61509	MEMS and Biosensor	3-1-0	4	Autumn	**MM61501**
MM61502	Biomedical Instrumentation	3-1-0	4	Spring	**MM61501**
MM61316	Biomaterials	3-1-0	4	Spring	**MM61501**

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

TABLE-III

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
MM77319	Minor Project-I	**0-0-6**	4	Autumn	**MM61501**
MM77320	Minor Project-II	**0-0-6**	**4**	Spring	**MM61501**

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

quantitative analysis of temporal and spatial features of human system in normal and diseased conditions. Human development biology: Basics-organogenesis system development. Fostering Dialogue amongst Medical sciences, Engineering sciences and Basic sciences: In terms of language, Terminology, History, Psychology, Logic interfaces, Social role and Application.

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, PCO_2 electrodes, selection criteria of electrodes.
Cardiovascular measurement: The cardio vascular system, Measurement of Blood Pressure, Blood flow, Cardiac output and Cardiac rate, Electrocardiography, Photocardio-graphy, balloistocardiography, Plethysmography, Magneta Cardiography,Cardiac pace-maker, computer applications. Measurement of Electrical Activities in Muscles and Brain: Electrimyography, Electroencephalograph and their interpretation.
Respiratory system Measurement: Respiratory mechanism, Measurement of gas volume, flow rate carbon dioxide and oxygen concentration in inhaled aided respiratory controller, Instrumentation for clinical laboratory: Measurement of pH value of blood, ESR measurements, hemoglobin measurement, oxygen and carbon dioxide concentration in blood, GS measurement, polarographic measurements, computer appilications.

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 electrochemisatry 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:-

Introduction to Materials, General structure and properties. Classification of common materials and applications. Chemical Bonding, Crystalline, Amorphous.

Melting, Solidification, Nucleation, Phase diagrams. Metal and alloys in Medical application: Stainless steel, Cobalt based alloys. Titanium based alloys (including shape memory alloys). Ceramics and glasses- bioceramics: Type of Ceramics and their classification, Calcinations, Annealing, Sintering, Nearly insert ceramics, bio-reactive glasses and glass ceramics, Calcium phosphate ceramics. Introduction to polymers: Definition, classification, Polymerization Rubber, plastics, fibres and resins and structure-properties relationship. Biodegradable polymers; Natural polymers, Composites, Pyrolitic carbon, Carbon nano tubes. Bulk Proper Surface properties and modification of surface properties. Basic principles of engineering manufacturing, methods and applications of common manufacturing processes, milling, grinding, finishing, rolling, forging, Concept of biomimetic synthesis, Preparation of fiber and wire, Fabrication of Porous Materials, Direct moulding Technique, Different advanced fabrication technique.

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-I

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
RE20001	Introduction to Reliability Engineering	2-0-0	2	Both	NA

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

TABLE-II

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

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

TABLE-III

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
RE67006	Project on System Reliability/Risk Analysis	0-0-6	4	Both	**RE20001**

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:-
Parameter Estimation, Regression analysis. Interval Estimation procedure for exponential, Gamma, Weibull, Log-normal and Fatigue life models. Point and interval reliability estimation. Testing reliability hypotheses for mean of distribution. Tests for Weibull, distribution, Reliability testing procedure, types of tests, accelerated life tests-parametric and nonparametric methods. Continuously increasing stress tests.

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

SYLLABUS:-
Concept of risk, objective and scope of risk assessment, probabilistic risk, risk perception and acceptability, Quantitative aspects of risk. Three levels of risk quantification, PRA management, preliminary hazard analysis, HAZOP and HAZAN, FMEA and FMECA analysis, Fault tree Analysis. Digraph and other approaches. Computation of Hazard probability, unavailability and other parameters using fault tree methodology. Monte Carlo Simulation technique, Event tree analysis, identification of initiating events, sequence and scenario development, system analysis, external events and dependent failures and quantification, Accident-consequence Analysis, uncertainty analysis, sensitivity analysis and importance measures, Bayesian approaches. Human Reliability Analysis.

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 :-

Functional Designs, design simplifications, de-rating and human factors and optimal design selection. Allocation problem, reliability, redundancy and optimal reliability and redundancy allocation. Failure and repair rate allocation. Various design problems and their relevant solution techniques. Optimal maintenance strategies. Spare parts provisioning and policies. Optimal manpower planning.

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

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
RT30001	Basic Science and Technology of Rubbers	2-0-0	2	Autumn	NA

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

TABLE-II

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
RT60016	Engineering Design with Rubbers	3-1-0	4	Spring	**RT30001**

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

TABLE-III

Sub no.	*Sub Name*	*LTP*	*Credits*	*Offering Semester*	*Pre-Requisite (if any)*
RT30003	Processing of Rubbers and Rubber like Materials	3-1-0	4	Autumn	**RT30001**

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-I

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
MS60009	Fundamentals of Electronic Materials	3-0-0	3	Both	NA

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

TABLE-II

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
MS61015	Materials for High Frequency Applications	3-1-0	4	Autumn	**MS60009**
MS31001	Photonic Materials & Applications	3-0-0	3	Autumn	**MS60009**
MS60032	Optoelectronic Materials and Devices	3-1-0	4	Spring	**MS60009**
MS67103	PROJECT*	0-0-6	4	Both	**MS60009**
MS61015	Materials for High Frequency Applications	3-1-0	4	Autumn	**MS60009**

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

TABLE-III

Sub no.	*Sub Name*	*LTP*	*Credits*	*Offering Semester*	*Pre-Requisite (if any)*
MS60023	Epitaxy of Compound Semiconductors	3-1-0	4	Autumn	**MS60009**
MS60044	Technology of Ceramics for Electronic Applications	3-1-0	4	Spring	**MS60009**
MS60052	Introduction to Nanotechnology and Nano-structured Materials	3-1-0	4	Spring	**MS60009**
MS60038	Polymers for Electronic and Photonic Applications	3-1-0	4	Spring	**MS60009**
MS67104	PROJECT*	0-0-6	4	Both	**MS60009**

***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-I

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
ES30001	Introduction to Bioenergy	2-0-0	2	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)
BT41002	Bioresource Technology	3-0-0	3	Spring	**ES30001**
CH60016	Fundamentals Of Bioenergy	3-0-0	3	Spring	**ES30001**
BT41013	Bioreactor Analysis And Design	3-0-0	3	Autumn	**ES30001**
ES60002	Waste To Wealth: Microbial Intervention	3-1-0	4	Spring	**ES30001**

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

TABLE-III

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

**** 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:

1. Bioenergy, Judy D. Wall, Caroline S Harwood, Arnold Demain, ASM Press, Washington. DC2008
2. Biogas from Waste and Renewablke sources, Dieter Deublein and Angelika Steinhauser, Wiley-VCH , Weinheim, 2011
3. Biohydrogen production: Fundamentals and Technology advances, D.Das, N. Khanna, C. NagDasgupta, CRC Press, New York, 2014

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; Biofertlizers; Value added product development and its cost effective recovery; Conventional and nonconventional techniques adopted for product

Reference Books:

1. Environmental Microbiology by Raina M. Maier, Ian L. Pepper, Charles P. Gerba, Academic Press Elsiver 2006.
2. Environmental Biotechnology by Bhattacharyya BC and Banerjee R, Oxford Univ Press, 2007.
3. Manual of Environmental Microbiology by Christon J. Hurst, Guy R. Knudsen, Michael J. McInerney, Linda D. Stetzenbach, Michael V. Walter, ASM Press Washington DC, 1997.

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.

Introduction: Biomass, diversity, sources, availability etc. Constitutional analysis of biomass: Qualitative and quantitative Proximate and ultimate analysis of biomass. Biochemical analysis using analytical tools: Total carbon, total organic carbon, protein, nitrogen, carbohydrate (Starch, cellulose, hemicellulose), lipid, total sugar, reducing sugar, non-reducing sugar, pectin and fibre, 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.

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 CH_4, CO_2, CO, H_2S, 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.

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.

Module No.	Course Content	Class Hours
1	Introduction: Biomass, diversity, sources, availability etc. Constitutional analysis of biomass: Qualitative and quantitative Proximate and ultimate analysis of biomass.	3
2	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.	5

3	Analysis of liquid bio-fuel such as Bio-ethanol ,Bio-butanol ,Bio-alkanes ,Bioalkenes ,Biodiesel	5
4	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	10
5	Analysis of gaseous bio-fuel: Determination of CH_4, CO_2, CO, H_2S, 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	6
6	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.	7
7	Advanced tools and techniques for bio-fuel research	6

Reference Books:

1. Catalysis for the Conversion of Biomass and Its Derivatives, by M.a.A.D. Behrens, Ed. Berlin, Germany: Max Planck Research Library for the History and Development of Knowledge.
2. Introduction to Biomass Energy Conversions by Sergio Capareda, CRC Press, 2013
3. Plant Biomass Characterization: Application of Solution- and Solid-State NMR Spectroscopy. In: Aqueous Pretreatment of Plant Biomass for Biological and Chemical Conversion to Fuels and Chemicals by Yunqiao Pu, BassemHallac and Arthur J. Ragauskas, John Wiley & Sons, Ltd, 2013
4. Analytical Methods And Techniques Applied To Crude Oil And Petroleum Products by James G. Speight, Encyclopedia of Life Support Systems(EOLSS)
5. Biodiesel Analytical Methods by J. Van Gerpen, B.Shanks, and R. Pruszko; D. Clements; G. Knothe. National Renewable Energy Laboratory, 2004.

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**: In the rapidly changing corporate world, innovation and entrepreneurial leadership skills of executives are inevitable for any business to remain competitive, agile, and grow. Leaders need to pre-empt the constantly changing aspirations of the customers, fast-changing technologies, and evolving management tools to remain ahead of the competition. The proposed micro specialization has been structured to impart entrepreneurial knowledge in diverse areas of venture management to future executives. The course will equip the students with the necessary competencies to effectively use innovative thinking, stay future-ready, resolve challenges and risks, and maximize value creation for the organizations they will manage and new ventures they may create.
3. **Minimum number of Subjects needed to earn the Micro-Specialization: 4**
4. **Credit needed to earn the Micro – Specialization : 12**
5. **Structure: A. Any one subject from Component–I below, B. At least two subjects from Component–II; and C. At least one theory subject or two lab subjects from Component–III below. The student has the flexibility to choose any subject from different components in any sequence following the above guidelines (No prerequisite).**

A. COMPONENT- I: (Any ONE of the following subjects)

TABLE-I

Sub no.	Sub Name	LTP	Credits	Offering Semester
EP61201	Entrepreneurship Essentials	3-1-0	4	Autumn & Spring
EP60020	Foundations of Entrepreneurship	3-0-0	3	
EP21201	Introduction to Innovation and Entrepreneurship	3-0-0	3	

B. COMPONENT- II (At least TWO subjects from this component)

TABLE-II

Sub no.	Sub Name	LTP	Credits	Offering Semester
EP60021	Engineering B-Plan Development – I	2-1-0	3	Autumn
EP60042	Engineering Design Process	3-0-0	3	Spring
EP60003	Product Development	3-0-0	3	Autumn
EP60006	Management of Growth venture	3-0-0	3	Spring
EP60007	Techno-Entrepreneurial Leadership	3-0-0	3	Autumn
EP60018	Innovation Management	3-0-0	3	Spring
EP60008	Economics of Entrepreneurship	3-0-0	3	Spring
EP60038	Entrepreneurship in Social Sector	3-0-0	3	Autumn
EP60029	Small Business Development	3-0-0	3	Autumn
EP60025	Special Topics in Entrepreneurship	3-0-0	3	Autumn
EP60005	Financial and Legal aspects of business	3-0-0	3	Autumn
EP60010	Financing New Venture	3-0-0	3	Spring
EP60022	Technology Entrepreneurship	3-0-0	3	Spring
EP60046	Crop Protection Chemicals & Technopreneurship Development	3-0-0	3	Spring
EP60044	Frugal Engineering	3-0-0	3	Autumn
EP60011	Design-Driven Innovation	3-0-0	3	Autumn
EP60201	Digital Entrepreneurship	3-0-0	3	Autumn
EP60004	Manufacturing Management	2-1-0	3	Spring
EP60002	Marketing and Market Research	2-1-0	3	

C. COMPONENT- III: (At least ONE theory OR TWO labs from this component)

TABLE-III

Sub no.	Sub Name	LTP	Credits	Offering Semester
EP61205	Innovation in Product Development Process	3-1-0	4	Autumn
EP61202	Operations & Supply Chain Management	3-1-0	4	Spring
EP61204	Technopreneurial Marketing	3-1-0	4	Spring
EP61203	Financial and Legal aspects of New Technology Ventures	3-1-0	4	Autumn
EP69201	Design Thinking Lab	0-0-3	2	Autumn
EP69202	Product Prototyping Lab	0-0-3	2	Spring

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-I

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
CY20103	Organic Chemistry-I	2-0-0	2	Autumn	NA
BT21101	Biochemistry	3-1-0	4	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)
CY41018	Structure and Function of Biomolicules	3-0-0	3	Spring	**CY20103 or BT21101**
CY60004	Biophysical Chemistry	3-0-0	3	Spring	**CY20103 or BT21101**
BT60007	Computation Structural Biology	3-1-0	4	Autumn	**CY20103 or BT21101**
BT61030	Protein Engineering	3-0-0	3	Spring	**CY20103 or BT21101**
BS60001	Pharmacokinetics and Pharmacogenomics	3-0-0	3	Autumn	**CY20103 or BT21101**
BS41004	Advances in Protein Structure & Function	3-1-0	4	Spring	**CY20103 or BT21101**
BS41002	Structure Determination of Biomolecules	3-1-0	4	Spring	**CY20103 or BT21101**

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

TABLE-III

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
CY60005	Drug design and development	3-0-0	3	Autumn	**CY20103 or BT21101**
CY61030	Medicinal Chemistry	3-0-0	3	Spring	**CY20103 or BT21101**
BS67001	Project/Term Paper	0-0-6	4	Both	**CY20103 or BT21101**

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 hos 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-I

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
CH61011	Adv. Fluid Mechanics	3-1-0	4	Autumn	NA
ME61003 OR ME61201	Advanced Fluid Mechanics **OR** Fluid Dynamics	3-1-0	4	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)
CH62039	Micro Scale Transport Process	3-0-0	3	Autumn	**CH61011 or ME60011**
CH30012	Transport Phenomena	3-1-0	4	Spring	**CH61011 or ME60011**
NT70002	Introduction to Nano Technology	3-1-0	4	Spring	**CH61011 or ME60011**
ME60310	Micro Fluidics	3-1-0	4	Spring	**CH61011 or ME60011**

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

TABLE-III

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
CH62052	Instability and patterning of thin polymer films	3-1-0	4	Spring	**CH61011 or ME60011**

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/ PH60030	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
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

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
I**M40001**	Introduction to industrial safety	2-0-0	2	Both	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)
IM60045	Engineering Systems Safety Design And Control	3-1-0	4	Autumn	I**M40001**
IM61020	Safety Analytics	3-1-0	4	Spring	I**M40001**
RE60018	Fault Diagnosis And Predictive Maintenance	3-1-0	4	Spring	I**M40001**
RE60011	Probabilistic Risk Assessment	3-1-0	4	Autumn	I**M40001**
CH62038	Hazard Analysis And Risk Management In Chemical Industry	3-1-0	4	Spring	I**M40001**
MI60058	Fire Safety Engineering	3-0-0	3	Spring	I**M40001**
MI50003	Rescue And Disaster Management	3-0-0	3	Autumn	I**M40001**
MI45008	Safety Engineering	3-0-0	3	Spring	I**M40001**

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

TABLE-III

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite
IM67003	Project/design/term paper	0-0-6	4	Both	I**M40001**

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-I

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
ET30002	Intelligent Tutoring system	2-0-0	2	Spring	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)
ET61002	Language Processing for e-learning	3-1-0	4	Spring	**ET30002**
ET60019	Knowledge Modelling and Semantic Technology	3-0-0	3	Autumn	**ET30002**
ET60021	Intelligent Game Design	3-0-0	3	Autumn	**ET30002**

C. COMPONENT- III: PROJECT (4 credits)

TABLE-III

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
ET67003	Learning System Design Project	0-0-6	4	Autumn	**ET30002**

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

1. Intelligent Tutoring Systems: An Overview, Hyacinth S. Nwana, Artificial Intelligence Review, (1990) 4, 251-277
2. Theoretical Foundations for Intelligent Tutoring Systems, John Self, Journal of Artificial Intelligence in Education, 1990, 1(4), 3-14
3. (1990), 42(1), 7-49
4. The Construction and Application of Student Models in Intelligent Tutoring Systems, Journal of Computer and Systems Sciences, 1994, 32(1).
5. Cognitive Mastery Learning in the ACT Programming Tutor, Albert Corbett, AAAI Technical Report, 2000
6. Cognitive Tutors: Lessons Learned, Anderson et al., Journal of the Learning Sciences, 1996, 4 (2)
7. Instructional Interventions in Computer Based Tutoring: Differential Impact on Learning Time and Impact, Albert Corbett and Holly Trask, Proceedings of ACM CHI'2000
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,
9. Using Bayesian Networks to Manage Uncertainty in Student Modelling, Conati C., Gertner A., VanLehn K. User Modelling and User-Adapted Interaction. (2002) 12(4)
10. A New Paradigm for Intelligent Tutoring Systems: Example-Tracing Tutors, Aleven et al., International Journal of Artificial Intelligence in Education 19 (2009) 105-154
11. The Behavior of Tutoring Systems, Kurt VanLehn, International Journal of Artificial Intelligence in Education, 2006, 16

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, NitinIndurkhya, Fred J. Damerau
3. Computer-Assisted Language Learning: Context and Conceptualization, Michael Levy
4. Automated Essay Scoring: A cross disciplinary perspective, MD Shermis, J Burstein
5. Handbook of Automated Essay Evaluation: Current Applications and New Directions edited by Mark D. Shermis, Jill 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

3. A Comparative Evaluation of Deep and Shallow Approaches to the Automatic Detection of Common Grammatical Errors, Proceedings of Empirical Methods in Natural Language Processing 2007, Joachim Wagner, Jennifer Foster and Josef van Genabith
4. Self-Assessment of Motivation: Explicit and Implicit Indicators in L2 Vocabulary Learnin, Proceedings of the 15th International Conference on Artificial Intelligence in Education, Dela Rosa, K. and Eskenazi, M.
5. Reconstructing readability: Recent developments and recommendations in the analysis of text difficulty. Educational Psychology Review, 24, Benjamin, R. (2012).
6. A connectionist multiple-trace memory model for polysyllabic word reading. Psychological Review; Psychological Review, 105(4):678, Ans, B., Carbonnel, S., and Valdois, S. (1998).
7. Early decomposition in visual word recognition: Dissociating morphology, form, and meaning. Language and Cognitive Processes, 23(3):394–421, Marslen-Wilson, W., Bozic, M., and Randall, B. (2008).
8. Morphology and meaning in the english mental lexicon. Psychological Review, 101(1):3, Marslen-Wilson, W., Tyler, L., Waksler, R., and Older, L. (1994).
9. Abstractness, allomorphy, and lexical architecture. Language and Cognitive Processes, 14(4):321–352, Marslen-Wilson, W. and Zhou, X. (1999).
10. Coh-metrix: Analysis of text on cohesion and language. Behavior Research Methods, 36(2):193–202, Graesser, A., McNamara, D., Louwerse, M., and Cai, Z. (2004).
11. Predicting reading difficulty with statistical language models. Journal of the American Society for Information Science and Technology, 56(13):1448–1462, Collins-Thompson, K. and Callan, J. (2005).
12. The Automated Text Adaptation Tool, Jill Burstein, Jane Shore, John Sabatini, Yong-Won Lee & Matthew Ventura, ACL 2007
13. A monolingual tree-based translation model for sentence simplification, Zhemin Zhu, Delphine Bernhard, and IrynaGurevych, 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

- explain features, rational and advantages of semantic web technologies
- describe and compare features of markup languages for semantic web
- explain semantic data modelling through RDF and RDF schema
- analyse the requirements and features of web ontology language (OWL)
- explain description logic framework as semantics of OWL
- build and analyse ontologies with ontology editors
- use programming paradigms for working with RDF data model and OWL
- analyze application scenarios in data integration, data exchange, knowledge management, e-learning, and digital library.

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

1. Education and the Semantic Web, Vladan Devedzic, International Journal of Artificial Intelligence in Education, 2004, 14
2. Ontologies and Semantic Web for E-Learning, D. Dicheva, Handbook on Information Technologies for Education and Training, 2008

3. Key Issues in Next-Generation Web-Based Education, Vladan B. Devedzic, IEEE Transactions on Systems, Man and Cybernetics, 2003, 33(3)
4. JeromeDL–adding semantic web technologies to digital libraries, SR Kruk, S Decker, L Zieborak, Database and Expert Systems, 2005
5. Defrosting the Digital Library: Bibliographic Tools for the Next Generation Web, Duncan Hull, Steve R. Pettifer, Douglas B. Kell, PLOS Biology, 2008

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, pathfinding, 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. AI for Game Developers, David Bourg and Glenn Seemann, O'Reilly

References

1. Narratology for Interactive Storytelling: A Critical Introduction. Marc Cavazza, David Pizzi. TIDSE 2006
2. A Platform for Symbolically Encoding Human Narratives. David K. Elson, Kathleen R. McKeown. 2007. In Proceedings of the AAAI 2007 Fall Symposium on Intelligent Narrative Technologies
3. Cinematic Visual Discourse: Representation, Generation, and Evaluation. ArnavJhala and R. Michael Young, (under review) IEEE Transactions of Computational Intelligence and AI in Games, 2010.
4. A Declarative Model for Simple Narratives. Raymond Lang. In Narrative Intelligence, Michael Mateas and Phoebe Sengers (Ed.). 2003.
5. An Intent-Driven Planner for Multi-Agent Story Generation. Mark Riedl and R. Michael Young. Proceedings of the 3rd International Joint Conference on Autonomous Agents and Multi Agent Systems, New York, 2004

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-I

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
IP60133	General Principles of Law for Engineers	2-0-1	3	Autumn	NA

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

TABLE-II

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
IP60102	Copyright	3-1-0	4	Spring	**IP60133**
IP60119	Law Of Patent-I	3-1-0	4	Autumn	**IP60133**
IP60123	Trademark And Design	3-1-0	4	Autumn	**IP60133**
IP60129	IP Management And Technology Transfer	3-1-0	4	Autumn	**IP60133**

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

TABLE-III

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
IP60174	Intellectual Property and Competition law	2-1-0	3	Spring	**IP60133**
IP60158	Competition law	2-1-0	3		**IP60133**
IP60164	Music and entertainment Industry law	2-1-0	3		**IP60133**

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

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
MA30014	Operations Research	3-0-0	3	Spring	NA
MA39014	Operations Research Lab	0-0-3	2	Spring	**MA30014**

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

TABLE-II

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
MA41010	Non linear Programming	3-1-0	4	Spring	**MA30014 and MA39014**
MA41109	Optimization by Vector Space Method	3-1-0	4	Spring	**MA30014 and MA39014**

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

TABLE-III

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
MA61061	Optimization Methods in Finance	3-0-0	3	Autumn	**MA30014 and MA39014**
MA60044	Multi Objective Programming	3-1-0	4	Spring	**MA30014 and MA39014**
MA61053	Numerical Optimization	3-1-0	4	Autumn	**MA30014 and MA39014**

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 counter parts 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-I

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
RD30005	Fundamentals of Rural Innovation and Management	3-0-0	3	Both	NA

B. COMPONENT- II ANY TWO SUBJECTS (3/4 credits) FROM TABLE-II (One each from 2 Elective groups)

TABLE-II

Sub No.	Name	L-T-P	Credit	Offering Semester	Pre-requisite (if any)
Elective I (Technology component)					
RD30007	Transfer and Adoption of Rural Technology	3-0-0	3	Both	**RD30005**
RD30006	Food Processing and Agri-value Chain	3-0-0	3	Spring	**RD30005**
RD30009	Economics of Rural sectors	3-0-0	3	Autumn	**RD30005**
Elective II (Management component)					
AG60002	Alternative energy sources	3-1-0	4	Spring	**RD30005**
RD30011	Rural Infrastructure Development and Management	3-0-0	3	Both	**RD30005**
EP60020	Foundations of Entrepreneurship	3-0-0	3	Both	**RD30005**

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

TABLE-III

Sub No.	Name	L-T-P	Credit	Offering Semester	Pre-requisite (if any)
RD67001	Project/design/term paper	0-0-0	4	Both	**Subjects of Table I and Table II**

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-I

Sub no.	Sub Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
TS70009	Methods In Molecular Simulations	3-1-0	4	Spring	NA

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

TABLE-II

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

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

TABLE-III

Sub No.	Name	L-T-P	Credit	Offering Semester	Pre-requisite (if any)
TS67001	Project/ term paper	0-0-0	4	Both	**TS70009**

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-I

Sub no.	Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
RE30003	Introduction to Quality	2-0-0	2	Both	Uploaded in ERPand Approved by Senate

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

TABLE-II

Sub no.	Name	LTP	Credits	Offering Semester	Pre-Requisite (if any)
RE60015 (OR) IM 31005	Statistical Process Control (OR) Quality Design and Control	3-0-0 3-1-0	3 4	Spring Spring	RE30003
RE60005	Quality of Services Analysis in Cloud Computing	4-0-0	4	Spring	RE30003
RE60025	Software Quality Assurance	3-0-0	3	Autumn	RE30003
IM 31002 (OR) IM 60062	Quality Engineering (OR) Six Sigma Fundamentals & Applications	3-1-0 3-0-0	4 3	Autumn Spring	RE30003
IM 60057	Total Quality Management	3-0-0	3	Spring	RE30003

C. COMPONENT- III PROJECT/DESIGN/TERM PAPER (4 credits) OR ONE (3/4 credit) SUBJECT

TABLE-III

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

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.

Detailed Syllabi of Courses

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

Basic concepts of Quality, Quality philosophies, Quality Costs and Statistics for Quality, Applications of Quality in Day-to-day Life: Air, Water, Food, and Power Quality. Quality Management Practices, Tools and Standards, Concepts of Service quality, Customer relations, Design for Quality, Concepts of Quality Control and Acceptance Sampling, Concepts of zero defects and six sigma, Quality Improvement- Roles of Management, Manufacture and Operators, Vendor Relations, Inspection and Tests, Quality Measurement, Field Relations and Quality

Text Books:
AmitavaMitra, “Fundamentals of Quality Control and Improvement”, Wiley.
J.M. Juran and Frank M. Gryna, Jr., “Quality Planning and Analysis”, McGraw-Hill.
InteazAlli, “Food Quality Assurance: Principles and Practices’, CRC Press.
J. Andres Vasconcellos, “Quality Assurance for the Food Industry: A Practical Approach”, CRC Press
E. Alley, “Water Quality Control Handbook”, WEF Press.
Angelo Baggini, “Handbook of Power Quality”, Wiley.

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)**
Basics of Cloud Computing: Definition, Characteristics, Architecture, Service Models, Deployment Models, Virtualization: Server, Storage, Network, Desktop; Hypervisor, Virtual Machine, Multi-tenancy, Opportunities and Risks, Quality Concepts, Quality Control, Quality Assurance Strategies. (**2 Lectures**)
Cloud System Reliability: Risks of Essential Cloud Characteristics, Risks of Service Models, Risks of Deployment Models, Risk Management, Risk Hedging, Reliability and Availability Risks of Virtualization, Reliability Analysis of Virtualization Techniques, Software Failure Rate Analysis,Failure analysis of Cloud System, Eight - Ingredient Framework,Reliability modeling, Service Reliability Metrics, Reliability Evaluation, Design Principles for Reliable Cloud, Availability and Disaster Recovery, Service Availability Metric, Hardware reliability, Capacity Planning, Capacity Management Risks, Recovery Models, Recovery Oriented Computing. (**15 Lectures**)
Cloud Security: Cloud Security Fundamentals, Vulnerability Assessment, Security and Privacy in Cloud, Cloud Computing Security Architecture: Identity Management and Access Control, Autonomic Security; VM Specific Security Techniques. (**3 Lectures**)
Cloud performance: Real time monitoring, Scheduling, admission control, traffic control, dynamic resource provisioning. (5 Lectures)
Cloud Service Level Agreement (SLA): Definition, Contract Design, Types of SLA, SLA Life Cycle, Issues **Related to Cloud SLA, SLA Frameworks:**WS-Agreement, WSLA, WSOL, Slang, Bilateral 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:
Software Quality Assurance by Daniel Galin, Pearson/Addison Wesley Publishing, 2009
Software Quality: Theory and Management by Alan C. Gillies, Thomson Computer Press, 1997
Software Testing and Quality Assurance by KshirsagarNaik and PriyadarshiTripathi, Wiley, 2008
Handbook of Software Quality Assurance edited by G. Gordon Schulmeyer, Artech House, 2008

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

SYLLABUS :-
Prerequisites: IM31005 Quality Design and Control Experimental designfundamentals; 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.

Books: Montgomery, D.C.(2004), Design and Analysis of Experiments, John Wiley

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

SYLLABUS :-
Prerequisites: IM21003 Operations Research-1

History and Evolution of Quality Control and Management.Management of Quality: Meaning of Management of Quality, Quality Engineering, Strategic Management of Quality, Management Programs for Quality, Fundamentals of Total Quality Management (TQM), Quality Loop, Quality System Standards (ISO 9000).Probability Models for Quality Control, Descriptive Statistics, Sampling, and Inferences.Statistical Process Control (SPC):(a)Control Chart Principles: Causes of Variation, Statistical Aspects of Control Charting, Concept of Rational Subgrouping, Detecting Patterns on Control Chart, (b) Control Charts for Attributes: p, np, c, u, and U charts, (c) Control Charts for Variables: R, X, S, and X charts, (d) Special Control Charts: Cusum, Trend, Modified and Acceptance, Moving Average, Geometric Moving Average, and Multivariate Control Charts, (e) Specifications and Tolerances: Natural Tolerance Limits and Specification Limits, Process Capability Ratios, and Process Capability Analysis.Acceptance Sampling: (a) Fundamental Concepts, (b)Acceptance Sampling by Attributes: Single, Double, Multiple, and Sequential Sampling Plans, MIL-STD-105E, Dodge-Romig, and ANSI-ASQC-Z1.4 Plans, Continuous Sampling Plans, (c) Acceptance Sampling by Variables: Types of Plans, Plans for a Process Parameter, Plans to Control the Lot Percent Nonconforming, MIL-STD-414 and ANSI/ASQC Z 1.9. Reliability Prediction and Life Testing: Reliability of a System, Exponential Model in Reliability, Life Testing using Exponential and Weibull Models, Fundamentals of Maintenance Management, Concept of Total Productive Maintenance (TPM).Product and Process Design: (a) Experimental Designs: Completely Randomized Design, Randomized Block Design, Latin

Square Design, (b) Factorial Experiments, (c) Taguchi Methods in Design and Quality Improvement: Taguchi Philosophy, Loss Function, S/N Ratio and Performance Measures, Experimental Design and Parameter Design in Taguchi Methods.

Textbook:
Mitra, A.Fundamentals of Quality Control and Improvement, Prentice-Hall, 2nd Edn.(1998), ISBN 0-13-645086-5

References:
Duncan, A. J., Quality Control and Industrial Statistics,
Richard D. Irwin, 5th ed. (1986).
Montgomery, D. C., Introduction to Statistical Quality Control, John Wiley, 3rd ed. (1996).
Banks, J., Principles of Quality Control, John Wiley, 1989.
Grant, E. L. and Leavenworth, R. S., Statistical Quality Control, McGraw Hill, 5th ed.(1988)

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 MalcomBalridge quality award;Identification and measurement of quality costs; Issues related to products,processes, organization, leadership, and commitment for total qualityachievement; Tools and techniques used in TQM: seven tools, new seven,essential features of QCC, ZD, Kaizen, and JITprogrammes; Fundamental conceptsabout Quality Function Deployment (QFD); Components of Total Quality System(TQS) in organizations, Quality Auditing: Introduction to ISO 9000 and 14000standards. Case studies.

Books
1. Total Qualtiy Management – Dr B Janakiraman, Prof R K Gopal – PHI, 2005
2. Quality Management Creating And Sustaining Organizational Effectiveness – CS Summers – Pearson/PHI, 2004 Keller, P. (2005). “Six Sigma Demystified”. Tata McGraw-Hill, New Delhi

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:
1. Keller, P. (2005). “Six Sigma Demystified”. Tata McGraw-Hill, New Delhi.

2. Breyfogle, F. W. III, Cupello, J. M. and Meadows, B. (2001). “Managing Six Sigma”. John Wiley and Sons, New York.
3. Pyzdek, T. (2003). “Six Sigma Handbook”. McGraw-Hill, New York.

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, ferro-resonance; 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: Terminology, Sources of water pollutants, pollution kinetics and reaction mechanism. Water Quality Standards: International and Indian Standards for drinking, irrigation, industrial and aquatic use. Water Quality Analysis: Methods and Instruments for analysis of all water quality parameters. Working principles of theInstruments. Water Purification: Mechanical, biological and membrane filters. Reverse Osmosis: Principle, application and related instruments. Water Treatment Methods: Aeration, nitrogen removal, pH control, removal of solids and gases in water, disinfection and ion-exchange. Use of chlorine, bromine, iodine, KMnO4 etc. for disinfection.
Water Treatment Plant: Components and Working Principles. Waste Water Treatment: Methods and Instruments. Water Quality Index: Principle, International and Indian standards, parameters considered for surface and ground water indexing. Water Pollution due to Pesticides and Toxic Metals: Sources of pollution and control
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 -I

Subject No	Subject name	L-T-P	Credit	Semester	Prerequisite(s)
HS62002	Science of Happiness and Wellbeing	3-0-0	3	Both	None

B. COMPONENT- II: Two subjects (Electives)

Table -II

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

C. COMPONENT- III: Project/Term Paper

Table -III

Subject no	Subject name	L-T-P	Credit	Semester	Prerequisites
RX67001	Project/Term Paper	0-0-6	4	Autumn/ Spring	None

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 of 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 quarter 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 tradtions 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:

M. Bayrami et al. Happiness and willingness to communicate in three attachment styles: a study on college students. Procedia: Social and Behavoral Sciences. Vol. 46. 2012.

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
4. The How Of Happiness: A Practical Guide to Getting The Life You Want by Lyubomirsky, Sonja
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

Warr, P. (2007). Work, happiness, and unhappiness. Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers.

Moss, J. (2016). Unlocking happiness at work: How a data-driven happiness strategy fuels purpose, passion and performance. US: Kogan Page, ISBN 9780749478070

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, Jaina, 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, Buddhis, Jaina, 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**

Chatterjee, S., & Datta, D. M. (1984). *An Introduction to Indian Philosophy.* Calcutta: University of Calcutta.

Dhillon, H. (2006). *The First Sikh Spiritual Master: Timeless Wisdom from the Life and Techniques of Guru Nanak.* Skylight Paths.

Hanh, T. N. (2015). *The Heart of Buddha's Teaching: Transforming Suffering into Peace, Joy and Liberation.* Berkely: Parallax Press.

Hanson, R., & Mendius, R. (2009). *Buddha's Brain: The Practical Neuroscience o Happiness, Love and Wisdom.* Oakland: New Harbinger Publications.

Horn, E. V. (2016). *The Little Book of Buddhist Virtue: The Buddha's teachings on happiness through skillful conduct (The Little Books of Buddhism 2).* Smashwords Publishing.

Narayana, N., Choudry, A., & Kalyanasundaram, V. B. (2017). *Happiness - Indian Perspectives.* Bangalore: Development Foundation.

Rakeshbhai, P. G. (2013). *Bliss Within.* Mumbai: Shrimad Rajchandra Adhyatmik Satsang Sadhana Kendra.

Seligman, M. E. (2002). *Authentic Happiness.* New York: Free Press.

Book: Relevant Sections from S. Dasgupta. A History of Indian Philosophy. Five Volumes. Amazon Kindle.

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

S. N.	Classes	No. of Sessions
1	Wellbeing and sports – interdependence	4
2	Physiological parameters of wellbeing	4
3	Individual difference in wellbeing	4
4	Sports and psychological skills	4
5	Sports skills and wellbeing	6
6	Bouncing back – special focus	6
	Total	30

References

1. Zullig , K. J., & White, R. J. (2010). Physical activity, life satisfaction, and self-rated health of middle school students. *Applied Research in Quality of Life.*

2. Haifang Huang nad Brad R.Humphreys, Sports participation and happiness: Evidence from US microdata, Journal of Economic Psychology, Volume 33, Issue 4, August 2012, Pages 776-793

3. Wheatley, D. & Bickerton, C. Subjective well-being and engagement in arts, culture and sport, J Cult Econ (2017) 41: 23. https://doi.org/10.1007/s10824-016-9270

4. Ruut Veenhoven, HEALTHY HAPPINESS Effects of happiness on physical health and the consequences for preventive health care, Journal of Happiness Studies, 2008 vol 9, 449-469

5. Haifang Huang∗ and Brad R. Humphreys†, Sports Participation and Happiness: Evidence from U.S. Micro Data, 2010. Semantic Scholarship.org

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 -I

Subject No	Subject name	L-T-P	Credit	Semester	Prerequisite(s)
BM63026	Advanced Business Analytics	2-0-0	2	2	None
BM63083	Time Series Econometrics	2-0-0	2	3	None

B. COMPONENT- II: Two subjects (Electives)

Table -II

Subject No	Subject name	L-T-P	Credit	Semester	Prerequisite(s)
BM63043	Supply Chain Analytics	2-0-0	2	3	None
BM63092	Marketing Analytics	2-0-0	2	3	None
BM63045	Product Analytics	2-0-0	2	4	None
BM63079	People Analytics	2-0-0	2	4	None
BM63076	Advanced Marketing Analytics	2-0-0	2	4	None

C. COMPONENT- III: Project/Term Paper

Table -III

Subject no	Subject name	L-T-P	Credit	Semester	Prerequisites
BM67011	Project I	0-0-0	2	Autumn	None
BM67012	Project II	0-0-0	2	Spring	None

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
2. Introductory Econometrics for Finance, C. Brooks, Cambridge University Press
3. The Econometrics of Financial Markets, J. Y Campbell, W. L. Andrew, and A. L. Mackinley, Princeton University Press
4. Forecasting in Economics and Business, C. W. Granger, Academic Press

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:

1. Supply Chain Management: Strategy & Analysis, Chopra, Meindl & Kalra, Pearson Education, Asia.

2. Supply Chain Management, Janat Shah, Pearson education, Asia.

3. Designing & Managing the Supply Chain, Simchi-Levi, & Kaminsky, McGraw-Hill Publication.

4. Business Logistics / SCM, Ballou & Srivastava, Pearson Education Publication.

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:

1. Marketing Analytics: Data Driven Techniques with Microsoft Excel, W.L Winston, Wiley
2. Marketing Analytics: A practical guide to real marketing science, M. Gribsby, Kogan Page Publishers
3. Marketing Analytics: Strategic Models and Metrics, S. Sorger, CreateSpace Independent Publishing Platform

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:

1. Product Design and Manufacturing, Chitale, A.K., and Gupta, R.C., Prentice Hall of India (PHI) Learning Pvt. Ltd..
2. Product Design and Development, Ulrich, K., Eppinger, S., and Goyal, A., McGraw Hill Education Pvt. Ltd.
3. Advances In Business, Operations, and Product Analytics, Drake, M.J., Pearson India Pvt. Ltd.

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.COMPONENTI: MANDATORY REQUIREMENT: (3 credit FOUNDATION COURSE)

TABLE-I

Subject No	Subject name	L-T-P	Credit	Semester	Prerequisite(s)
AT30001	Fundamentals of Embedded Control and Software	3-0-0	3	Autumn	None

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

TABLE-II

Subject No	Subject name	L-T-P	Credit	Semester	Prerequisite(s)
AT60001	Embedded Control System	4-0-0	4	Autumn	None
AT60002	Principles of Automotive Dynamics & Control	3-0-0	3	Spring	None
AT60003	Embedded Software Design and Validation	4-0-0	4	Autumn	None
AT60004	Security Aware IoT and CPS Design	3-0-0	3	Spring	None
AT60005	Embedded Machine Learning	3-0-0	3	Autumn	None
AT60006	Embedded Sensing, Actuation and Interfacing System	4-0-0	4	Spring	None
AT60008	Embedded Communication Networks	3-0-0	3	Spring	None
CS61063	Computational Foundations of Cyber Physical Systems	3-1-0	4	Autumn	None

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

TABLE-III

Subject No	Subject name	L-T-P	Credit	Semester	Prerequisite(s)
AT67005	Project	0-0-6	4	Both	None

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

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

	e. Actuators: Principles, motors, solenoids etc f. Interfacing of sensors and actuators with embedded system	
9	Embedded Motor Control System a. Dynamic Equations b. Motor transfer function c. PWM based operation d. Inverters and their control e. Closed loop motor control using microcontroller	[2]

Text Books/ References:

1. Peter Marwedel, "Embedded System Design", Springer, 3rd ed. 2018.
2. Wayne Wolf, "Computers as Components: Principles of Embedded Computing System Design", Morgan Kaufmann Series, 2008
3. Stuart R. Ball, "Analog Interfacing to Embedded Microprocessor Systems", Elsevier 2004
4. Frank Vahid and Tony Givargis, "Embedded System Design: A Unified Hardware/Software Introduction", Wiley 2006.
5. Ali Mazidi, "AVR Microcontroller and Embedded Systems" Prentice Hall.
6. K. Ogata, "Modern Control Engineering", Pearson, 2015.
7. Charles L. Phillips and H. Troy Nagle, "Digital Control System Analysis and Design", (3rd edition): Prentice Hall.
8. Lee, Leung and Son, "Handbook of Real-Time and Embedded Systems", CRC Press.
9. Edward A. Lee and Sanjit Arunkumar Seshia, Introduction to Embedded Systems: A Cyber-Physical Systems Approach, MIT Press.

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.
11:Automotive standards :Autosar, Functional Safety Standard (ISO 26262)

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

1. Introductory Lecture
2. Specification Models for Embedded Systems: Finite State Machine, Concurrent State Machine, Hierarchical State Machine/State Charts, Message Sequence Chart, Timed Automata, Hybrid Automata
3. Model/Implementation Validation:Temporal Logic,Model Checking, Program verification (using CBMC)
4. Communication Validation : Protocol Converter Synthesis
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)

1. Security Issues of Cyber Physical System: Types of attack models in CPS, Jamming attack in CPS and Anti-jamming, Case Study:Jamming Attacks on Mobile CPS in Target Tracking Applications.

2. FSM based and Graph based Security Aware CPS design

3. Security aware CPS design methodologies: Security mechanisms for CAN, Security aware TDMA Based Real Time System, Security mechanisms for V2V Communication

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.

7. Authentication/Authorization for Smart Devices:Transport Encryption, Secure Cloud/Web Interface, Secure Software/Firmware, Physi-cal Layer Security.

8. IOT Node Authentication: Public-Key-Based Authentication, Identify-Based Authentication, Lightweight Cryptography.

9. Security in Enabling Technologies: Security in Identification and Tracking Technologies, Security in Integration of WirelessSensor Network and RFID

10. Security Challenges for cloud assisted IoT applications: Secure data sharing challenges, Encrypted Computation. Case Studies: Security forIOT in Retail and Health-care.

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.

3. Interfacing of Sensors and actuators to embedded controller: Signal conditioning circuit, loading effect, Op-Amp based circuit implementation, ADC, DAC, environmental effects, Driver circuits and elements, Signal Processing: Sampling, Z-transform, Digital Filters.

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.

6. Miniatuarized sensors, actuators and interface: Requirement of miniatuarization, Technology used, Various types of miniaturized sensors and actuators, Working Principle, CMOS compatible miniatuarization process, System-on-Chip integration, Applications.

7. Energy Harvesting and its applications in embedded network: Energy harvesting techniques: Vibration: Piezoelectric, Electromagnetic,; Solar, RF; Interfacing circuits; Sensors and Actuators in Wireless networks, Power sources to embedded system: battery, Supercapacitor, Power Management circuits-Buck/boost/switched capacitor converter, Applications

8. Security aspects of cyber physical sensor system: System concepts and applications, Various attacks on sensor systems and their remedies.

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

2. Communication Protocols for Embedded Systems: Inter System Protocol and Intra System Protocol; -Inter system protocol: USB Communication protocols, UART Com-munication protocols, USART Communication protocols; -Intra System Communication Protocols: I2C Protocol, SPI Protocol, CAN Protocol, CAN FD; Flexray, JTAG and Boundary Scan.

1. Advanced Topics: Industrial control network: Modbus, Smart Grid Communication Protocol Standards, Time Sensitive Networking, Remote Upgrade of Firmware, Automotive Ethernet and Time triggerred ethernet, Communication standards for IIoT.
2. Dependable I/O Systems: Redundancy, Dependable Individual Sensors and Actuators, Fieldbus, Intelligent I/O
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

5. Basics of Fault Tolerance Computing: Faults and their manifestation, System Fault Response stages, Reliability and Availability Techniques in Embedded System, Fault Injection , Basics of hardware fault tolerance and software fault tolerance.

6. Fault Tolerance Analysis of Safety-Critical Embedded Systems : Fault tolerant net-work, Software Defect Masquerade Faults in Distributed Embedded Systems, Critical Message Integrity Over a Shared Network, Fault Tolerance Tradeoffs in Moving from Decentralized to Centralized Embedded Systems.

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 1 C. Performance Analysis - effect of scheduling, bus latency, sense and actuation faults on control performance D. Methods for Robust CPS implementation 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-Taliro B. Hybris Automata Modeling : Flowpipe construction using Flowstar, SpaceX and Phaver tools C. CPS SW Verification: Frama-C, CBMC iv. Secure Deployment of CPS [6] 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, Flight (pitch, yaw, roll) Control Systems ii. Heathcare : Artificial Pancreas iii. 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

(Prior to 2023 admission batch)

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 - I

Subject No	Subject name	L-T-P	Credit
AI61005	Artificial Intelligence Foundations And Applications	3-1-0	4
AI42001	Machine Learning Foundations And Applications	3-0-3	5

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

Table – II

Subject No	Subject name	L-T-P	Credit
AI61002	Deep Learning Foundations And Applications	3-1-0	4
AI61003	Linear Algebra For AI And ML	3-1-0	4
AI60002	Machine Learning For Earth System Sciences	3-0-0	3
AI61004	Statistical Foundation For Artificial Intelligence And Machine Learning	3-1-0	4
AI61006	Artificial Intelligence For Cyber Physical Systems	3-1-0	4
AI61009	Artificial Intelligence For Manufacturing	3-1-0	4
AI60003	Artificial Intelligence For Economics	3-0-0	3
AI60004	Big Data Processing	3-0-0	3
AI60006	Dependable And Secure AI-ML	3-0-0	3
AI60008	Knowledge Modelling And Semantic Web Technologies	3-0-0	3
AI60007	Graph Machine Learning: Foundations And Applications	3-0-0	3
AI60201	Graphical And Generative Models For Machine Learning	3-0-0	3

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

Name of the Micro-Specialization: Artificial Intelligence and Applications

(2023 admission batch onwards)

1. **School/Center: Centre of Excellence in Artificial Intelligence**
2. **Brief Description:**
   This micro-specialization comprises one foundation course on Artificial Intelligence and two electives 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. There is a diverse elective list that includes courses on mathematical foundations and various aspects of AI and Machine Learning and their applications.
3. **Number of Subjects needed to earn the Micro-Specialization:** *3*
4. **Credits needed to earn the Micro-Specialization: 10 credits**
5. **Structure:**

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

Table - I

Subject No	Subject name	L-T-P	Credit
AI61005	Artificial Intelligence Foundations And Applications	3-1-0	4

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

Table – II

Subject No	Subject name	L-T-P	Credit
AI42001	Machine Learning Foundations And Applications	3-0-3	5
AI61002	Deep Learning Foundations And Applications	3-1-0	4
AI61003	Linear Algebra For AI And ML	3-1-0	4
AI60002	Machine Learning For Earth System Sciences	3-0-0	3
AI61004	Statistical Foundation For Artificial Intelligence And Machine Learning	3-1-0	4
AI61006	Artificial Intelligence For Cyber Physical Systems	3-1-0	4
AI61009	Artificial Intelligence For Manufacturing	3-1-0	4
AI60003	Artificial Intelligence For Economics	3-0-0	3
AI60004	Big Data Processing	3-0-0	3
AI60006	Dependable And Secure AI-ML	3-0-0	3
AI60008	Knowledge Modelling And Semantic Web Technologies	3-0-0	3
AI60007	Graph Machine Learning: Foundations And Applications	3-0-0	3
AI60201	Graphical And Generative Models For Machine Learning	3-0-0	3
AI61201	Visual Computing with AI/ML	3-1-0	4
AI60205	Interpretable Machine Learning	3-0-0	3
AI60209	AI/ML for Robot Autonomy	4-0-0	4
AI60202	Advanced Learning Paradigms in AI	3-0-0	3

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

Name of the Micro-Specialization: Cryogenics for Energy & Environment

6. School/Center: Cryogenic Engineering Centre

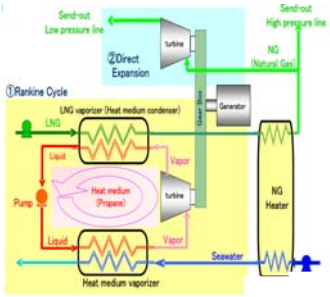
7. Brief Description:

Cryogenics is a technology pertaining to the realm of low temperature (below -150^{o}C down to absolute zero) that involves production, maintenance and application of this environment. The so called liquefied permanent gases (cryogens) such as Krypton, Methane, oxygen, argon, Nitrogen, Neon, Hydrogen and helium are the fluids that constitute this technology.

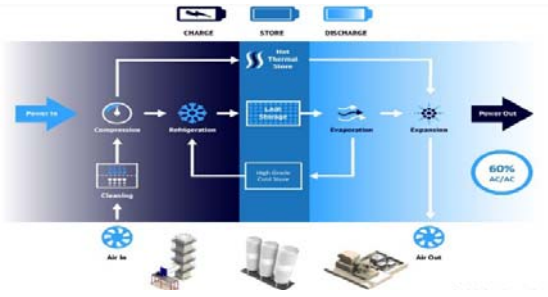
With the increase in energy demands, there is necessity for enhancing the production of energy. However, keeping the environmental concerns in mind, the energy sources should be clean to reduce the carbon footprint. Hence there is growing demand for renewable energy sources along with other clean fuel like hydrogen and fusion energy.

Cryogenics is emerging as an important technology that plays a vital role directly or as a supporting technology in realising the above mentioned goals in energy sector. A few of the major applications of cryogenic technology are:

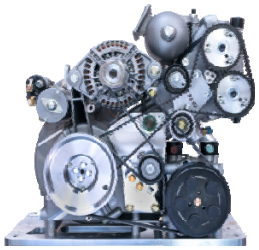
1) **Energy generation** such as using cold energy utilization of LNG, and in fusion technology

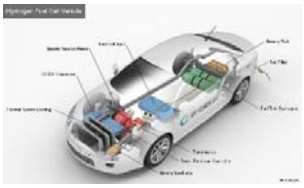


2) **Energy storage** such as cryogenic liquid air energy storage for storing renewable energy and large scale grid energy storage and superconducting magnetic energy storage systems

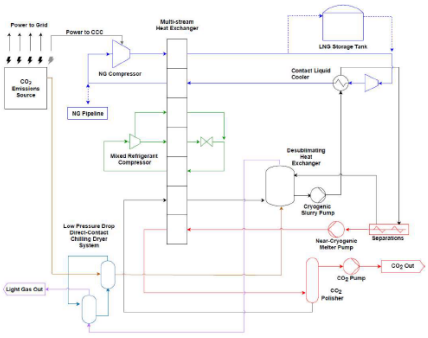


3) Transportation such as liquid air/nitrogen based engines, liquid hydrogen and LNG for space, aviation, marine and ground transport





4) Carbon capture, water treatment and desalination using cryogenic techniques



This micro-specialization, which is a unique academic programme both in the national and international level, will impart students the necessary background and exposure to the field of cryogenics with its relevance and applications in the technological domain of energy and environment. With theoretical, practical and project based approach, the course content has been developed that is envisaged to cater to the present and future need of the industry and research organisations in the field of energy. It will supplement in enhancing both the breadth and depth of the knowledgebase of the students of any branch of engineering and science in general and mechanical, chemical, electrical, aerospace, mining engineering etc. in particular.

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

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

10. Structure:

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

TABLE-I

Sl. No.	Sub No.	Name	LTP	Credits	Offering Semester
1.	CR61003	Cryogenic Liquefaction Systems And Cryocoolers	4-0-0	4	Autumn

B. COMPONENT-II: ANY TWO SUBJECTS (2/3 credits each) FROM TABLE-II

TABLE-II

Sl.	Sub No.	Name	LTP	Credits	Offering	Pre-requisite, If Any

No.					Semester	
1.	CR61014	Upstream LNG Technology	2-0-0	2	Spring	None
2.	CR61016	Downstream LNG Technology	2-0-0	2	Spring	None
3.	CR61020	Cryogenic carbon capture	2-0-0	2	Spring	None
4.	CR61012	Cryogenic Process Plants Simulation	1-0-3	3	Spring	None
5.	CR61028	Hydrogen Technology	3-0-0	3	Spring	None
6.	CR61032	Cryogenic Air Separation	3-0-0	3	Spring	None

C. COMPONENT-III: COMPULSORY SUBJECT (STUDENT TO SELECT ANYONE OF THE FOLLOWING SUBJECTS) FROM TABLE-III

TABLE-III

Sl. No.	Sub No.	Name	LTP	Credits	Offering semester	Pre-requisite, If Any
1.	CR67005	Project/Design/Term Paper (On Cryogenic Energy Storage or other relevant topics)	4-0-0	4	Autumn / Spring	None
2.	CR61001	Introduction to Cryogenics and Superconductivity	4-0-0	4	Autumn	None

Name of the Micro-Specialization: Medical Imaging, Instrumentation and Informatics

1. **School/Centre: School of Medical Science and Technology**
2. **Eligibility:** MMST students (joining in and after 2023)
3. **Brief Description:** MMST students with special interest in the field of Medical Imaging, Instrumentation and Informatics (MIII) while receiving education in the fundamental areas of medical science and technology, will be provided with an opportunity to micro-specialize in this field
4. **Number of Subjects needed to earn the Micro - Specialization:** 3 Subjects +1 Minor Project
5. **Credits needed to earn the Micro – Specialization: 10-12 credits in addition to MMST course requirements**
6. **Structure:**
    a. **Component I (Foundation subject): One Subject (3-0-0) (To be covered as a part of the MMST course)**
    b. **Component II: Two Subjects (3-1-0/ 3-0-0) (One subject to taken as additional elective subject in Semester 2 and another subject to be taken as additional elective in Semester 3)**
    c. **Component III: Minor Project (0-0-6) to be taken in Semester 4**

COMPONENT- I: MANDATORY REQUIREMENT: FOUNDATION COURSE - To be covered as a part of the MMST course

Sub No	Sub Name	L-T-P	Credits	Offering Semester	Pre-requisite/ Remarks
MM60201	Quantitative Techniques In Medicine And Biology	3-0-0	3	Autumn	To be covered as a part of the MMST course

Component II: Two Subjects (3-1-0/ 3-0-0) (One subject to taken as additional elective subject in Semester 2 and another subject to be taken as additional elective in Semester 3)

- *One subject to taken as additional elective subject (additional to MMST elective subjects) in Semester 2 from the following list:*

Sub No	Sub Name	L-T-P	Credits
MM60024	Biomedical Imaging Informatics	3-0-0	3
MM61210	Biomicrofluidics And Biomems	3-1-0	4
MM61218	Bio-Medical Devices	3-1-0	4
MM61228	Nanobio Technology Enabled Point-Of-Care	3-1-0	4
MM61504	Pattern Recognition And Machine Intelligence In Medicine	3-1-0	4
MM61506	Pathological Image Processing	3-1-0	4

- *One subject to taken as additional elective subject (additional to MMST elective subjects) in Semester 3 from the following list:*

Sub No	Sub Name	L-T-P	Credits
MM61503	Digital Image Processing And Applications	3-1-0	4
MM61505	Physics And Instrumentation Of Medical Imaging	3-1-0	4
MM61509	Mems And Biosensors	3-1-0	4
MM72333	Simulation Of Biomedical Systems	3-0-0	3
PH60039	Biophysics	3-0-0	3

Component III: Minor Project (0-0-6) to be taken in Semester 4

Sub No	Sub Name	L-T-P	Credits
MM77321	Minor Project for Microspecialization	0-0-6	4

Name of the Micro-Specialization: Molecular and Regenerative Medicine

1. **School/Centre: School of Medical Science and Technology**
2. **Eligibility:** MMST students (joining in and after 2023)
3. **Brief Description:** MMST students with special interest in the field of Molecular and Regenerative Medicine (MRM) while receiving education in the fundamental areas of medical science and technology, will be provided with an opportunity to micro-specialize in this field
4. **Number of Subjects needed to earn the Micro - Specialization:** 3 Subjects +1 Minor Project
5. **Credits needed to earn the Micro – Specialization: 10-12 credits in addition to MMST course requirements**
6. **Structure:**
    a. **Component I (Foundation subject): One Subject (3-1-0) (To be covered as a part of the MMST course)**
    b. **Component II: Two Subjects (3-1-0/ 3-0-0) (One subject to taken as additional elective subject in Semester 2 and another subject to be taken as additional elective in Semester 3)**
    c. **Component III: Minor Project (0-0-6) to be taken in Semester 4**

COMPONENT- I: MANDATORY REQUIREMENT: FOUNDATION COURSE - To be covered as a part of the MMST course

Sub No	Sub Name	L-T-P	Credits	Offering Semester	Pre-requisite/ Remarks
MM61313	Medical Biotechnology	3-1-0	4	Autumn	To be covered as a part of the MMST course

Component II: Two Subjects (3-1-0/ 3-0-0) (One subject to taken as additional elective subject in Semester 2 and another subject to be taken as additional elective in Semester 3)

- *One subject to taken as additional elective subject (additional to MMST elective subjects) in Semester 2 from the following list:*

Sub No	Sub Name	L-T-P	Credits
MM60010	Biomaterials-Tissue Interactions	3-0-0	3
MM61214	Stem Cell Biology And Therapy	4-0-0	4
MM61216	Advanced Immunology And Immunotherapeutics	3-1-0	4
MM72335	Cancer Biology	3-1-0	4

- *One subject to taken as additional elective subject (additional to MMST elective subjects) in Semester 3 from the following list:*

Sub No	Sub Name	L-T-P	Credits
MM73337	Advanced Biomaterials	3-1-0	4
MM60003	Proteomics And Metabolomics In Health And Disease	3-0-0	3
MM60009	Advances In Genome Engineering Technologies	3-0-0	3
MM61215	Animal Transgenic Technologies	3-1-0	4

Component III: Minor Project (0-0-6) to be taken in Semester 4

Sub No	Sub Name	L-T-P	Credits
MM77321	Minor Project for Microspecialization	0-0-6	4

Name of the Micro-Specialization: High-performance Computing and Applications

1. **School/Centre: Centre for Computational and Data Sciences**

2. **Brief Description:** This Micro-specialization course will primarily focus on introducing the high-performance computing (HPC) environment to students which helps them to speed up their computations. The course has been designed to have a foundation subject, where the students will learn the basic and essential tools needed to work efficiently on the HPC platforms, followed by interdisciplinary subjects that focus on the applications of HPC systems. It is suitable for students with or without a computer science background.

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

7. **Credits needed to earn the Micro – Specialization: 12 credits**

8. **Structure:**

   a. **Component I (Foundation subject): One Subject (3-1-0)**
   b. **Component II: Two subjects, with a requirement that at least one subject must be selected from the subjects offered by CCDS (3-1-0/2-0-3)**

COMPONENT- I: MANDATORY REQUIREMENT: FOUNDATION COURSE

Table - I

Sub No	Sub Name	L-T-P	Credits	Offering Semester	Pre-requisite/ Remarks
CD61002	High performance scientific computing	3-1-0	4	Autumn	Basic linear algebra and PDS (first year) or equivalent courses in computer programming.

Component II: Two Subjects (8 Credits) From Table - II

Table - II

Sub No	Sub Name	L-T-P	Credits	Offering Semester	Pre-requisite (If any)
CD61001	Quantum mechanics and quantum computing	3-1-0	4	Spring	-
CD61006	Quantum methods in molecular simulations	2-0-3	4	Spring	-
CD61004	High performance computing and its applications in complex physical systems	3-1-0	4	Autumn	-
CS61060	Computational biophysics: algorithms to applications	3-1-0	4	Autumn	-
CY62204	Classical methods of molecular simulation	2-0-3	4	Spring	-
CY62206	Modeling of quantum systems and processes	2-0-3	4	Spring	-
CS61064	High Performance Parallel Programming	3-1-0	4	Spring	-

CD61002: HIGH PERFORMANCE SCIENTIFIC COMPUTING (3-1-0)

SYLLABUS:

SPARSE MATRICES: discretization of differential equations, storage schemes for sparse matrices, permutations and reorderings, direct solution methods

ITERATIVE METHODS AND CONVERGENCE: SOR, gradient search methods: steepest descent, conjugate gradient algorithm, Krylov subspaces methods: Arnoldi's method, GMRES, symmetric Lanczos algorithm, convergence analysis, block Krylov methods, preconditioning techniques, ILU factorization preconditioners, multigrid methods.

DOMAIN DECOMPOSITION: Schwarz algorithms and the Schur complement, graph partitioning: geometric approach, spectral techniques

PARALLEL COMPUTING: architectures for parallel computing, shared and distributed memory performance metrics, parallelization of simple algorithms

MPI and OpenMP: basic MPI and OpenMP calls, parallelizing matrix solvers using domain decomposition

CUDA: GPGPU architecture, thread algebra for matrix operations, accelerating matrix solvers using CUDA

CD61001: QUANTUM MECHANICS AND QUANTUM COMPUTING (3-1-0)

SYLLABUS:

FUNDAMENTAL CONCEPTS: Stern-Gerlach experiment, kets, bras and operators, base kets and matrix representations measurements, observables and the uncertainty relations, change of basis, position, momentum and translation, wave functions in position and momentum space, time evolution and the Schrödinger equation.

THEORY OF ANGULAR MOMENTUM: rotations and angular momentum commutation relations Spin 1/2 systems and Finite rotations, SO(3), SU(2) and Euler rotations, density operators and pure versus mixed ensembles, eigenvalues and eigenstates of angular momentum addition of angular momenta, Schwinger oscillator model of angular momentum spin correlation measurement and Bell's inequality, tensor operators.

QUANTUM COMPUTING: qubits, quantum entanglement; reversible computation, quantum gates; quantum parallelism and simple quantum algorithms; quantum Fourier transforms and its applications, quantum search algorithms; introduction to quantum error correcting codes; entanglement assisted communication; elements of quantum information theory and quantum cryptography.

CD61006: QUANTUM METHODS IN MOLECULAR SIMULATIONS (2-0-3)

SYLLABUS:

THEORY COMPONENT: analytical solution of hydrogen and hydrogenic systems; Born-Oppenheimer approximation; formulation of Hartree-Fock method for molecular systems; post HF methods overview; exchange and correlation concepts; configuration interaction techniques; coupled cluster technique for many-body systems; density functional theory; exchange-correlation functionals, dispersion corrections; time-dependent DFT; geometry optimization techniques; basis sets in quantum chemistry; general framework of molecular simulations;

quantum chemical simulations of solids and crystalline materials; simulation of molecular catalysis; vibrational analysis and frequency calculations; simulation of molecular properties.

LAB COMPONENT: building molecules; Z-matrices; internal coordinates; SCF calculations of atoms and small-to-medium sized molecules, restricted and unrestricted Hartree Fock calculations; SCF convergence criteria; geometry optimization techniques; vibrational frequency calculations and analysis of vibrational modes; calculation of Gibbs free energy of formation and Gibbs reaction energy; CI, MP2, coupled-cluster calculations of small molecules; multi-configuration SCF calculations; concept of active space; density functional calculations of large molecules; cost-benefit analysis; effects of basis sets and electron correlation - a comparison of methods; framework for crystalline solids; building crystal planes and supercells; DFT calculations of crystalline solids; simulation of molecular catalysis; biomolecular simulation using hybrid QM/MM approach.

CD61004: HIGH PERFORMANCE COMPUTING AND ITS APPLICATIONS IN COMPLEX PHYSICAL SYSTEMS (3-1-0)

SYLLABUS:

INTRODUCTION TO HPC ARCHITECTURE AND PARALLEL PROGRAMMING: basic architecture and organization: memory hierarchy, shared and distributed memory architectures, multiprocessor architecture, parallel programming, introduction to MPI, optimizing cluster operations: running jobs in HPC environment, job scheduler, cluster level load balancing

SPECIAL METHODS FOR STUDYING COMPLEX SYSTEMS: basics of statistical mechanics, potential energy surface, an introduction to molecular mechanics, Simulation methods: molecular dynamics and Monte Carlo simulations, enhanced sampling methods, coarse-grain modelling

APPLICATIONS TO COMPLEX SYSTEMS: Open-source software: MD and MC simulation packages, parallelization in software: domain/spatial decomposition, distribution of nonbonded interactions, dynamic load balancing, multiprocessor communication, modeling of soft matter systems such as biomolecules, polymers, carbon nanostructures, etc., computation of thermodynamic, kinetic and mechanical properties of different complex systems

CS61060: COMPUTATIONAL BIOPHYSICS: ALGORITHMS TO APPLICATIONS (3-1-0)

INTRODUCTION: central dogma of molecular biology, Relevant databases in computational biophysics, molecular visualization software.

ALGORITHMIC TECHNIQUES FOR MODELLING: Monte Carlo simulation, replica-exchange Monte Carlo simulation, simulated annealing, neural network method.

PROTEIN/NUCLEIC ACID STRUCTURE MODELLING: methods for protein secondary structure prediction, comparative modelling, threading and fold recognition, ab initio modelling, combined modelling approaches, CASP: a blind protein structure prediction competition.

PROTEIN-PROTEIN/NUCLEIC ACID INTERACTION PREDICTION: Fast Fourier Technique, geometric hashing, designing scoring function, protein-protein docking algorithms, protein-nucleic acid docking methods, CAPRI: a blind protein interaction prediction competition. Selected topic (any one of the following will be covered): (i) protein function annotation: gene ontology, enzyme classification, sequence and structure-based function annotation, meta

servers. (ii) protein design: force field design, simulation techniques, ab initio design, interaction design

CY62206: MODELLING OF QUANTUM SYSTEMS AND PROCESSES (2-0-3)

SYLLABUS:

MODULE 1 THEORY: 1. Overview of variational principle and perturbation theory 2. Multi-electron wave functions, Self-consistent field method for atoms and molecules, Fock operator, canonical HF equations, Hartree-Fock Roothan Equation 3. Basis Sets: Hydrogenic functions, Slater type, contracted Gaussian functions, splitvalence, polarization, correlation-consistent basis functions, Effective core potentials 4. Post Hartree-Fock methods (Brief introduction to CI/MP2/CC/DFT) 5. Wave function analysis, Population analysis and atomic charges: Mulliken, Lowdin, natural population 6. Molecular Electrostatic Potential, ESP charge, restrained charge fitting 7. Theory of atoms-in-molecules 8. Frontier Molecular Orbital Theory 9. Inter-molecular interactions 10. Hybrid QM/MM methods: additive/subtractive schemes 11.Molecular response to electric and magnetic fields

MODULE 2: LABORATORY: 1. Z-matrix, Models for small molecules and large bio/nano-complexes 2. Hartree-Fock calculation for small molecules: Analysis of density matrix, Fock matrix, HF Convergence analysis 3. Geometry optimization with density functional methods: Comparison of functionals, energy and other molecular properties 4. Hessian Calculation, Frequency analysis, IR/Raman/VCD spectra simulation 5. Thermochemistry: Evaluation of zero-point energy, enthalpy, entropy, and Gibbs free energy of simple chemical reactions 6. Excited state calculation with TDDFT, Simulation of UV-Vis and emission spectra 7. Simulation of Vibronic spectra with Franck-Condon factors, Duschinsky matrix 8. Techniques of potential energy surface scanning, linear interpolation of geometry, reaction coordinates 9. Transition state search with different techniques, IRC, transition state characterization 10. Wave function analysis: Molecular orbital analysis, partial charge, bond order, density of states 11. Visual study of weak interaction: atoms-in-molecules, critical points, non-covalent interaction plots 12. Calculation of reactivity descriptors: electronegativity, hardness, polarizability, electrophilicity index; local reactivity descriptors: local softness, Fukui functions 13. Comparison of solvation models: PCM, SMD models, solvation parameters, solvation free energy 14. QM/MM modelling: Layer definition, link atom, embedding schemes

CY62204: CLASSICAL METHODS OF MOLECULAR SIMULATION (2-0-3)

SYLLABUS: MODULE 1: THEORY: 1. Introduction: Definition of simulation and its history of development 2. Concept of Force-Fields for atomic and molecular systems 3. Handling bulk systems: periodic boundary convention and minimum image convention 4. Molecular dynamics method: Generalized coordinates and equations of motions (EOM): Newton's, Lagrange's and Hamilton's EOM 5. Finite difference methods to integrate EOM: Predictor-corrector, Verlet and Velocity Verlet methods 6. Shifted potential and shifted-force potential; Verlet neighbour list method 7. A few important concepts of Statistical Mechanics 8. Generating initial configuration of a system in a simulation 9. Measurement of temperature and its control in a simulation; Equilibration process 10. Algorithm to develop a molecular dynamics code for a simple Lennard-Jones system 11. Monte Carlo Method: Metropolis scheme and derivation of acceptance criteria 12. Algorithm to develop Metropolis Monte Carlo code for a simple Lennard-Jones system 13. Biased Monte Carlo methods to study flexible molecules 14. Analysis of simulated trajectory: Concepts of distribution functions and time correlation functions 15. Introduction to Extended

phase-space approach: NVT and NPT ensemble simulations 16. Introduction to rare event simulation methods 17. Concept of collective variables 18. Simulation of free energy along a chosen collective variable using umbrella sampling and metadynamics 19. Estimation of the rate of activated barrier crossing 20. Application of machine learning and deep learning methods in molecular simulation

MODULE 2: LABORATORY: 1. Generation of Random numbers 2. Calculations of simple pair-wise interaction potentials and their plots 3. Application of periodic boundary conditions and minimum image conventions 4. Calculation of forces acting between interacting particles 5. Development of a routine to integrate EOM using Verlet method 6. Generating initial configurations by random insertion method and from regular lattice

Module 3 Short project:

PROJECT-1: Development of a molecular dynamics code for a Lennard-Jones system.

PROJECT-2: Development of a Metropolis Monte Carlo code for a Lennard-Jones system.

PROJECT-3: Molecular dynamics simulation of liquid water.

PROJECT-4: Potential-of-mean-force for a pair of simple solutes in water.

PROJECT-5: Free energy surface of alanine dipeptide in water.

PROJECT-6: Monte Carlo/Molecular dynamics simulation of a small protein in water.

PROJECT-7: Machine learning-based analysis of MD trajectories

CS61064: HIGH PERFORMANCE PARALLEL PROGRAMMING (3-1-0)

SYLLABUS:

Introduction to HPC Systems - Introduction to basic architecture and OS concepts - Multi-core CPUs - High-speed interconnects - High performance file systems - GPU systems - High performance clusters Parallel Programming Models, Runtime Systems - OpenMP and MPI - Thread Management, Workload manager and Job Schedulers - CUDA / OpenCL - HW schedulers, Software runtime systems – MapReduce System Architecture and runtime management Benchmarks and Case Studies - Developer Libraries- Linear Algebra : MKL, BLAS, Lapack – Distributed Machine Learning using Spark Framework - Benchmarks: A. GPU Benchmarks : Parboil, Rhodinia, B. Computational Science : BLAST and SOM (Bioinformatics), Fluid Dynamics (CFD packages)- Hybrid Parallel Programming: Putting it together (Python, MPI, OpenMP, CUDA) Tutorials - Familiarization with HPC softwares : OpenMP and MPI, Spark Framework for Map-Reduce - Benchmark based performance evaluation experiments on HPC systems - HPC Application development: Drug design, Fault Simulation, Machine Learning Application development

Name of the Micro-Specialization: Biodesign for Affordable Healthcare

1. **School/Center: Centre of Excellence in Affordable Healthcare**

2. **Brief Description:** India envisions itself as a leading global healthcare provider by 2047, offering affordable and cost-effective healthcare services to its estimated population of 1.64 billion. This vision encompasses several key aspects that aim to revolutionize healthcare delivery in the country and position India at the forefront of global health leadership. One of the primary goals of this healthcare vision is to provide accessible and affordable medical services to all individuals, irrespective of their socioeconomic status or geographic location. Technology and innovation can play an important role in addressing some of the major grand challenges being faced in healthcare sector and institutes/universities can be potential public spaces for such innovations and for development of necessary human resources. The proposed Micro-Specialization in Biodesign for Affordable Healthcare is a major step in building an ecosystem facilitating students and faculty to take their innovative ideas in medical technology from classrooms/labs to market/people/society. The objectives of the proposed minor area is to sensitize and excite students about role of medical technology in addressing national health needs and to provide opportunity to engage in design & innovation. It will also provide opportunity for students/faculty to engage in coming up with affordable solutions in the area of medical technology.

The present curriculum of relevant individual B.Tech courses such as ECE, EE, CSE, AI, BT, ME, CH, AG though might contain related subjects, but they do not teach all three in a combined and coordinated manner as per the present healthcare market requirements. For example, the ECE and EE's B.Tech course of IIT KGP has the courses of "Biomedical Instrumentation", "Biomedical Signal Processing", "Measurements and Electronic Instruments" and "Embedded Systems". However, the real world's (usually complex) diagnostics systems and assistive devices involve associated design and development challenges due to the integration and require detailed analysis and simultaneous understanding of multi-disciplinary concepts, generally not covered in the existing courses.

Hence, by studying in detail about the affordable healthcare device and system, integrated fundamental knowledge, and hands-on system design with the application of AI/ML and respective software, one will be equipped to tackle the knowledge and skill requirements of healthcare industries. The course will enable students to explore the industrial world by solving the software challenges along with the embedded design to execute the control algorithm prevalent in practical systems such as automated medical devices and automotive systems. Students will understand how medical devices capture data and their capabilities in affordable healthcare. Further, they will also develop skills to analyze human health data

utilizing signal/image processing, AI/ML models, and finally, to develop biomedical healthcare products while executing the projects.

This kind of multi-disciplinary course, having the integrated essential aspects of biomedical system design, biomedical signal & image processing, and biomechanics & assistive technology, is expected to create competencies for the new generations of B.Tech. students, particularly in the streams of ECE, EE, CSE, AI, BT, ME, CH, and AG, who can actively contribute to the design, development, and testing of healthcare products.

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

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

5. Structure: Component I: One Subject (3-0-0)

Component II: Two Subjects (4-0-0/3-1-0/ 2-0-2)

Component III: Project (0-0-6)

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

TABLE-I

Sub no.	Sub Name	LTP	Credits	Offering Semester
FH32201	Biodesign Concept & Practice	2-0-2	3	Autumn

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

TABLE-II

Sub no.	Sub Name	LTP	Credits	Offering Semester
FH62201	Embedded System Design for Affordable Healthcare	2-0-2	3	Autumn
FH60202	Introduction to Movement Biomechanics and Rehabilitation	3-0-0	3	Spring
FH62202	Design for Digital Health	2-0-2	3	Spring
FH62203	Biomedical Assistive System	2-0-2	3	Autumn

C. COMPONENT- III: PROJECT (4 credits)

TABLE-III

Sub no.	Sub Name	LTP	Credits	Offering Semester
FH67001	Biodesign Project	0-0-6	4	Both semesters

Annexure-I

1. **Name of the Academic Unit:** Centre of Excellence in Affordable Healthcare
2. **Subject Name:** Biodesign Concept & Practice
3. **L-T-P:** 2-0-2 **Credits:** 3
4. **Status of the subject**
   a. **Specify the Session, Semester to be offered:** 2024-2025 Spring
   b. **Please Specify the Level of the Subject:** UG/PG
   c. **Whether the subject will be offered as compulsory or elective:** Elective
   d. **The semester in which the subject will be offered:** Autumn
   e. **Name(s) of the Programme(s) in whose curricula this subject will be included:** **CoE-AH**
5. **Pre-requisites:** None
6. **Objective and Contents:**
   a. **Objective:**
   Course would introduce medical technology and process of medical device design as a first course to UG/PG interested students. At the end of course, students should have learnt the process of medical device design through lectures and have gained some experience by addressing a small healthcare need by coming up with a work-alike prototype of a device by working in teams. Course will also expose students to opportunities in medtech and possible career options through case studies.

   Outcome: At the end of the course students

- Be able to learn the theoretical and applied concepts of medical device design
- Be able to apply the knowledge of medical device design to create innovative medical devices addressing real-life medical problems
- Be able to assess a real-life clinical problem by identifying the underlying medical cause
- Select and apply an appropriate design method and skills to generate and categorize conceptual design solutions that solve the relevant medical problem
- Should work in the team to accomplish the small course project demonstrating working design concept of the medical device

Sl. No.	Topic	No. of lectures
L1.	Introduction to medical device design, its significance and implication in the current healthcare scenario	4
L2.	Basic human anatomy and physiology, introduction to the common medical devices, medical design terminology and definition, design standards, medical device design consideration	4
L3.	Conceptual models of the medical device design, different approaches to medical device design, biocompatibility	4

L5.	Identification of need, immersion, disease burden, disease state fundamentals, and the need for validation	**4**
L6.	Development of concepts, ideation & brainstorming, evaluation of concepts, risk/benefit analysis	**3**
L7	Usability analysis & methods of prototyping, compliance, and validation methods	**2**
L8	IP and regulatory requirements, marketing and launching	**2**
P1	Study of few commercial medical devices-case study	**4**
P2	Observations and Problem Identification through interaction with doctors in hospitals & primary healthcare centers	**8**
P3	Development and evaluation of concepts, Risk/benefit analysis	**4**
P4	Prototyping and testing of the medical device design	**8**
P5	Feedback from stakeholders	**2**
	Total number of hours	**52**

b. Contents (100 to 150 words):

Names of the faculty members of the Department/Centers/School who have the necessary expertise and will be the willing to teach the subject (Minimum two faculty members):

Dr. Debanjan Das, Assistant Professor, CoE-AH Dr.
Ashutosh Tiwari, Assistant Professor, CoE-AH

7. Do the contents of the subject have an overlap with any other subject offered in the Institute?

a. **Subject Name:** Translational Health Research-MM61314;

b. Approximate percentage of overlap: 2%

c. Reasons for offering the new subject in spite of the overlap:

No existing course with a similar focus exists.

8. Recommended Text Books/References Books

a. Theory (Text Books):

- Paul G. Yock, Stefanos Zenios, Joshua Makower and Todd J. Brinton, 'Biodesign - The process of innovating medical technologies,' (2nd ed.). Cambridge: Cambridge University Press, ISBN- 978-1107087354
- Peter J. Ogrodnik, 'Medical Device Design: Innovation from Concept to Market,' Academic Press Inc; 1 edition (2012), ISBN-10: 0123919428
- J. Paulo Devim, 'The design and manufacture of medical devices,' Elsevier, ISBN-978-1907568725

b. References (Literature):

- Paul H. King, Richard C. Fries, Arthur T. Johnson, 'Design of Biomedical Devices and Systems,' Third Edition, ISBN 9781466569133, Marcel Dekker.
- Theodore R. Kucklick, 'The Medical Device R&D Handbook,' ISBN- 978- 1439811894, CRC press.

9. Names of Departments/Centers/Schools/Programmes whose students are expected to register for this subject:

- CoE-AH
- School of Medical Science and Technology

- ECE
- EE
- CSE
- AI
- BT
- ME
- CH
- AG
- ATDC

Annexure-II

1. **Name of the Academic Unit:** Centre of Excellence in Affordable Healthcare
2. **Subject Name:** Design for Digital Health
3. **L-T-P:** 2-0-2 **Credits:** 3
4. **Status of the subject**
   f. **Specify the Session, Semester to be offered:** 2024-2025 Spring
   g. **Please Specify the Level of the Subject:** PG/UG
   h. **Whether the subject will be offered as compulsory or elective:** Elective
   i. **The semester in which the subject will be offered:** Spring
   j. **Name(s) of the Programme(s) in whose curricula this subject will be included: CoEAH**
5. **Pre-requisites:** None
6. **Objective and Contents:**
   c. **Objective:**

   As our world is becoming more and more digitized, patients and their devices are generating streams of valuable data that can provide meaningful clinical insights. This digital health revolution provides great opportunities to design and validate new digital health concepts. This course is ideal for students who are interested in creating a digital platform that will directly impact healthcare or clinical research. The course will enable students to learn about various aspects of digital health technology including regulation, digital health frameworks such as HealthKit, Electronics Health Record and Data Analytics, Smartphone Applications development, and its importance in translational healthcare. Students will conclude the course with the knowledge and experience to engineer a successful digital health project.

   Outcome: At the end of the course, students should understand:
   - Be able to recognize, describe, and apply the needs-driven Biodesign approach to the creation of innovative solutions in digital health
   - Gain exposure to unmet needs in the healthcare field and learn to design and build secure digital solutions to address them
   - Become familiar with digital health platform (CardinalKit) for data collection and diagnosis

- Be able to develop digital healthcare applications while executing the projects.

d. Contents (100 to 150 words):

Sl. No.	Topic	No. of lectures
1.	Introduction to Digital Health, Key components of Digital Health, Digital Health Need, Digital Health Technology Innovation Landscape with its Regulations	**4**
2.	Biodesign Methodology in Digital Health: Biodesign process identifying clinical needs, Concept Generation; Designing with the patient and clinician; Software as a medical device; Case studies	**6**
3.	Digital Health Technologies: mHealth, Smartphone into digital healthcare workflow; Smartphone Applications to develop clinical apps; Mobile Apps in health monitoring, fitness and wellness; Smartphone vision and acoustic system in healthcare; Case Studies on Stanford Spezi ecosystem, CardinalKit Solutions in Mental Health and Physical Well-being	**6**
4.	Telemedicine and IoT in Remote Healthcare: Healthcare Cyber-Physical Systems (H-CPS); Telemedicine Platforms; Benefits and Challenges of Telemedicine; Case studies	**4**
5.	Electronic Health Records and digital health infrastructures: Artificial Intelligence for health data analytics, Decision Support Systems	**4**
6.	Prototyping and Testing Digital Health Solutions: Prototyping in the Context of Digital Health; Clinical trials, and Certification processes.	**4**
7	Hands-on activities on the above modules with mini- projects based on used cases	**12x2**
	Total number of hours	**52**

7. Names of the faculty members of the Department/Centers/School who have the necessary expertise and will be the willing to teach the subject (Minimum two faculty members):

Dr. Debanjan Das, Assistant Professor, CoE-AH Dr.
Ashutosh Tiwari, Assistant Professor, CoE-AH

8. Do the contents of the subject have an overlap with any other subject offered in the Institute?

d. **Subject Name:** Translational Health Research-MM61314;

e. Approximate percentage of overlap: 2%

f. Reasons for offering the new subject in spite of the overlap:
No existing course with a similar focus exists.

9. Recommended Text Books/References Books

c. Theory (Text Books):

- H. Rivas, & T. Boillat (eds), Digital Health: From Assumptions to Implementations. Springer, 2nd Edition, ISBN 978-3031176685.
- Paul H. King, Richard C. Fries, Arthur T. Johnson, Design of Biomedical Devices and Systems, Third Edition, ISBN 9781466569133

d. References (Literature):

- Peter J. Ogrodnik, Medical Device Design: Innovation from Concept to Market, Academic Press Inc; 1 edition (2012), ISBN-10: 0123919428
- Wolf, Marilyn. Embedded System Interfacing: Design for the Internet-of- Things (IoT) and Cyber-Physical Systems (CPS). Morgan Kaufmann, 2019. ISBN-10 0128174021, ISBN-13 978-0128174029

10. Names of Departments/Centers/Schools/Programmes whose students are expected to register for this subject:

- CoE-AH
- School of Medical Science and Technology
- ECE
- EE
- CSE
- CoE-AI
- ATDC

Annexure-III

1. **Name of the Academic Unit:** Centre of Excellence in Affordable Healthcare

2. **Subject Name:** Biomedical Assistive System

L-T-P: 2-0-2 **Credits:** 3

3. **Status of the subject**

a. **Specify the Session, Semester to be offered:** 2024-2025 Autumn

b. **Please Specify the Level of the Subject:** PG

c. **Whether the subject will be offered as compulsory or elective:**
Elective

d. **The semester in which the subject will be offered:** Autumn

e. **Name(s) of the Programme(s) in whose curricula this subject will be included:**

- 1st year, Biomedical Engineering (PG)
- 1st year, Mechanical Engineering (PG)
- 1st year, Medical Science and Technology (PG)
- 1st year, Biosciences and Biotechnology (PG)

Pre-requisites: None

Objective and Contents:

Objective: Assistive systems for biomedical applications are widely used for the augmentation and rehabilitation purposes. Increasing rate of disability particularly related to the motor dysfunction led to the extensive research and development in the field of assistive systems for healthcare. Speedy and effective recovery of the individuals post disability depends on assistive system design and most importantly symbiotic interaction between the assistive system the human body. This course is designed to help students understand and learn the design of the assistive devices for various locomotor dysfunction by providing them with applied theoretical knowledge and hands on experience. The end goal of this course is to prepare students to solve real- life problems related to movement disability by designing assistive systems, understand the human system interaction, and inculcate student mindset towards product creation for society.

Outcome: At the end of the course, students should: understand the design and architecture of the assistive system and its components, understand various sensing and actuator involved in the development of the assistive

devices; able to conceptualize the biomechanical assistive systems for gait dysfunction; able to identify and critically assess the need of assistive system and then apply knowledge and skills to design and develop assistive systems.

Contents (100 to 150 words):

SL. No.	Topic	No. of lectures
1.	Introduction to emerging field of wearable systems with its opportunities and challenges, Role of wearable systems in medicine and healthcare, Relevance of wearable system design to industry 5.0 in healthcare domain	**03**
2.	Design consideration in the medical wearable systems, architecture and essential component of design, scope for the future application in healthcare	**03**
3.	Introduction to the commercialized and laboratory research based wearable system used in the healthcare application	**03**
4.	Wearable sensors type and their selection for healthcare applications, sensor fusion techniques and wearable sensor based human activity recognition, physiological measurement, and Human performance measurement during ADL	**03**
5.	Haptics system design and application, and inertial algorithm development and highlights clinical and sports applications	**03**
6.	Data streaming and processing: lab streaming layer, Basics of Kalman filter,	
7.	Wearable biofeedback system for gait augmentation and rehabilitation, relevance	**03**
8.	Actuators in wearable robots and its applications, introduction to the human robot interaction (HRI) and user experience	**03**

9.	Assistive robotics for locomotion: lower limb prostheses, orthosis, and exoskeleton devices	**03**
10.	AR/VR based wearable system for motion tracking and training	**04**
11.	Hands on laboratory design, development, and testing of wearable devices	**18**
Total number of hours		**52**

12. Names of the faculty members of the Department/Centers/School who have the necessary expertise and will be the willing to teach the subject (Minimum two faculty members):

- Dr. Ashutosh Tiwari, CoE-AH
- Dr. Debanjan Das, CoE-AH

13. Do the contents of the subject have an overlap with any other subject offered in the Institute?

a. **Subject Name:** Introduction to Human Body Mechanics (ME60300);
b. Approximate percentage of overlap: <5%
c. Reasons for offering the new subject in spite of the overlap:
No existing course with a similar focus exists.

14. Recommended Text Books/References Books

a. Theory (Text Books):

- Pathirana, P.N., Li, S., Lee, Y.S. and Pham, T., 2021. *Human Motion Capture and Identification for Assistive Systems Design in Rehabilitation*.
- John Wiley & Sons. Dietz V., Nef, T., Rymer, W. Z., 2012. Neurorehabilitation technology. Springer.

b. References (Literature):

- Uchida, T.K. and Delp, S.L., 2021. Biomechanics of movement: the science of sports, robotics, and rehabilitation. MIT Press.
- Burdet, E., Franklin D. W., Milner, T. E., 2013. Human Robotics: Neuromechanics and Motor Control. MIT Press

15. Names of Departments/Centers/Schools/Programmes whose students are expected to register for this subject:

- Centre of Excellence in Affordable Healthcare
- School of Medical Science and Technology
- Department of Mechanical Engineering
- Department of Bioscience and Biotechnology
- Department of Electrical Engineering
- Department of Electrical and Electronic Engineering