Open Elective Courses

Offered by Various Departments

(to be opted in 5th and 6th Semesters)

National Institute of Technology Hamirpur

Hamirpur – 177 005 (India)

Department of Chemical Engineering

Open Elective-I

CH-306	Energy and Environmental Engineering	5
CH-370	Nanoscience and Nanotechnology	6

Open Elective-II

CH-306	Energy and Environmental Engineering	5
CH-380	Industrial Safety and Hazard Management	7

Department of Chemistry

Open Elective-I / II

CY-306	Bionanotechnology	8

Department of Civil Engineering

Open Elective-I/II

CE-306	CPM and PERT	9
CE-307	Disaster Management	10
CE-308	Air Pollution Control	11

Department of Computer Science & Engineering

Open Elective-I

CS-306	Data Structures	12
CS-370	Operating System	13

Open Elective-II

CS-306	Data Structures	12
CS-380	Computer Networks	14

Department of Electronics & Communication Engineering

Open Elective-I

EC-370	MEMS Design	15

Open Elective-II

EC-380	Microcontroller and its Applications	16

Department of Electrical Engineering

Open Elective-I

EE-370	Neural Networks and Fuzzy Logic Systems	17
EE-371	Elements of Control System	18

Open Elective-II

EE-380	Sensors and Transducers	19
EE-381	Non-Conventional Energy Resources	20

Department of Humanities and Social Sciences

Open Elective-I

Open Elective-II

Department of Management Studies

Open Elective-I

Open Elective-II

Department of Materials Science & Engineering

Open Elective-I

Open Elective-II

Department of Mathematics & Scientific Computing

Open Elective-I

Open Elective-II

Department of Mechanical Engineering

Open Elective-I

Open Elective-II

Department of Physics and Photonics Science

Open Elective-I

PH-370	Laser and Photonics	39
PH-371	Physics of Semiconductor Devices	40

Open Elective-II

PH-380	Nuclear Technology	41
PH-381	Microwave Physics	42

Course Name: **Energy and Environmental Engineering**
Course Code: **CH-306**
Course Type: **Open Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To inculcate fundamental knowledge and understanding of the major energy conversion processes.
- To impart the knowledge about the resource requirement and their impacts on environment.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Interrelationship between energy and environment, the need of sustainability, nature & issues; environment conservation and management as the key requirements of sustainability, scope and importance, need for public awareness, energy chain and common forms of usable energy, classification of energy sources, present energy scenario, world energy status, energy scenario in India.	**08L**
UNIT-02	**Conventional Energy:** Environmental impacts related to harnessing to fossil fuels (coal, oil, natural gas), nuclear energy, hydropower (overview of micro mini and small hydro power, classification of hydropower schemes), impact of energy production on climate change.	**06L**
UNIT-03	**Renewable Sources of Energy:** Solar energy; active and passive systems, measurement and applications including solar water heating, solar cooking, solar drying, solar distillation and solar refrigeration, heating and cooling of buildings, solar thermal power generation, solar photo-voltaic power generation, process economics and environmental impacts, biomass energy; generation, characterization, biogas (aerobic and anaerobic bio-conversion processes), properties of biogas, waste to energy (domestic sewage, municipal solid wastes); biorefineries, biohydrogen production, environmental aspects of biofuel utilization - techno-economic features of bio-fuels, wind energy, wind diesel hybrid systems, control of hybrid power systems, power generation through OTEC systems - various types - energy through waves and tides - energy generation through geothermal systems – types.	**14L**
UNIT-04	**Social Issues and the Environment:** Environmental degradation, environment ethics, issues and possible solutions, urban problems related to energy, water conservation, rain water harvesting, water shed management.	**08L**

Course Outcomes

Upon successful completion of the course, the student will be able to
CO1: Describe basic energy concepts.
CO2: Analyze the consequences of today's energy consumption.
CO3: Account for conventional energy technologies and the relationship between energy production, consumption and climate change.
CO4: Reflect and evaluate the environmental impact of energy production through renewable sources of energy.

Books and References

1. Energy and the Environment by R.A. Ristinen, and J.J. Kraushaar, 2nd edition, 1998.
2. Fundamentals of Renewable Energy Sources by G.N. Tiwari, and M.K. Ghosal, Narosa Publishing House, New Delhi, 2007.
3. Energy Technology by S. Rao, and B.B. Parulekar, 4th edition, Khanna Publishers, 2005.
4. Energy Science: Principles, Technologies and Impacts by J. Andrews, and N. Jelley, Oxford Universities Press, 2013.
5. Renewable Energy, Power for a Sustainable Future by G. Boyle, Oxford University Press, 2012.
6. Renewable Energy Systems, Advanced Conversion Technologies and Applications by L.Y. Fang, and Y. Hong, CRC Press, 2012.

Course Name**: Nanoscience and Nanotechnology**
Course Code**: CH-370**
Course Type**: Open Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the basic concepts of nanoscience and nanotechnology.
- To introduce the fundamental concepts relevant to different classes of nanomaterials.
- To enable the students to understand the factors that causes the design and fabrication of nanoparticles.

Unit Number	Course Content	Lectures
UNIT-01	**Nanoscience:** Introduction and importance, definition of nano, atomic structure and size, emergence and challenges of nanoscience, formation of CNT to Graphene, influence of nano over micro and macro, size effects, surface effects on the properties.	**06L**
UNIT-02	**Nanostructure and Nanomaterials Properties:** Types of nanostructure and properties of nanomaterials, one dimensional, two dimensional and three dimensional nanostructured materials, quantum dots shell structures, semiconductors, composites, mechanical-physical-chemical properties.	**07L**
UNIT-03	**Nanotechnology:** Introduction, emergence and challenges of nanotechnology, synthesis, vapor condensation methods, sputtering, laser method, spray pyrolysis, thermo chemical, flame decomposition of metals, organic precursors methods.	**05L**
UNIT-04	**Characterization Tools:** X-Ray diffraction (XRD), Scanning electron microscopy, transmission electron microscopy, atomic force microscopy, UV spectroscopy.	**06L**
UNIT-05	**Classification and Fabrication:** Introduction and classification, electronic properties of atoms and solids, nanometer length scale effects, fabrication methods; top down and bottom up fabrication approach, self-assembly, bio-mediated assembly, safety and storage issues.	**07L**
UNIT-06	**Industrial Applications:** Coating, **c**osmetics, nano sensor, nano catalysts, water treatment, paints industry, food and agriculture Industry, biological and environmental applications.	**05L**

Course Outcomes

Upon Successful completion of the course, the students will be able to
CO1: Identify and understand the peculiar properties of nano-materials at nanoscale.
CO2: Describe the chemistry involved in the synthesis and fabrication of nanomaterials.
CO3: Apply principle of nanoscience and nanotechnology to understand the properties of nanomaterials.
CO4: Assess the importance of applications of nanomaterials in related fields.

Books and References

1. Introduction to Nanoscience and Nanotechnology by G.L. Hornyak, H.F. Tibbals, J. Dutta, and J.J. Moore, CRC Press, 2009.
2. Introduction to Nanotechnology by C. Poole, and F. Owens, Wiley India, 2007.
3. Nanoscale Science and Technology by R. Kelsall, I.M. Hamley, and M. Geoghegan, John Wiley, 2005.
4. NANO: The Essentials: Understanding Nanoscience and Nanotechnology by T. Pradeep, McGraw Hill, 200.

Course Name: **Industrial Safety and Hazard Management**
Course Code: **CH-380**
Course Type: **Open Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about various aspects of industrial safety and occupational health.
- To enable the students to identify hazard and assess risk.
- To teach about various safety acts and rules along with safety education and training.

Unit Number	Course Content	Lectures
UNIT-01	**Concepts and Techniques:** History of safety movement –Evolution of modern safety concept - Incident Recall Technique (IRT), disaster control, safety analysis, safety survey, safety inspection, safety sampling. Safety Audits-components of safety audit, types of audit, audit methodology, non-conformity reporting (NCR), audit checklist- identification of unsafe acts of workers and unsafe conditions in the industry.	**08L**
UNIT-02	**Occupational Health and Toxicology:** Concept and spectrum of health, functional units and activities of occupational health services, occupational related diseases and levels of prevention of diseases. Toxicology- local, systemic and chronic effects, temporary and cumulative effects, carcinogens entry into human systems.	**08L**
UNIT-03	**Hazard Identification and Risk Assessment:** The process of risk management, hazard identification, evaluation (risk assessment, risk matrix), risk control implementation, action and recommendation.	**06L**
UNIT-04	**Acts and Rules:** Indian boiler Act 1923, static and mobile pressure vessel rules (SMPV), motor vehicle rules, mines act 1952, workman compensation act, rules–electricity act and rules–hazardous wastes (management and handling) rules, 1989, with amendments in 2000- the building and other construction workers act 1996., Petroleum rules, Explosives Act 1983-Pesticides Act, Factories Act 1948, Air Act 1981 and Water Act 1974.	**07L**
UNIT-05	**Safety Education and Training:** Importance of training-identification of training needs-training methods – programmes, seminars, conferences, competitions – method of promoting safe practice - motivation – communication - role of government agencies and private consulting agencies in safety training – creating awareness, awards, celebrations, safety posters, safety displays, safety pledge, safety incentive scheme, safety campaign – domestic Safety and Training.	**07L**

Course Outcomes

Upon successful completion of the course, the student will be able to

CO1: Identify the key aspects of industrial safety and mitigating them
CO2: Describe various types of solution to problems arising in safety operations and hygiene.
CO3: Apply principles of OSHA in controlling industrial disasters and losses
CO4: Assess the overall performance of safety protocols of chemical industries and hazard management.

Books and References

1. Industrial Accident Prevention by H.W. Heinrich, McGraw-Hill, 1980.
2. Safety Management in Industry by N.V. Krishnan, Jaico Publishing House, Bombay, 1997.
3. Loss Prevention in Process Industries by F.P. Lees, Butterworth, London, 1990.
4. Safety at Work by J.R. Ridley, Butterworth, London, 1983.
5. Chemical Process Safety Fundamentals with Applications by D.A. Crowl, and J.F. Louvar, Prentice Hall, 2002.

Course Name: **Bionanotechnology**
Course Code: **CY-306**
Course Type: **Open Elective- I / II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the fabrication and characterization of different nanomaterials.
- To familiarize the students with the underlying principles that govern the structure and function of nanomaterials for harnessing their unique properties for novel applications.
- To make the students enable for the understanding of technical applications of nanomaterials in diverse filed of engineering and sciences such as imaging, biosensors, sustainable energy, biomedical engineering, drug delivery etc.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Nanotechnology and Bionanotechnology– an overview, significance of nanodomain, nanostructures and nanosystems, Opportunities and challenges of Bionanotechnology, Growth potential of Bionanotechnology, Bionanotechnology today and its future	**03L**
UNIT-02	**Fabrication and Characterization Techniques:** General techniques of fabrication of nanomaterials — Physical, Chemical and Biological methods, Microscopic techniques for characterization (Scanning Electron, Transmission Electron, Scanning Near-field optical, Scanning Tunneling, Atomic Force Microscopy), Spectroscopic and Diffraction techniques for characterization.	**07L**
UNIT-03	**Nano-structured Biomaterials and their Applications:** Silica based nanomaterials, Inorganic materials, Bio-templated/bio-inspired fabrications and their applications, bionanomaterials for gene delivery.	**05L**
UNIT-04	**Nanotubes and their Biological Applications:** Preparation, properties and application of carbon nanotubes, Specific application of ferromagnetic filled carbon nanotubes in cancer, Nanotube membranes.	**04L**
UNIT-05	**Bionanotechnology for Drug delivery, Biomedical engineering and Sensor development:** Conventional drug delivery, nanosized carriers for drug delivery, targeted drug delivery by Bionanomaterials and their applications, advantages of targeted drug delivery systems, Nanomedicine, proteoliposomes and their uses as vaccine adjuvants, gene and drug delivery systems with soluble inorganic careers, nanotechnology for cancer therapy, Bionano chips for cardiac diagnostics, local cancer therapy using magnetic nanoparticles, applications in Implant materials, *In vitro* clinical diagnosis by nanoparticles, Magnetic nanoparticles for MR imaging, Semiconductor quantum dots for molecular and cellular imaging, Ultrasound contrast agents, Nanomaterials based Biosensors for sensing of glucose, alcohol, food quality etc. Applications of bionanotechnology in Stem Cell Biology.	**17L**

Course Outcomes

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

CO1: Understand the concept of nanoscience/nanomaterials and its role in bionanotechnology.

CO2: Explore various nano and bionanostructures for diverse applications in different fields.

CO3: Apply the principles of bionanotechnology for the development of tools and techniques for biomedical engineering.

Books and References

1. BioNanotcchnology by Elisabeth S. Papazolou and Aravind Parthasarathy, Morgan & Claypool Publishers.
2. Nanotechnology: Principles and Practices by S. K. Kulkarni, Springer
3. Bionanotechnology: Global prospects by David E. Reisner (Ed.), CRC Press.
4. Nanobiotechnology: Bioinspired devices and materials of the future by Oded Shoseyov & Ilan Levy (Ed.), Springer

Course Name: **CPM and PERT**
Course Code: **CE-306**
Course Type: **Open Elective-I /II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To introduce the fundamental concepts relevant to project scheduling
- To impart knowledge about the basic principles of CPM and PERT
- To enable the students to find probability of completion of a project in a specified duration

Unit Number	Course Content	Lectures
UNIT-01	**Project Planning:** Work breakdown structure, scheduling by bar charts, limitation of bar charts, milestone charts, and multiple calendar date scheduling using bar chart.	**06L**
UNIT-02	**Network Techniques in Project Management-I (CPM):** Introduction with network techniques, classification of activities, rules for developing networks, network development-logic of network, numbering events, network analysis, determination of project schedules, critical path, floats in activities, updating, resources allocation, resources smoothing and resources leveling.	**12L**
UNIT-03	**Network Techniques in Project Management-II (PERT):** Probability concept in network, optimistic time, pessimistic time, most likely time, lapsed time, deviation, variance, standard deviation, slack critical path, probability of achieving completion time, central limit theorem.	**10L**
UNIT-04	**Cost-Time Analysis:** Cost versus time, direct cost, indirect cost, total project cost and optimum duration, contracting the network for cost optimization, steps in time cost optimization.	**08L**

Course Outcomes

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

CO1: Develop bar-chart based schedule and understand its limitations,
CO2: Develop critical path method (CPM) based network and estimate various times and floats,
CO3: Understand the implementation of network technique,
CO4: Develop PERT based network and find probability of completion of a project in a specified duration, and
CO5: Understand time-cost relationship for projects.

Books and References

1. Project Planning and Control with PERT and CPM by B.C. Punmia and K.K. Khandelwal.
2. Project Management Technique in Planning and Controlling Construction Projects by H.N. Ahuja.
3. Construction Project Management: Planning, Scheduling and Control by K.K. Chitkara.
4. Project Management with CPM, PERT and Precedence Diagramming byJ. Moder, , C. Phillips and E. Davis.
5. PERT and CPM -Principles and Applications by L.S. Srinath.

Course Name: **Disaster Management**
Course Code: **CE-307**
Course Type: **Open Elective-I /II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the disaster Management …
- To introduce the fundamental concepts relevant to various aspect of disaster
- To enable the students to understand the factors that causes the disaster…

Unit Number	Course Content	Lectures
UNIT-01	**Understanding Disasters** :Understanding the Concepts and definitions of Disaster, Hazard, Vulnerability, Risk, Capacity – Disaster and Development, and disaster management Types, Trends, Causes, Consequences and Control of Disasters :Geological Disasters; Hydro-Meteorological Disasters, Biological Disasters and Man -made Disasters Global Disaster Trends – Emerging Risks of Disasters – Climate Change and Urban Disasters	**06L**
UNIT-02	**Disaster Management Cycle and Framework** :Disaster Management Cycle – Paradigm Shift in Disaster Management Pre-Disaster – Risk Assessment and Analysis, Risk Mapping, zonation and Microzonation, Prevention and Mitigation of Disasters, Early Warning System; Preparedness, Capacity Development; Awareness During Disaster – Evacuation – Disaster Communication – Search and Rescue – Emergency Operation Centre – Incident Command System – Relief andRehabilitation – Post-disaster – Damage and Needs Assessment, Restoration of Critical Infrastructure – Early Recovery – Reconstruction and Redevelopment; IDNDR, Yokohama Strategy , Hyogo Framework of Action	**12L**
UNIT-03	**Disaster Management in India** :Disaster Profile of India – Mega Disasters of India and Lessons Learnt Disaster Management Act 2005 – Institutional and Financial Mechanism National Policy on Disaster Management, National Guidelines and Plans on Disaster Management; Role of Government (local, state and national),Non-Government and Inter- Governmental Agencies	**06L**
UNIT-04	**Applications of Science and Technology for Disaster Management** :Geo-informatics in Disaster Management (RS, GIS, GPS and RS) Disaster Communication System (Early Warning and Its Dissemination) Land Use Planning and Development Regulations Disaster Safe Designs and Constructions Structural and Non Structural Mitigation of Disasters S&T Institutions for Disaster Management in India	**12L**

Course Outcomes

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

CO1: Identify the types of disaster
CO2: Describe disaster
CO3: Apply principles of management
CO4: Assess the solution for handling disaster

Books and References

1. Manual on natural disaster management in India by M C Gupta, NIDM, New Delhi
2. Encyclopedia of disaster management, Vol I, II and IIIL Disaster management policy and Administration by S L Goyal, Deep & Deep, New Delhi,
3. Management of Natural Disasters in developing countries by H.N. Srivastava & G.D. Gupta, Daya Publishers, Delhi,
4. Disaster Management Act 2005, Publisher by Govt. of India
5. Publication of National Disaster Management Authority (PNDMI) on Various Templates and Guidelines for Disaster Management

Course Name: **Air Pollution Control**
Course Code: **CE-308**
Course Type: **Open Elective - I /II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To understand the sources, characteristics and effects of air pollutants
- To know the methods of controlling air pollution

Unit Number	Course Content	Lectures
UNIT-01	**Sources and effects of air pollutants** - Classification of air pollutants – Particulates and gaseous pollutants – Sources of air pollution – Source inventory – Effects of air pollution on human beings, materials, vegetation, animals – global warming-ozone layer depletion, Sampling and Analysis – Basic Principles of Sampling – Source and ambient sampling – Analysis of pollutants – Principles	**10L**
UNIT-02	**Dispersion of air pollutants** - Elements of atmosphere – Meteorological factors – Wind roses – Lapse rate – Atmospheric stability and turbulence – Plume rise – Dispersion of pollutants – Dispersion models – Applications.	**10L**
UNIT-03	**Air Pollution Control -** Concepts of control – Principles and design of control measures – Particulates control by gravitational, centrifugal, filtration, scrubbing, electrostatic precipitation – Selection criteria for equipment – gaseous pollutant control by adsorption, absorption, condensation, combustion – Pollution control for specific major industries	**16L**

Course Outcomes

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

CO1: understand the nature and characteristics of air pollutants, noise pollution and basic concepts of air quality management
CO2: identify, formulate and solve air and noise pollution problems
CO3: design stacks and particulate air pollution control devices to meet applicable standards

Books and References

1. Anjaneyulu, D., “Air Pollution and Control Technologies”, Allied Publishers, Mumbai, 2002.
2. Rao, C.S. Environmental Pollution Control Engineering, Wiley Eastern Ltd., New Delhi, 1996.
3. Rao M.N., and Rao H. V. N., Air Pollution Control, Tata McGraw Hill, New Delhi, 1996.
4. Mahajan S.P., “Pollution Control in Process Industries”, Tata McGraw Hill Publishing Company, New Delhi, 1991.

Course Name: **Data Structures**
Course Code: **CS-306**
Course Type: **Open Elective-I/II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about linear and non-linear data structures as the foundational base for computer solutions to problems.
- To introduce the fundamental concepts relevant to binary trees, binary tree traversals, binary search trees and perform related analysis to solve problems.
- To enable the students to understand various types of sorting algorithms.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Data types, data structures, abstract data types, the running time of a program, the running time and storage cost of algorithms, complexity, asymptotic complexity, big O notation, obtaining the complexity of an algorithm.	**07L**
UNIT-02	**Development of Algorithms:** Notations and Analysis, Storage structures for arrays - sparse matrices - structures and arrays of structures, Stacks and Queues: Representations, implementations and applications. Linked Lists: Singly linked lists, Linked stacks and queues, operations on Polynomials, Doubly Linked Lists, Circularly Linked Lists, Operations on linked lists.	**10L**
UNIT-03	**Trees:** Basic terminology, General Trees, Binary Trees, Tree Traversing: in-order, pre-order and post-order traversal, building a binary search tree, Operations on Binary Trees.	**07L**
UNIT-04	**Graphs:** Basic definitions, representations of directed and undirected graphs, the single-source shortest path problem, the all-pair shortest path problem, traversals of directed and undirected graphs, directed acyclic graphs, strong components, minimum cost spanning tress, articulation points and biconnected components, graph matching.	**06L**
UNIT-05	**Sorting and Searching Techniques:** Bubble sorting, Insertion sort, Selection sort, Shell sort, Merge sort, Heap and Heap sort, Quick sort, Sequential searching, Binary Searching, Index searching, Hash table methods.	**06L**

Course Outcomes

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

CO1: Interpret and compute asymptotic notations of an algorithm to analyze the time complexity.
CO2: Use of linear and non-linear data structures as the foundational base for computer solutions to problems.
CO3: Demonstrate the ability to implement various types of static and dynamic lists.
CO4: Implement binary trees, binary tree traversals, and binary search trees and perform related analysis to solve problems.
CO5: Implement various types of sorting algorithms.

Books and References

1. An Introduction to Data Structures with applications by J.P. Tremblay and P.G. Sorenson, Tata McGraw Hill.
2. Data structures, Algorithms ad Applications in C++ by Sartaj Sahni, WCB/McGraw Hill.
3. Data Structures and Algorithms by Alfred V. Aho, Jeffrey D. Ullman and John E. Hopcroft, Addison Wesley.
4. Data Structures using C by Y. Langsam, M. J. Augenstein and A. M. Tenenbaum, Pearson Education.
5. Data Structures – A Pseudocode Approach with C by Richard F. Gilberg and Behrouz A. Forouzan, Thomson Brooks /COLE.

Course Name: **Operating System**
Course Code: **CS-370**
Course Type: **Open Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the concepts of operating system and its management.
- To introduce the fundamental concepts scheduling of processes for a given problem instance.
- To enable the students to understand memory management techniques and implement replacement algorithms and understand and implement file systems.

Unit Number	Course Content	Lectures
UNIT-01	**Evolution of Operating Systems:** Evolution of operating systems, Types of operating systems. The process concept, system programmer's view of processes, operating system's views of processes, operating system services for process management.	**05L**
UNIT-02	**CPU Scheduling:** Scheduling concepts, scheduling algorithms, algorithm evaluation, multiple processor scheduling, real time scheduling.	**06L**
UNIT-03	**Concurrent Programming and Deadlocks:** Critical regions, Conditional critical regions, Monitors, Interprocess communication, Messages, Pipes, Semaphores, Modularization, Synchronization, Concurrent languages. Deadlocks: Characterization, Prevention, Avoidance, Detection and Recovery, Combined approach to Deadlock Handling, precedence graphs.	**06L**
UNIT-04	**Memory Management:** Memory Management, Contiguous allocation, static-swapping, overlays, dynamic partitioned memory allocation, demand paging, page replacement, segmentation. Non-contiguous allocation, paging, Hardware support, Virtual Memory.	**07L**
UNIT-05	**File Systems:** A Simple file system, General model of a file system, Symbolic file system, Access control verification, Logical file system, Physical file system, Allocation strategy module, Device strategy module, I/O initiators, Device handlers, Disk scheduling.	**06L**
UNIT-06	**Networks, Security and Design Principles:** Network operating system, distributed operating system, external security, operational security.	**06L**

Course Outcomes

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

CO1: Understand and analyze the concepts of operating system and its management.
CO2: Illustrate the scheduling of processes for a given problem instance.
CO3: Identify the dead lock situation and provide appropriate solution.
CO4: Analyze memory management techniques and implement replacement algorithms.
CO5: Understand and implement file systems.

Books and References

1. Operating System Concepts by J.L. Peterson and A. Silberchatz, Addison Wesley.
2. An Introduction to Operating System by Harvey M. Dietel, Addison Wesley.
3. Operating Systems - A Design Oriented Approach by C. Crowley, Irwin Publishing.
4. Operating systems by W. Stallings, Prentice Hall.
5. Modern Operating system by A.S. Tanenbaum, Prentice Hall of India.

Course Name: **Computer Networks**
Course Code: **CS-380**
Course Type: **Open Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the network models and architectures.
- To introduce the fundamental concepts relevant to performance of various routing protocols and design of new routing protocol.
- To enable the students to understand computers, software, networking technologies and information assurance to an organization's management, operations, and requirements.

Unit Number	Course Content	Lectures
UNIT-01	**Introductory Concepts:** Goals and Applications of Networks, LAN, WAN, MAN, Wireless network, Network software: Protocol hierarchies, design issues of layers, Interfaces and services. Reference Model: The OSI reference model, TCP/IP reference model, Example networks: Novell Netware, The ARPANET, The Internet, X-25 Networks, network standards.	**05L**
UNIT-02	**Physical Layer:** Fourier Analysis, Maximum data rate of a channel, Transmission media, Wireless transmission, Narrowband ISDN, Broadband ISDN and ATM, Virtual circuits, Circuit switching, Communication satellite.	**04L**
UNIT-03	**Data Link Layer:** Data link layer design issues, services provided to network layers, Framing, Error control, Flow control, Error detection and correction, Elementary data link protocols, An unrestricted Simplex protocol, A Simplex Stop-and-Wait protocol, Simplex Protocol for a noisy channel, Sliding Window protocols, A one-bit Sliding protocol, A protocol using go-back-N, A protocol using selective repeat, Protocol specification and verification, Example data link protocol-HDLC, PPP and SLIP.	**06L**
UNIT-04	**Medium Access Sublayer:** Channel Allocations, Static and dynamic allocation in LAN and MAN, Multiple Access protocols, ALOHA, Carrier Sense multiple access protocols, WDMA protocols, Wireless protocols, Collision free protocols, Limited contention protocols, IEEE standard 802.3 and Ethernet, IEEE standard 802.4, Token bus IEEE standard 802.5, Token Ring, Distributed Queue Dual bus, Logical link control, bridges, High speed LAN, Satellite networks.	**06L**
UNIT-05	**Network Layer:** Network Layer design issue, Routing algorithms, Congestion Control Algorithms, Internetworking. **Transport Layer:** Transport services, Design issues, elements of transport protocols, simple transport protocols, Connection management, TCP, UDP.	**10L**
UNIT-06	**Session, Presentation and Application Layer:** Session Layer, Design issues, remote procedure call. Presentation Layer, Design issues, Data compression techniques, cryptography. Application Layer - File Transfer, Access and Management, Electronic mail, Virtual Terminals, Other applications, Example Networks - Internet and Public Networks.	**05L**

Course Outcomes

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

CO1: Understand network models and architectures.
CO2: Identify the pros and cons of choosing a suitable MAC layer protocol.
CO3: Analyze the performance of various routing protocols and design of new routing protocol.
CO4: Solve basic network design problems using knowledge of common local and wide area network architectures.

Books and References

1. Computer Networks by A.S. Tanenbaum, Prentice Hall of India.
2. Computer Networking: A Top-Down Approach Featuring the Internet by J. Kurose and K.W. Ross, Addison-Wesley.
3. Data and Computer Communication by W. Stallings, Prentice Hall of India.

Course Name: **MEMS Design**
Course Code: **EC-370**
Course Type: **Open Elective- I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the need and applications of microsystem in engineering.
- To introduce the fundamental concepts relevant to fabrication and machining process of MEMS sensors and actuators.
- To enable the students to understand the various sensing and actuation mechanisms.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:**Introduction to MEMS and Microsystems, MEMS Materials, Structural and Sacrificial Materials, Properties of Silicon, Polymers, Ceramics, and Composites, Basic Modeling of Elements in Electrical and Mechanical Systems, Sensors/Transducers, Sensors Characterization and Classifications, Microactuators, Application of MEMS	**04L**
UNIT-02	**MEMS Fabrication:** Silicon Growth, Additive Techniques: Oxidation, Physical Vapor Deposition, Chemical Vapor Deposition, Thin Film Deposition, Photolithography, Etching, Bulk and Surface Micromachining, Etch Stop Technique and Microstructure, Microstereolithography LIGA, and Wafer Bonding	**10L**
UNIT-03	**Mechanical Sensors and Actuators:** Beam and Cantilever, Capacitive Sensors, Modeling a Capacitive Sensor, Capacitive Accelerometer, Pressure Sensors, Piezoresistance Effect and Its Modeling, Piezoresistive Sensor, Flow Measurement, Piezoelectricity, Piezoactuators, Inertial Sensors, Micro accelerometer, MEMS Gyroscope, and Parallel-Plate Actuator.	**08L**
UNIT-04	**Thermal Sensors:** Need and Classification, Temperature Coefficient of Resistance, Thermo-Electricity, Thermocouples, Thermal and Temperature Sensors, Heat Pump, Gas sensors, Micromachined Thermocouple Probe, Thermo-resistive Sensor, Thermal Flow Sensors, Pyroelectricity, Shape Memory Alloy, and Thermal Actuators	**08L**
UNIT-05	**Micro-opto-electromechanical Systems:** Properties of Light, Light Modulators, Beam Splitter, Microlens, Micromirrors, Digital Micromirror Devices, Light Detectors, Grating Light Valve, and Optical Switch	**06L**

Course Outcomes

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

CO1: Identify structural and sacrificial materials for MEMS.
CO2: Describethe fabrication steps in designing of various MEMS parts.
CO3: Apply principles for the design of Sensor and actuators.
CO4: Apply MEMS for different applications in various fields of engineering.

Books and References

1. Introductory MEMS Fabrication and Applications by T. M. Adams and R. A. Layton, Springer Publications.
2. Sensors and Transducers by M. J. Usher, McMillian Hampshire.
3. MEMS by N. P. Mahalik, Tata McGraw Hill.
4. Microsensors by R.S. Muller, Howe, Senturia and Smith, IEEE Press.
5. Analysis and Design Principles of MEMS Devices by Minhang Bao, Elsevier.
6. Semiconductor Sensors by S. M. Sze, Willy –Interscience Publications.

Course Name: **Microcontroller and its Applications**
Course Code: **EC- 380**
Course Type: **Open Elective - II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the architecture and instruction set of typical 8-bit microprocessor .
- To introduce the fundamental concepts relevant to, Assembly Language, Timers, Interrupts.
- To learn to make use of computer for real world applications

Unit Number	Course Content	Contact Hours
UNIT-01	**Introduction to Microprocessors:** History and Evolution, types of microprocessors, Microcomputer Programming Languages, Microcomputer Architecture, Pipelining, Clocking, Intel 8085 Microprocessor, Register Architecture, Bus Organization, ALU, Control section, ISA of 8085, Instruction format, Addressing modes, Types of Instructions.	**06L**
UNIT-02	**Assembly Language Programming and Timing Diagram:** Assembly language programming in 8051, Macros, Labels and Directives, Microprocessor timings, Micro instructions, Instruction cycle, Machine cycles, T-states, State transition diagrams, Timing diagram for different machine cycles, Memory and I/O interface.	**08L**
UNIT-03	**Basic Function Blocks:** Instruction Set, Instruction Usage Examples, implementation of various structures like loop, switch, functions, subroutines.	**09L**
UNIT-04	**Interrupts and Serial Data Transfer:** Interrupts in 8051, Serial interrupts, RST instructions, Issues in implementing interrupts, Multiple interrupts and priorities, Daisy chaining, Interrupt handling in 8051, Enabling, Disabling & masking of interrupts.	**07L**
UNIT-05	**Applications:** Low power sensor networks, LEDs 7 segment, LCD, and ADCs, Defining Buses and Protocols, Embedded Computing	**06L**

Course Outcomes

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

CO1: Understand the architecture of 8051

CO2: Impart the knowledge about the instruction set and program components

CO3: Understand the basic idea about the practical applications

Books and References

1. The 8051 Microcontroller and Embedded Systems by Mazidi Muhammad Ali, Pearson Publications, Second Ed.
2. The Definitive Guide to ARM Cortex-M3 processors by Joseph Yiu, Newnes Publication Third Ed.
3. Computer Systems: An Embedded Approach by Ian Vince McLoughlin, McGraw-Hill Education.
4. 8051 Microcontroller by Scott MacKenzie, Parson Publications, 4th Ed.

Course Name: **Neural Networks and Fuzzy Logic Systems**
Course Code: **EE-370**
Course Type: **Open Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To gain the introduction of Neural networks and fuzzy logic systems for future applications.
- To impart knowledge about the application of artificial intelligence techniques in different field of engineering.
- To identify, formulate and solve the neural network and fuzzy logic based problems.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction** Biological foundation, mathematical model of biological neuron, feed-forward and feedback ANN models, types of activation function.	**05L**
UNIT-02	**Learning Paradigms of ANN** Supervised and unsupervised learning, learning rules, single layer and multilayer perceptron model, error back propagation learning algorithm, pattern classification, clustering, Kohonen self-organizing feature map, radial basis function network, Hopfield network, applications of ANN models to engineering problems**.**	**11L**
UNIT-03	**Fuzzy Sets and Theory** Crisp sets, fuzzy sets, fuzzy set operations, properties, membership functions, measures of fuzziness, fuzzification and defuzzification methods, fuzzy relations, operation on fuzzy relations, fuzzy numbers and arithmetic, fuzzy implications, approximate reasoning, systems based on fuzzy rules, fuzzy inference.	**10L**
UNIT-04	**Fuzzy Control Systems** Introduction, fuzzy logic controllers with examples, special forms of fuzzy logic models, classical fuzzy control problems.	**05L**
UNIT-05	**Hybrid Intelligent Systems** Genetic algorithms, neuro-fuzzy systems, adaptive neuro-fuzzy inference system, evolutionary neural networks, fuzzy evolutionary systems.	**05L**

Course Outcomes

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

CO1: Describe working of artificial neural network and fuzzy logic systems.
CO2: Able to apply these techniques in different field, which involve perception, reasoning and learning.
CO3: Analyze and design a real world problem for implementation and understand the dynamic behavior of a system and assess the results obtained by ANN and fuzzy systems .

Books and References

1. Introduction to Artificial Neural Systems by Jacek M Zurada,West Publisher.
2. Neural Networks-Algorithms, Applications, and Programming Techniques by J.A. Freeman, & D. M. Skapura, Pearson Education.
3. Essentials of Fuzzy Modeling and Control by Ronald R. Yager and Dimitar P. Filev, John Wiley & Sons Inc.
4. Fuzzy System Theory and its applications by T. Terano K Asai and M. Sugeno, Academic Press.
5. Neural Networks, Fuzzy logic and genetic Algorithm: Synthesis and Applications by Rajasekaran S. and Pai G. A. Vijaylakshmi Pal, PHI New Delhi.

Course Name: **Elements of Control System**
Course Code: **EE-371**
Course Type: **Open Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about developing mathematical models of physical systems and deriving their transfer function.
- To introduce the concept of stability in time domain and frequency domain for linear time invariant systems.
- To introduce the concept of state variables and system analysis using state space analysis.

Unit Number	Course Content	Lectures
UNIT-01	**Basic Concepts:** Historical review, Definitions, Classification, Relative merits and demerits of open and closed loop systems.	**01L**
UNIT-02	**Mathematical Models of Control System:** Linear and non-linear systems, Transfer function, Mathematical modelling of electrical, mechanical and thermal systems, Analogies, Block diagrams and signal flow graphs.	**07L**
UNIT-03	**Control Components:** DC servomotor, AC servomotor, Potentiometers, Synchros, Stepper-motor, Sensors and transducers.	**03L**
UNIT-04	**Time and Frequency Domain Analysis:** Transient and frequency response of first and second order systems, Correlation ship between time and frequency domain specifications, Steady-state errors and error constants, Concepts and applications of P, PD, PI and PID types of control.	**08L**
UNIT-05	**Stability Analysis:** Definition, Routh-Hurwitz criterion, Root locus techniques, Nyquist criterion, Bode plots, Relative stability, Gain margin and phase margins.	**09L**
UNIT-06	**State Variable Analysis:** Introduction, Concept of State, State variables and State models, State Space representation of linear continuous time systems. State models for linear continuous –time systems and linear discrete time systems, Solution of state equations, Concept of Controllability and Observability, control systems design using state feedback control.	**08L**

Course Outcomes

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

CO1: Identify different physical systems and classify them as open loop and close loop control systems.
CO2: Describe the mathematical relation between input and output for LTI systems.
CO3: Apply different time domain and frequency domain tools to analyse the absolute and relative stability of LTI systems.
CO4: Apply the concept of state space analysis for the analysis of linear time invariant systems.

Books and References

1. Discrete time Control Systems by K. Ogata, Prentice Hall International.
2. Control System Engineering by I. J. Nagrath and M. Gopal, New Age International.
3. Digital Control Systems by B.C. Kuo, Oxford University Press.
4. An Introduction to Control Systems by Warwick and Kevin, World Scientific Publishing Co. Pvt. Ltd.
5. Control System Fundamentals by W. S. Levine, CRC Press.

Course Name: **Sensors and Transducers**
Course Code: **EE-380**
Course Type: **Open Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To makes students familiar with the constructions and working principle of different types of transducers.
- To knows the methods of measurement, classification of transducers and to analyze error.
- To understand the behavior of transducers under static and dynamic conditions.

Unit Number	Course Content	Lectures
UNIT-01	**Science of Measurements and Classification of Sensors and Transducers:** Units and standards, Static calibration, Classification of errors, Limiting error and probable error, Error analysis, Statistical methods, Odds and uncertainty, Classification and selection of sensors and transducers.	**06L**
UNIT-02	**Characteristics of Transducers**: Static characteristics: Accuracy, precision, resolution, sensitivity, linearity, span and range. Dynamic characteristics: Mathematical model of transducer, Zero, I and II order transducers, Response to impulse, step, ramp and sinusoidal inputs.	**06L**
UNIT-03	**Variable Resistive Transducers:** Principle of operation, construction details, characteristics and applications of potentiometer, strain gauge, resistance thermometer, Thermistor, hot-wire anemometer, Piezo-resistive sensor and humidity sensor.	**06L**
UNIT-04	**Variable Inductance Transducers:** Inductive transducers: Principle of operation, construction details, characteristics and applications of LVDT, Induction potentiometer, Variable reluctance transducers, Synchros, Microsyn.	**06L**
UNIT-05	**Variable Capacitance Transducers:** Principle of operation, construction details, characteristics of capacitive transducers, Different types and Signal Conditioning of capacitive transducers, Applications- Capacitor microphone, Capacitive pressure sensor, Proximity sensor.	**06L**
UNIT-06	**Others Transducers:** Piezoelectric transducer, Hall Effect transducer, Magneto elastic sensor, Digital transducers, Fiber optic sensors, Environmental Monitoring sensors (Water quality & Air pollution), Introduction to MEMS – Introduction to Smart transducers and its interface standard.	**06L**

Course Outcomes

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

CO1: Ability to analyze the problems related to transducers.
CO2: Ability to determine the static and dynamic characteristics of transducers.
CO3: Ability to analyze the problems related to transducers.

Books and References

1. Measurement Systems by E.O. Doebelin and D.N. Manik, McGraw-Hill Education Pvt. Ltd.
2. Instrument Transducers – An Introduction to Performance and Design by H.K.P. Neubert, Oxford University Press.
3. Transducers and Instrumentation by D.V.S. Murthy, Prentice Hall of India Pvt. Ltd., New Delhi.
4. Sensors and Transducers by D. Patranabis, Prentice Hall of India Pvt. Ltd., New Delhi.

Course Name: **Non-Conventional Energy Resources**
Course Code: **EE-381**
Course Type: **Open Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To familiarize the students with general power scenario, various renewable energy technologies and grid integration of renewable energy resources.
- To familiarize the students with renewable energy sources like solar, geothermal, wind and fuel cell.
- To familiarize the students with thermos-electric power generation.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction to Energy Sources:** World energy futures, Conventional energy sources, Nonconventional energy sources, Prospects of Renewable energy sources.	**04L**
UNIT-02	**Solar Energy:** Introduction to solar radiation and its measurement, Introduction to Solar energy Collectors and Storage, Solar thermal electric conversion, Thermal electric conversion systems, Solar electric power generation, Solar photo-voltaic, Solar Cell principle, Semiconductor junctions, Conversion efficiency and power output, Basic photo-voltaic system for power generation.	**07L**
UNIT-03	**Wind Energy and Wind Energy Conversion:** Introduction to wind energy conversion, the nature of the wind, Power in the wind, Wind data and energy estimation, Site Selection considerations, basic Components of a Wind energy conversion system, Classification of WEC Systems, Schemes for electric generation using synchronous generator and induction generator, wind energy storage.	**08L**
UNIT-04	**Direct Energy Conversion Processes:** Magneto Hydro Dynamic Power Generation: Principles of MHD power generation, Open cycle systems, Closed cycle systems, Voltage and power output, Materials for MHD generators.	**05L**
UNIT-05	**Thermo-Electric Generation and Thermionic Generation:** Basic principles of thermo-electric power generation, Seebeck, Peltier, Thomson effects, Thermo-Electric power generator, and Analysis materials. Thermionic emission and work function, Basic thermionic generator.	**04L**
UNIT-06	**Thermo-Nuclear Fusion Energy and Fuel Cells:** The basic Nuclear Fusion and Fission Reactions Plasma confinement, Thermo-Nuclear function reactors. H_2, O_2 cells, classification of fuel cells, types, Advantages, Electrodes, Polarization.	**04L**
UNIT-07	**Energy from Biomass:** Biomass conversion technologies, photosynthesis, Bio-gas generation, types of bio-gas plants, Biomass as a Source of Energy: Methods for obtaining energy from Bio-mass, Bio-logical conversion of Solar energy.	**04 L**

Course Outcomes

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

CO1: Analyze the energy scenario of the world and nation.
CO2: Carry out a comparative analysis of different types of coal, including their treatment, liquefaction and gasification.
CO3: Compare the liquid and gaseous fuels sourced from petroleum including their characterization.
CO4: Analyze the potential of alternate energy sources and their scope and limitations.
CO5: Solve energy related problems related to combustion and non-combustion.

Books and References

1. Renewable energy sources and conversion technology by N.K. Bansal, M. Kleemann, & M. Heliss, Tata McGraw-Hill.
2. Renewable Energy by S. Bent, Academic Press.
3. Renewable Energy: Power for a Sustainable Future by G. Boyle, Oxford University Press.

Course Name: **Creative Writing and Translation**
Course Code: **HS-306**
Course Type: **Open Elective-I/II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

The general objective of the course 'Creative Writing and Translation' is to develop amongst students understanding, skills and professional knowledge about the art of creative writing and translation. The course not only intends to stimulate and refine the creative abilities of the students but also helps them to establish themselves as freelance writers or translators.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction** Introduction to creative writing and translation, Different genres in creative writing (prose fiction, poetry, creative non-fiction and dramatic forms), Introduction to translation as creation (transcreation), Translation and multilingualism, Inter-mediality of art forms, Translation: its types and significance in Indian context	**08L**
UNIT-02	**Reading Creative works** Reading a composition (Personal Writing): diary entry, memoir, travelogue, autobiography, and feature article Reading a literary work: a poem, a play, a fiction, an image or a painting, adaptations and remakes, film and book reviews, self-translation, screenplays and advertisement scripts	**08L**
UNIT-03	**Basics of Creative Writing and Translation** Fundamental norms of writing, how to achieve lucidity and directness, authenticity and credibility in writing, original work vs translation, author's/translator's voice, structure of the write-up: opening, climax, and ending, preliminary tasks in creative writing and translation	**08L**
UNIT-04	**Process and the key elements in Creative Writing and Translation** Developing a fiction/play/poetry: plot/structure, atmosphere, theme, setting, character, narration, symbols and imagery, diction, avoiding clichés Writing for radio/TV: documentary, Interviews/discussions, writing script for advertisements and screenplays, dubbing and subtitling Domestication and foreignization, para-textual elements, advanced tasks in creative writing and translation	**12L**

Course Outcomes

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

CO1: Acquire the requisite training in creative writing and translation.
CO2: Develop an independent outlook on writing
CO3: Have opportunities for a prospective career in films/TV/radio, advertisement industry, and translation industry.

Books and References

1. A Companion to Creative Writing (2013) edited by Graeme Harper. Wiley-Blackwell: UK.
2. Translation and Creativity: Perspectives on Creative Writing and Translation (2006) edited by Manuela Perteghella, Eugenia Loffredo. Bloomsbury: London.
3. The Cambridge Introduction to Creative Writing (2007) by David Morley. Cambridge University Press: Cambridge.
4. The Creative Writing Coursebook (2001) by Julia Bell & Paul Magrs. Macmillan: London.

Course Name: **Industrial Psychology**
Course Code: **HS-370**
Course Type: **Open Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To introduce the basic concepts about insustrial psychologyand its theories.
- To cultivate the basic understanding of personnel selection and evaluation with various type of testing.
- To enlighten the relationships between employee-management interface.
- To study various methods and factors related to jobs and work situations.
- To have insight of industrial accidents and human errors with their effects.

Unit Number	Course Content	Lectures
UNIT-01	**NATURE, SCOPE OF INDUSTRIAL PSYCHOLOGY** (a) Nature of Industrial Psychology (b) Industrial Psychology as a science (c) applications of industrial Psychology in Industrial settings (d) scope of Industrial Psychology	**07L**
UNIT-02	**PERSONNEL SELECTION AND EVALUATION** (a) Methods of Personnel Selection- Interview, Personal Data, Sources of Information about Job candidates (b) General Principles of Personnel Testing – Psychological Tests and their uses (c) Human abilities and their measurement.	**08L**
UNIT-03	**ORGANIZATION AND SOCIAL CONTEXT OF HUMAN-WORK** (a) Nature and frame-work of groups (b) Group- Dynamics and morale (Leadership behavior in Industry (Employee-Management relationships: Communication, Participation, Conflicts.	**08L**
UNIT-04	**THE JOBS AND WORK SITUATION** (a) Human Factors in Engineering (B) Human factors in Jon Design (c) Working Environment (Conditions) in Industry: (i) Illumination (ii) Atmospheric Conditions (iii) Noise (iv) Work-Schedule (v) Rest-Pause.	**07L**
UNIT-05	**INDUSTRIAL ACCIDENTS AND HUMAN ERRORS** (a) Accidents- Nature, Definition and their effects (b) Accidents Proneness (c) Causes and Control of Accidents (d) Safety- Devices.	**06L**

Course Outcomes

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

CO1: Give the basic evidence about Industrial Psychology.
CO2: Understand the key concepts of Personnel Selection and Evaluation Techniques.
CO3: Analyse the various Nature and frame-work of groups along with relationship between Employee – Management.
CO4: Comprehend the underline factors realted to jobs and work situations in Industrial Psychology.
CO5: Apprehend the noble concepts and their effects realted to various Accidents and Human Errors occur in Industrial Psychology.

Books and References

1. Blum, N.L. & Naylor, J.C., Industrial Psychology: Its Theoretical and Social Foundation, CBS
2. Viteles, M.S., Motivation and Morale in Industry, W.W Norton & Company.
3. Singh, n., Industrial Psychology, McGraw-Hill Education.
4. Gosh, P,K. & Ghorpade, M.B., Industrial Psychology, Himalaya Publishing House.

Course Name: **Dynamics of Behavioral Science in Industry**
Course Code: **HS-380**
Course Type: **Open Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge to students about human behavior.
- To cultivate the basic understanding of Industrial Sociology and its Scope.
- To enlighten theconcept of Group Dynamics and its Characteristics.
- To study the siginificance of Leadership and its theories.
- To have insight of Motivation and its types.

Unit Number	Course Content	Lectures
UNIT-01	**BEHAVOURAL SCIENCE:** an overview: definition, Man-the critical factor, behavioral science and its historical development.	**07L**
UNIT-02	**INDUSTRIAL SOCIOLOGY:** Concept, scope and definition, importance for engineers, Hawthorne study, industry and community, social change, effect of technology on social institution.	**08L**
UNIT-03	**GROUPS DYNAMICS:** Meaning and definition, types of groups, characteristics, functions of formal and informal groups, merits and demerits of informal groups. Trade Unions: meaning and definition, functions of Indian trade Unions**.**	**07L**
UNIT-04	**Leadership:** Nature, significance, Classical and Traditional theories of Leadership. Emerging Approaches to Leadership: Transactional leadership and transformational leadership.	**07L**
UNIT-05	**Motivation**: Nature, types of motives (Primary, General and secondary Motives), Theories of Motivation: Maslow, Alderfer, Herzberg, and McClelland. (b) Morale- Measures, Determinates, methods of increasing industrial Morale.	**07L**

Course Outcomes

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

CO1: Give the basic evidence about Behavourial Science.
CO2: Understand the key concepts of Industrial Sociology and its impact in Society.
CO3: Analyse the various Group Dynamics and its Characteristics with in various Groups.
CO4: Comprehend the underline factors realted to Leadership and its related Theories.
CO5: Recognize the noble concepts of Motivation and its Types.

Books and References

1. Rihal, P.C., Dynamics of Behavioural Science in Industry. H.G. Publication, New Delhi.
2. Gisbert,P., Fundamental of Industrial Sociology, Oxford Press.
3. Kumar,N., Agenesis of Behavioural Sciences, Prashant Prakashan Lucknow.
4. Monapa, A., Industrial Relations, Tata Mcgraw Hill.

Course Name: **Entrepreneurship and Innovation Management**
Course Code: **MB-306**
Course Type: **Open Elective- I/II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the basics of entrepreneurship and innovation in engineering.
- To know the different financial and other assistance available for establishing industrial units based on innovative ideas.
- To enable the students to understand the various insights into the management, opportunity search, identification of a product, market flexibility studies, project finalization etc. required for a business enterprise.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction**: Concept, Myths & Realities about entrepreneurship, entrepreneurial qualities, Why start-ups fail?, managerial Vs entrepreneurial approach, Mission, vision, Value proposition, Business Model canvas, Business model generation, Dos & Don'ts in entrepreneurship, Role of entrepreneurship in economic development, Factors driving success and failure of ventures	**08L**
UNIT-02	**Starting the venture:** Lean start-up, Legal forms of business, Generation business idea- sources of new ideas, methods of generating ideas, creative problem solving, opportunity recognition, environment scanning, competitors and industry analysis, feasibility study-market feasibility, technical/operational feasibility, financial feasibility, drawing business plan, preparing project report, presenting business plan	**10L**
UNIT-03	**Functional plans:** Marketing plan- marketing research for new venture, steps in preparing marketing plan, contingency planning, product costing, product pricing; Organizational plan- form of ownership, designing organization structure, job design, manpower planning; Financial plan- cash budget, working capital, Performa income statement, performa cash flow, performa balance sheet, break even analysis, cost-volume-profit analysis, margin of safety and degree of operating leverage, capital budgeting for comparing projects or opportunities	**10L**
UNIT-04	**Sources of finance:** Debt or equity financing, commercial banks, venture capital; financial institutions supporting entrepreneurs; legal issues- Intellectual property rights, patents, trademarks, copyrights, trade secrets, licensing, franchising	**05L**
UNIT-05	**Innovation and incentives:** Design thinking, design-driven innovation, systems thinking, open innovation, Innovation Vs Invention, TRIZ, how to start a start-up?, government incentives for entrepreneurship, incubation, acceleration	**05L**

Course Outcomes

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

CO1: Assess and analyze entrepreneurship as a career choice.
CO2: The course provides all students a very unique opportunity by exposing them to turn an idea into a real, scalable business.
CO3: The course immerses students in a safe but rigorous environment to test their limits and fuel their growth as entrepreneurs
CO4: Efficiently work in a complex and dynamic environment which comprised of multicultural interdisciplinary teams.

Books and References

1. Effective Entrepreneurial Management: Strategy, Planning, Risk Management, and Organization by Robert D. Hisrich and Veland Ramadani, Springer Publications
2. Entrepreneurship - Theory, Process Practice by Kuratko and Hodgetts, Thompson South-Western Publication
3. Entrepreneurship by Robert D. Hisrich (Edition-9)
4. Entrepreneurship development small business enterprises by Poornima M Charantimath, Pearson Publications

Course Name: **Innovation and Start-up Policy**

Course Code: **MB-370**

Course Type: **Open Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- Develop a strategic framework for assessing market opportunities
- Anticipate and take advantage of the customer decision process with consumer insight Leverage innovation and design thinking to capture value for customers.
- Choose marketing channels best suited for their product and market Communicate more effectively with the marketing team Link between Innovation, marketing and meaning of customer value

Unit Number	Course Content	Lectures
UNIT-01	**Innovation:** Types of Innovation, Innovator's Dilemma – the essence of marketing to resolve the dilemma, the link between innovative ideas, innovation and Marketing, How to Succeed in Marketing, Marketing Remix- Introducing 4A's, Think like a customer, Managing Acceptability, Managing Affordability, Managing Accessibility, Managing Awareness, Applying 4 A Analysis	**05L**
UNIT-02	**Understanding Consumer Behavior**: Consumer's Hierarchy of Motivations, Why we buy, what we buy? Consumer Decisions and Relationships, Climate Consumption and Culture, Online Consumer Behavior, Introduction to New Product Development, A framework for successful New Product Development, The factors of success for new product development, Product Development Methodologies and Organization, Opportunity Identification and Selection	**06L**
UNIT-03	**Design Thinking Process for Product development:** Building Capabilities for Execution, Applying design thinking to drive innovation, Improving product development and innovation strategy, Examining the best practices in prototyping and experimentation	**07L**
UNIT-04	**Managing Innovation:** Why do most innovations fail? How to Develop Affordable innovations? Disruptive Innovation Model, Diffusion of Innovation Theory, Assessing the drivers of new product adoption, Consumer Adoption Patterns, Determining promotional strategy, Considering overall product positioning, Factors of the success of Product innovation	**06L**
UNIT-05	**Linking Innovation strategy to Product Launch:** Bringing Innovations to Market, the Innovators License, Network Externalities or Effects, the trajectory of buzz, Go-to Market Campaign, Targeting revenue leaders instead of Influencers, Innovation and Start-ups, Innovation and innovation eco-system, The policy Framework , Start-up Landscape and Innovation Hubs, Digital India and Make in India, Linking Innovation with IPR, Raising Finance for Start-ups in India, Innovation in Indian Context, Writing a Business Plan.	**07L**

Course Outcomes

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

CO1: Students will understand the basics of innovation, types of innovation.

CO2: Students will be able to leverage marketing concepts to influence the outcomes of new products and innovations

CO3: As budding managers/ practitioners they will learn to identify the right product for the right market opportunity.

CO4: Students will learn about how to evaluate market attractiveness, think about the design and management of distribution channels and understand pricing architectures.

Books and References

1. Four A's of Marketing- Creating Value for customers by Prof Jagdish N Seth and Rajendra S Sisodia
2. The Innovators Dilemma by Clay Christensen
3. Innovation and Entrepreneurship by Peter F. Drucker (Classic Drucker Collection, 2007)
4. Joseph A. Schumpeter's views on entrepreneurship and innovation by Perihan Hazel

Course Name: **Managing E-commerce and Digital Communication**
Course Code: **MB-380**
Course Type: **Open Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- Understanding of concepts and techniques of internet marketing.
- Finding out the opportunities for marketers on digital platform.
- Understanding the role of several e commerce models in customer value creation.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction to digital marketing:** Digital marketing meaning scope and importance. Internet versus traditional marketing. Use of business to consumer and business to internet marketing, internet marketing strategy, Incorporating self-service technologies (SSTs)	**06L**
UNIT-02	**Online buyer behaviour and models:** marketing mix in online context. Managing online customer experience, planning website design, understanding site user requirement, site design and structure, integrated marketing communications (IIMC), measurement of interactive marketing communication, e-WOM.	**07L**
UNIT-03	**Digital promotion techniques:** email marketing, strategy to craft email marketing campaign, permission marketing, viral marketing, blogs, search engines marketing (SEM), Search engine optimization, content marketing	**08L**
UNIT-04	**Social media marketing:** designing content for social media marketing, mobile marketing – advertising on mobile devices, mobile apps, tracking mobile marketing performance, and introduction to web analytics – meaning types, key metrics and tools.	**08L**
UNIT-05	**Introduction to eCommerce and Retailing in Online Space:** advantages of eCommerce Platforms, Differentiate Show-rooming and Web-rooming, e-tailing, eCommerce Business Process, Business Models, Interpret eCommerce Shopping Cart Software & Other Factors of eCommerce based business, role of aggregators in eCommerce business.	**10L**

Course Outcomes

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

CO1: Understand strategies used in digital marketing.
CO2: Apply digital promotion techniques for marketing of product and services.
CO3: Evaluate the role of web analytics in social media marketing.
CO4: Apply and design various e commerce models for e business.

Books and References

1. Kotler, P. and Keller, K.L. (2017). Marketing Management. 15th ed. India: Pearson Education.
2. Chaffey, D. and Ellis-Chadwick, F. (2012). Digital Marketing: Strategy, Implementation and Practice. 1st ed. Harlow: Pearson Education.
3. Digital Marketing: Cases from India by Rajendra Nargundkar and Romi Sainy, Notion Press, Inc.
4. Understanding Digital Marketing: Marketing Strategies for Engaging the Digital Generation by Damian Ryan, Kogan Page Publisher.
5. Marketing 4.0: Moving from Traditional to Digital by Philip Kotler, Publisher Wiley.

Course Name: **Materials Characterization Techniques**
Course Code: **MS-370**
Course Type: **Open Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the materials characterization
- To introduce fundamental concepts relevant to materials analysis
- To enable the students to understand properties of engineering materials and various advanced characterization methods

Unit Number	Course Content	Lectures
UNIT-01	**Optical Microscopy:** Optical microscope - Basic principles and components, Different examination modes (Bright field illumination, Oblique illumination, Dark field illumination, Phase contrast, Polarized light, Hot stage, Interference techniques), Stereomicroscopy, Photomicroscopy, Colour metallography, Specimen preparation, Applications.	**06L**
UNIT-02	**Electron Microscopy:** Interaction of electrons with solids, Scanning electron microscopy Transmission electron microscopy and specimen preparation techniques, Scanning transmission electron microscopy, Energy dispersive spectroscopy, Wavelength dispersive spectroscopy.	**06L**
UNIT-03	**Diffraction Methods:** Fundamental crystallography, Generation and detection of X-rays, Diffraction of X-rays, X-ray diffraction techniques, Electron diffraction.	**06L**
UNIT-04	**Thermal characterization**: Thermo gravimetric analysis (TGA), Differential thermal analysis (DTA), Differential scanning Calorimetry (DSC), Dynamic mechanical analysis (DMA), Thermomechanical analysis (TMA) and Dynamic mechanical thermal analysis (DMTA), Basic theory, Instrumentation and applications	**06L**
UNIT-05	**Surface Analysis:** Atomic force microscopy, scanning tunneling microscopy, X-ray photoelectron spectroscopy.	**06L**
UNIT-06	**Spectroscopy:** Atomic absorption spectroscopy, UV/Visible spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy.	**06L**

Course Outcomes

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

CO1: Understand common use of characterization technique
CO2: Describe and analysis the various properties of materials
CO3: Understand principle of materials characterization technique

Books and References

1. Materials Characterization Techniques by Sam Zhang, Lin Li and Ashok Kumar, CRC Press.
2. Materials Characterization: Introduction to Microscopic and Spectroscopic Methods by Yang Leng, Wiley & Sons.
3. Characterization of Materials by Elton N. Kaufmann, Wiley & Sons.
4. Growth of Single Crystals by R.A. Laudise, Prentice Hall.
5. Springer Handbook of Crystal Growth by G. Dhanaraj, K. Byrappa, V. Prasad and M. Dudley, Springer-Verlag.

Course Name: **Materials for Renewable Energy**

Course Code: **MS- 371**

Course Type: **Open Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To provides an introduction to energy systems and renewable energy resources, with a scientific examination of the energy field and an emphasis on alternate energy sources and their technology and application
- To emphasized the Energy conservation methods

Unit Number	Course Content	Lectures
UNIT-01	**Nuclear Metallurgy:** Structures and properties of materials with special relevance for nuclear power generation:uranium and other actinides, beryllium, zirconium, rare-earth elements, graphite. The materials of nuclear fuels and nuclear fuel element fabrication. Reprocessing of nuclear fuel elements. Nuclear Power Plant and Their Materials: Nuclear reactor, pressurised reactor, breeder reactor. Materials for fuel, control rods, coolant, moderator, shielding	**09L**
UNIT-02	**Effects of Radiation on Materials Properties:** Effects of X- rays on creep, fatigue, tensile, and other properties of metals, alloys, ceramics, polymers, rubbers etc. Effects on electrical, electronic and magnetic behaviour of materials, Effects on crystal structure, grain size etc.	**09L**
UNIT-03	**Materials in Fuel cells and Solar Cells:** Electrocatalyst materials for low temperature fuel cells, Conductive membranes for low-temperature fuel cells, Materials for high temperature fuel cells, silicon, quantum dots for solar energy, nanomaterials for solar thermal energy and photovoltaic	**06L**
UNIT-04	**Materials in Thermal Power Generation**: Superalloys, steels, ceramics, TBC, hydrogen membrane materials, sensor and sensor materials, biomass, coal, fly ash, etc .Materials in Hydro Power Generation Materials for power plant components, steel, stainless steel, ceramics, etc.	**06L**
UNIT-05	**Energy storage**: Artificial photosynthesis/solar to fuels, CO_2 separation and utilization, Safer nuclear waste disposal, biofuels production, biological fuel cell technologies, reduction of energy use in manufacturing processes, Improved grid technologies, sustainable energy economic.	**06L**

Course Outcomes

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

CO1: List and generally explain the main sources of energy and their primary applications in the India, and the world

CO2: Describe the challenges and problems associated with the use of various energy sources

CO3: List and describe the primary renewable energy resources and technologies.

Books and References

1. Introduction to Nuclear Science by J. C. Bryan, CRC Press.
2. Nuclear Reactor Materials and Applications by B.M. Ma, Van Nostrand Reinhold Company.
3. Nuclear Reactor Materials by C.O. Smith, Addison-Wesley Publishing Company.
4. Structural Materials in Nuclear Power Systems by J. T. A. Roberts, Plenum Press.
5. Handbook of Fuel Cells by Wolf Vielstich, Arnold Lamm, Hubert A. Gasteiger, and Harumi Yokokawa, John Wiley and Sons, Inc.

Course Name: **Electronic and Optical Properties of Materials**
Course Code: **MS-380**
Course Type: **Open Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To introduce the fundamentals of electronic materials, their properties and examples.
- To expose the properties and applications of functional materials in modern technology.
- To familiarize the students with various concepts related to electronic and optical properties and their exploitation to develop the useful materials based on the structure, chemistry and the processing techniques.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Review of quantum mechanical concepts, In adequacies of free electron theory, Electron in metals-consequences of interaction with lattice, Brillouin zones and nearly free electron model.	**06L**
UNIT-02	**Electrical properties of metals & alloys:** Classical theories of conductivity, Quantum mechanical theory of conductivity, Experimental results & their interpretations: metals, alloys, ordering & phase stability. **Electrical resistivity:** Electrical resistivity of metals, Alloys, Multiphase solids And Mattheissen rule.	**09L**
UNIT-03	**Semiconducting Materials:** Semiconductor band diagrams, direct and indirect bandgap, applications of semiconductors; intrinsic and extrinsic semiconductors, and mobility measurements;	**06L**
UNIT-04	**Dielectric and Insulating Materials:** Review of polarization, Clausius Mosotti equation, Mechanisms of polarization, Dielectric permittivity and loss (in brief), Dielectric break down in materials, High K dielectric, Non-linear dielectrics: Ferroelectric, Piezoelectric pyroelectric phenomena	**09L**
UNIT-05	**Optical Materials**: electron-hole recombination, bandgap engineering; Light interaction with materials transparency, translucency and opacity, refraction and refractive index, reflection, absorption and transmission	**06L**

Course Outcomes

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

CO1: Learn the basics of materials used in present electronic industry.
CO2: Explain the behavior of conductivity of metals and classifications of semiconductor materials
CO3: Explain the importance of optical properties.

Books and References

1. Physics of Semiconductor Devices by S.M. Sze, Wiley.
2. Semiconductor Opto-electronic Devices by P. Bhattacharya, PHI.
3. Optoelectronics by Wilson Hawkes, PHI.
4. The Science and Engineering of Microelectronics Fabrication by S. Campbell,Oxford.
5. Electronic Properties of Materials by Hummel, Springer

Course Name: **Nanomaterials and Nanotechnology**

Course Code: **MS- 381**

Course Type: **Open Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To provides an introduction to Nanomaterials and Nanotechnology
- To provide an introduction to synthesis of nanomaterials
- To provide an understanding on various process involved in nanomaterials synthesis

Unit Number	Course Content	Lectures
UNIT-01	**Introduction to Nanotechnology** – Importance of size distribution and control -Effects of size on physiochemical properties of nanomaterials – Size effects on surface area and aspect ratios – Size induced Metal Insulator Transition- Introduction to basic nanostructures	**09L**
UNIT-02	**Introduction to chemical bonds and forces** -Surface energy – Surface charge density-Chemical Potential and Surface curvature – Ostwald Ripening process – Stabilization against agglomeration -Electrostatic and Steric Stabilization– Interaction between two particles DVLO theory,Diffusion in Nanostructures	**06L**
UNIT-03	**Top down and bottom up synthesis-** mechanical alloying, Mechanical ball milling, Ion implantation, Inert gas condensation, Arc discharge, RF-plasma arc technique, Laser ablation, Template assisted synthesis. Self-assembly, self-assembled monolayers (SAMs).	**06L**
UNIT-04	**Synthesis of nanomaterials:** Gold, Silver, different types of Nano oxides, TiO2, ZnO by using sol-gel method, Carbon nanotubes, Graphene preparation, properties and applications, vapors deposition: Epitaxial growth techniques: Molecular beam epitaxy, Atomic layer deposition, Pulsed laser deposition, Magnetron sputtering, Spin coating, Micro lithography Etching process: Dry etching, Wet etching.	**09L**
UNIT-05	**Properties of nanomaterials,** 1D, 2D and 3D quantum confinement, quantum effects on density of states, band gap energy, Brus equation, surface plasmon resonance, role of size, surface and quantum confinement on properties of nanomaterials – physicochemical, optical, luminescence, electrical electronic, magnetic, thermodynamic, mechanical, and catalytic properties. Application of Nanotechnology	**06L**

Course Outcomes

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

CO1: List and generally explain the nanotechnology

CO2: Describe the process of synthesis nanomaterials

CO3: List and describe the primary application of technology

Books and References

1. Handbook of Nanoscience, Engg. and Technology by W.Gaddand, D.Brenner, S.Lysherski and G.J.Infrate, CRC Press.
2. A Textbook of Nanoscience and Nanotechnology by T. Pradeep, Tata McGraw Hill Education
3. Introduction to Nano Technology by C. P. Poole, Jr., F. J. Owens, Wiley.
4. Springer Handbook of Nanotechnologyby B. Bhushan, Springer-Verlag Berlin Heidelberg.
5. Nanoscale Science and Technology by R. Kelsall, I.W. Hamley, and M. Geoghegan, John Wiley & Sons.

Course Name: **Statistical Quality Control**
Course Code: **MA-370**
Course Type: **Open Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To understand the basic concepts of quality monitoring.
- To understand the statistical underpinnings of quality monitoring.
- To learn various available statistical tools of quality monitoring.
- To learn the statistical and economical design issues associated with the monitoring tools.
- To demonstrate the ability to design and implement these tools.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Concept of Quality – Quality movement in India – Standardization for Quality – Quality movement – Quality management – Quality circles – Total Quality Management – ISO 9001; Need for SQC in industries	**05L**
UNIT-02	**Process Control:** Chance and assignable causes of variation - specification and tolerance limits; process capability- Statistical basis for control charts: X-bar, R and standard deviation charts - their construction and analysis	**06L**
UNIT-03	**Control Charts for Attributes** – p, np, c and u charts – their construction and analysis	**05L**
UNIT-04	**Product Control:** Acceptance sampling by attributes; Producer's and Consumer's risk; Notions of AQL, LTPD and AOQL **Modified Control Charts for Mean**: CUSUM chart – technique of V-mask – Weighted Moving average charts – multivariate control charts – Hotelling's T^2 control charts and Economic design of X-bar chart	**14L**
UNIT-05	**Sampling Plans:** OC, AOQ, ASN, ATI curves for Single and double sampling plans – Concept of Sequential sampling plan for attributes.	**06L**

Course Outcomes

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

CO1: Understand the philosophy and basic concepts of quality improvement
CO2: Demonstrate the ability to use the methods of statistical process control
CO3: Demonstrate the ability to design, use, and interpret control charts for variables.
CO4: Perform analysis of process capability and measurement system capability
CO5: Design, use, and interpret exponentially weighted moving average and moving average control charts.

Books and References

1. Introduction to Statistical quality control by D.C. Montgomery, John Wiley & Sons..
2. Fundamentals of Applied Statistics by S.C. Gupta and V.K. Kapoor, Sultan Chand and Sons.
3. Process Quality Control by E.R. Ott, Mc Graw Hill.

Course Name: **Applied Time Series Analysis**
Course Code: **MA-371**
Course Type: **Open Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the areas of practical time series statistics.
- To apply the concepts of practical time series statistics to real data sets.
- To enable the students to assimilate data applied to real, scientific and interesting problems.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:** Components of time series, trend, periodic changes, irregular component, analysis of time series, uses of time series, time series decomposition.	**06L**
UNIT-02	**Measurement of Trend:** Graphic method, Method of semi-averages, method of curve fitting by principles of least squares, growth curves and their fitting, moving average method.	**06L**
UNIT-03	**Measurement of Seasonal Fluctuations:** Method of simple averages, ratio to trend method, ratio to moving average method, link relative method, measurement of cyclic movement.	**06L**
UNIT-04	**Auto – Regression Series:** First order auto – regression (Markoff's Series), Second order autoregressive series (Yule's Series), General auto – regression, auto – correlation and correlogram, random component in time series, variate difference method.	**06L**
UNIT-05	**Simple Regression:** Least square estimation, the coreelation coefficient, simple regression and the correlaton coefficient, Residulas, outliers and influential observations, correlation and causation, inference and forecasting with simple regression **The Box Jenkins Methodology:** Examining correlation in time series data, stationarity of time seris data, ARIMA models for time series data	**12L**
		36L

Course Outcomes

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

CO1: Understand and analyze the theoretical & practical aspects of time series data.
CO2: Understand the basic structure of time series and its components.
CO3: Identify and decompose time series model into its components.
CO4: Understand the genesis of the Box Jenkins Methodology and models based on it.

Books and References

1. Time Series Analysis: Forecasting and Control by George E.P. Box, G.M. Jenkins, G.C. Reinsel, G.M. Ljung, John Wiley & Sons.
2. Introduction to Time Series and Forecasting by P.J. Brockwell, R.A. Davis, Springer.
3. Time Series Analysis by J.D. Hamilton, Princeton University Press.

Course Name: **Principles of Design of Experiments**
Course Code: **MA-380**
Course Type: **Open Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the issues and principles of Design of Experiments (DOE)
- To introduce the fundamental concepts relevant to Experimental Designs and Multiple Comparison tests
- To enable the students to understand the factors that cause the Factorial Experiments and block designs …

Unit Number	Course Content	Lectures
UNIT-01	**Basic Principles for Designing Statistical Experiments:** Randomization, Replication and local control techniques - Determination of experimental units and notion of experimental error - Analysis of variance with one–way and two–way classifications - Models and Methods of analysis.	**08L**
UNIT-02	**Experimental Designs:** Completely Randomized Design (CRD) and Randomized Block Design (RBD)- Models and estimates of parameters and their standard error - Analysis of data arising from such designs, Analysis when one or two observations are missing. Latin Square Design (LSD) – Model – Estimation of parameters – Method of analysis – Missing Plot technique in LSD	**10L**
UNIT-03	**Multiple Comparison Tests:** Least Significant Difference, Student-Newman–Keuls test, Duncan's Multiple Range test, Tukey's test.	**04L**
UNIT-04	**Factorial Experiments:** 2^2, 2^3 and 3^2 designs; estimation of main effects and interactions and their standard errors	**04L**
UNIT-05	**Balanced Incomplete Block Design (BIBD):** Types of BIBD – Simple construction methods – Concept of connectedness and balancing – Intra Block analysis of BIBD – Recovery of Inter Block information – Partially Balanced Incomplete Block Design with two associate classes – intra block analysis only - Split plot and strip plot design and their analysis.	**10L**

Course Outcomes

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

CO1: Identify the experimental designs in CRD, RBD and LSD
CO2: Describe the relationship among designs and factorial experiments
CO3: Apply principles of multiple comparison tests and block designs with examples

Books and References

1. Design and Analysis of Experiments by M.N. Das, M.N., N.C. Giri, Wiley eastern.
2. Design of Experiments by D.C. Montgomery, John Wiley and Sons.
3. An Introduction to Linear Statistical Models by F.A. Graybill, Mc-Graw Hill.
4. An Outline of statistical theory by A.M. Goon, M.K.Gupta, B. Dasgupta, World Press Calcutta.
5. Fundamentals of Applied Statistics by S.C. Gupta, V.K. Kapoor, Sultan Chand & Sons.
6. Applied Statistics by P. Mukhopadhyay, Books and Allied (P) Ltd.

Course Name: **Numerical Methods for Partial Differential Equations**
Course Code: **MA-381**
Course Type: **Open Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge about the various numerical methods to solve the partial differential equations.
- To enable the students to examine the compatibility, convergence and stability of the numerical schemes.
- Detailed study of finite difference methods to solve PDEs of parabolic, elliptic and hyperbolic type.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction to Partial Differential Equations:** Classification of PDE, Standard forms of PDE, Boundary conditions.	**04L**
UNIT-02	**Introduction of Numerical Methods for Partial Differential Equations:** Taylor's series expansion, Analysis of truncation error, Finite difference approximation, Order of approximation, Polynomial fitting and one sided approximation, Finite difference method, finite element method, quadrature method, Exposure to MATLAB and computational experiments based on algorithms.	**12L**
UNIT-03	**Solution of Parabolic Equation:** Explicit and Implicit scheme for 1D parabolic equation, Compatibility, convergence and stability conditions, Derivative boundary condition with example, Explicit and implicit scheme for 2D parabolic equation, Alternating direction implicit (ADI) Scheme for 2D parabolic equation.	**08L**
UNIT-04	**Solution of Elliptic Equation:** Solution of Laplace equation using standard five point formula and diagonal five point formula, Successive over relaxation (SOR) and Alternating direction implicit (ADI) methods for elliptic equation.	**06L**
UNIT-05	**Solution of Hyperbolic Equation:** Explicit and implicit scheme for hyperbolic equations, Stability analysis of scheme, Characteristics of PDE and their significance, Method of characteristic, Lax-Wendroff's method, Wendroff's method, Stability analysis of methods.	**06L**

Course Outcomes

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

CO1: Use numerical methods to obatin the approximate solutions of initial and bondary value problems
CO2: Classify PDE's and to obatin their numerical solutions
CO3: Assess the compatibility, convergence and stability of numerical schemes

Books and References

1. Applied numerical analysis by C.F. Gerald and P.O. Wheatley, Pearson.
2. Numerical solution of partial differential equations: Finite Difference Method by G.D. Smith, Clarendon press.
3. Numerical analysis of differential equations by M.K. Jain, Wiley Earstern.
4. Computational methods in ordinary differential equations by J.D. Lambert, Wiley.
5. The Finite Difference Method in Partial Differential Equations by A.R. Mitchell and R. Wait,, John Wiley & Sons.
6. Numerical Methods for Engineers by S.C. Chapra and R.P. Canale, McGraw Hill Education.
7. Numerical Analysis of Partial Differential Equations by C.A. Hall and T. A. Porsching, Prentice Hall.

Course Name: **Computer Aided Design**
Course Code: **ME-370**
Course Type: **Open Elective-I**

Contact Hours/Week: **2L+2P** Course Credits: **03**

Course Objectives

- To impart the basic knowledge of use of computers in product development and design.
- To introduce the students to mathematical and computational modelling of curves, surface and solids.
- To enablethe student to use computer for product modelling andanalysis.

Unit Number	Course Content	Lectures
UNIT-01	**Introduction:**Introduction to CAD/CAM/CAE and Historical Developmentof CAD,Product Development Cycle,Typical CAD SystemArchitecture,Graphic Devices and Classification, Input/output Devices, Operating Systems and Environments,Applications, Advantages and Limitations of CAD,Concept of Coordinate Systems,. Line Generation Algorithm: DDA, Bresenham's Algorithms.Graphics Exchange Standards and Database Management Systems.	**03L**
UNIT-02	**Modelling of Curves and Surfaces:**Curve Representation: Parametric vs Non-parametric, Implicit vs Explicit vs Intrinsic, Advantages of Parametric Representation, Analytic Curves, Synthetic Curves: Concept and Types of Continuity, Cubic Spline: Equation, Bezier Curve, B-Splines and NURBS, Various Types of Surfaces along with Their Typical Applications, Properties, Blending of Curves/Surfaces.	**06L**
UNIT-03	**Modelling of Solids:** Properties of Solid Model, Properties of Representation Schemes, Concept of Half-Spaces, Boolean Operations, Schemes: Boundary Representation (B-Rep), Constructive Solid Geometry (CSG), Sweep Representation, Analytical Solid Modelling (ASM), Primitive Instancing, Solid Manipulations.	**03 L**
UNIT-04	**Geometric Transformations:** Homogeneous Representation, Translation, Reflection, Rotation, Scaling, Shear in 2D and 3D, Combined Transformations, Modelling and Coordinate Transformations, Graphic Projections: Orthographic, Axonometric,Oblique, and Perspective Projections.	**03 L**
UNIT-05	**Finite Element Analysis:** Review of Stress-Strain Relation and Generalized Hooke's Law, Plane Stress and Plane Strain Conditions; Concept of Total Potential Energy; Basic Procedure for Solving a Problem using Finite Element Analysis, 1-D Analysis: Concept of Shape function and natural coordinates, 1-D structural problems with elimination and penalty approaches	**06 L**
UNIT-06	**Design Optimization:** Introduction, Gradient-based and Heuristic Methods, Johnson Method of Optimization Normal Specification Problem, Redundant Specification Problem,.	**03 L**

Course Outcomes

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

CO1: To use computers in mechanical component design.

CO2: To use mathematical concepts of curve, surface and solid formulations in CAD.

CO3: To use design and analysis techniques and softwares in CAD.

Books and References

1. CAD/CAM Theory and Practice by I. Zeid, McGraw Hill.
2. Mathematical Elements for Computer Graphics by David Rogers and J Alan Adams, TMH Publication.
3. Introduction to Finite Elements in Engineering by Chandrupatla T A and Belegundu A D, PHI.
4. Principles of Optimum Design: Modeling and Computation by Paplambros P. Y., Wilde D. J., Cambridge University Press, UK

Course Name: **Product Design and Development**
Course Code: **ME-371**
Course Type: **Open Elective- I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To make student confident in their own abilities to produce a new product.
- To provide awareness about the role of various functions such as marketing, finance, industrial design, production etc. in product development.
- To enable students to understand the basics of engineering and production in producing a new product.
- To enhance the ability to coordinate multiple, interdisciplinary tasks in order to achieve a common objective

Unit Number	Course Content	Lectures
UNIT-01	**Introduction**: Introduction and Significance of Product Design, Product Design and Development Process, Sequential Engineering Design Method, Challenges of Product Development, Concept Development, Product Development and AMF Development Process, AMF Organizations.	**06L**
UNIT-02	**Product Planning and Identifying Customer Needs**: Product Planning Process, Interpret Raw Data in terms of Customers Need, Organize Needs in Hierarchy and Establish the Relative Importance of Needs: Assessing Needs & Impact of Industrial Design, Industrial Design Process and Management, Assessing Quality of Industrial design.	**09L**
UNIT-03	**Concept Generation**: Activities of Concept Generation, Clarifying Problem, Concept Selection: Overview, Concept Screening and Concept Scoring, Methods of Selection, Concept Testing, Product Architecture, Industrial Design.	**06L**
UNIT-04	**Embodiment Designand Detailed Design**: Design for Prototyping& Manufacturing, Robust Design, Design for Manufacturing, Detailed Drawings and Specifications, Life Cycle Assessment.	**09L**
UNIT-05	**Intellectual Property and Environmental Guidelines**: Elements and Outline, Patenting Procedures, Claim Procedure, Design for Environment: Impact, Regulations from Government ,ISO System.	**06L**

Course Outcomes

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

CO1: Distinguish different product development processes.
CO2: Distinguish associated engineering information with the product developmentprocesses.
CO3: Think about the sustainable design of a product and processes for competitive market.
CO4: Manage, construct and defend product data and its supporting technologies for its development to disposal.

Books and References

1. Product Design and Development by Karl Ulrich and Steven D. Eppinger, Tata McGraw-Hill Education.
2. Product Design by K. Otto and K. Wood, Pearson Education.
3. Product Design: Creativity, Concepts and Usability by Prashant Kumar, PHI.
4. Making It: Manufacturing Techniques for Product Design by Chris Lefteri, McGraw-Hill Education.
5. Engineering Design, by George E. Dieter and Linda C. Schmidt, McGraw-Hill Education.

Course Name: **Mechatronics and Robotics**
Course Code: **ME- 380**
Course Type: **Open Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To impart knowledge and use of mechatronic system and different types of sensors and actuators.
- To introduce the fundamentals of microprocessors, microcontrollers and PLCs and their architecture.
- To impart the knowledge of robotics, robotic programming and robot vision.

Unit Number	Course Content	Lectures
UNIT-01	**Fundamentals of Mechatronics:** Definition, Applications, Block Diagram of Mechatronic System, Functions of Mechatronics Systems, Benefits of Mechatronics in Manufacturing. Analog Devices, Signal Conditioning, Digital Electronics, Data Acquisition systems	**03L**
UNIT-02	**Sensors and Actuators:** Static characteristics of sensors and actuators, Position, Displacement and Proximity Sensors, Force and torque sensors, Pressure sensors, Flow sensors, Temperature sensors, Acceleration sensors, Level sensors, Light sensors, Smart material sensors, Micro and Nano sensors, Selection criteria for sensors, Actuators: Electrical Actuators (Solenoids, Relays, Diodes, Thyristors, Triacs, BJT, FET, DC motor, Servo motor, BLDC motor, AC motor, Stepper motors), Hydraulic and Pneumatic actuators, Design of Hydraulic and Pneumatic circuits, Piezoelectric actuators, Shape memory alloys.	**09L**
Unit-03	**Microprocessors, Microcontrollers and Programmable Logic Controllers:** Logic Concepts and Design, System Interfaces, Communication and Computer Networks, Fault Analysis in Mechatronic Systems, Synchronous and Asynchronous Sequential Systems, Microcontrollers, Programmable Logic Controllers (PLCs): Architecture, Basics of PLC Programming, Logics, Timers and Counters, PLC Applications	**09L**
UNIT-04	**Introduction of Robotics**: Definition of a robot, types of robotic joints and motions, classifications of robot based on: Physical configurations, actuators and motion control; Terminologies used for robotics specification and selection for industrial applications; Types of end effectors.	**03L**
UNIT-05	**Robot Kinematics and Dynamics:** Homogeneous co-ordinates and co-ordinate transformations, kinematic parameters, use of Denavit-Hartenberg representation for finding arm equation of robotic arms, forward and inverse kinematics for basic industrial robotic configurations, SCARA configurations, Basics of Robot Dynamics.	**06L**
UNIT-06	**Robot Vision and Programming:** Sensing and digitization of vision data, image processing: image data reduction, segmentation, feature extraction, object recognition, and training of vision system, Robot programing methods, Robot Programming Languages.	**06**

Course Outcomes

Upon successful completion of the course, the students will be able to
CO1: Generate conceptual design for mechatronics products based on potential customer requirements
CO2: Select appropriate sensors and actuators and devise a system for collecting information about processes
CO3: Demonstrate the concepts of kinetics & dynamics of robot, and Identify an application of robots in manufacturing.

Books and References

1. Mechatronics: Electronic control systems in Mechanical and Electrical Engineering by W. Bolton, Pearson Edu.
2. Introduction to Mechatronics & Measurement Systems by David G Alciatore and Michael B Histand, McGraw-Hill.
3. Industrial Robotics: Technology, Programming and Applications by M.P. Grover and N. G. Odrey, TMH Edu. India
4. Robotics: Control and Programming by J. Srinivas, Rao V. Dukkipati and K. Ramji, Alpha Science International.

Course Name: **Total Quality Management**
Course Code: **ME-381**
Course Type: **Open Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- To understand the concept of Quality in Manufacturing and Service units
- To understand the Implication of Quality in Business
- To understand how to implement Quality Programs in an Organization
- To have exposure to challenges in Quality Improvement Programs

Unit Number	Course Content	Lectures
UNIT-01	**Introduction**: Evolution of Quality, Historical Perspectives, Relationship among Quality, Vision, Mission and Objectives of an Organization, Role of Quality in a Corporate Structure of an Organization, Attributes of Product and Service Quality, Quality Characteristics: Quality of Design, Quality of Performance and Quality of Conformance, Zero Defect and Continuous Improvement.	**06L**
UNIT-02	**Conceptualization of TQM**: Introduction to Total Quality Management (TQM), Barriers to TQM, Benefits of TQM implementation, Basic Approaches of TQM, TQM Models, Quality Information System and Planning, Importance of TQM in manufacturing and Service Industry.	**06L**
UNIT-03	**Organization Structure in TQM:** Role of Top Management, Quality Council, Quality Circles, Organization Structure for Quality Circles, Quality Policies, Role of Middle and Lower Management, Problem Solving Techniques.	**03L**
UNIT-04	**Tools and Systems for Quality Management:** Basic Tools: Cause & Effect Diagram, Flow Diagrams, Trend Charts, Histogram, Scatter Diagram, Control Chart, Advanced Tools: Affinity Diagram, Inter Relationship Diagram, Tree Diagram, Matrix Diagram, Process Decision Program Chart (PDPC) and Matrix Data Analysis, Fault Tree Analysis, Quality Function Deployment (QFD):Definition and Phases in QFD , Taguchi Approach To Quality System Design, Six-sigma :Definition & Implementation Steps, Just In Time Production System, Quality Production through JIT and Kanban, Failure Mode and Effect Analysis (FMEA): Scope, Mode, Illustrative Example and Applications.	**09L**
UNIT-05	**Quality Assurance** : Causes of Quality Failure, Quality Assurance: Need and Various Elements in Quality Assurance Programme, Quality Control- on Line and off Line, Statistical Concepts in Quality, Chance and Assignable Causes, Bench Making in Quality Management.	**06L**
UNIT-06	**Implementation and Need of ISO 9000:** ISO 9000 – 2000 Quality System: Elements, Registration, Documentation, Implemental Steps, Quality Audit, Product and Process Audit: Scope, Steps and Benefits.	**06L**

Course Outcomes

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

CO1: Identify the significance of quality in an organization

CO2: Describe how to manage quality improvement teams

CO3: Apply the tools of quality improvement programs in an organization

CO4: Assess the benefits of implementing TQM Program in an organization

Books and References

1. Total Quality Management by Dale H Bersterfilled, PHI Publication.
2. Total Quality Management by N.V.R Naidu, G. Rajendra, New Age international Publication.
3. Total Quality Management by L. Sugandhi and Samuel Anand, PHI Publication.
4. Total Quality Management by R.S Naagarazan, New Age International Publication.

Course Name: **Laser and Photonics**

Course Code**: PH-370**

Course Type: **Open Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- An ability to understand a Laser system
- An understanding of concepts of photonics.
- The broad education necessary to understand Laser and photonic systems
- A knowledge of concepts / technologies based on lasers

Unit Number	Course Content	Lectures
UNIT-1	Laser Physics: The Einstein coefficients, light amplification, the threshold condition, laser rate equations, line broadening mechanisms, cavity modes, optical resonator, quality factor, mode selection, Q-switching, mode locking in lasers; gas lasers, solid state lasers, semiconductor lasers and dye lasers.	**8L**
UNIT-2	Photonics: optical properties of anisotropic media, wave refractive index, optical activity and Faraday effect, liquid crystals;	**7L**
UNIT-3	Principles of electro-optics, magneto-optics, photo refractive materials, acousto-optics and related devices;	**7L**
UNIT-4	Nonlinear optical susceptibilities, second harmonic generation, self-focussing and Kerr effect; basic principles and applications of holography;	**7L**
UNIT-5	Step index and graded index optical fibers, attenuation and dispersion; fiber optic communications; optical detectors.	**7L**

Course Outcomes

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

CO1: Describe the Optical devices and their applications.

CO2: Identify the applications of lasers.

CO3: Write down the concepts related to lasers and photonics.

CO4: Learn to apply concepts learnt in lasers and photonics.

CO5: Learn the importance in the advancement of technologies.

Books and References:

1. W. T. Silfvast, Laser Fundamentals, 2nd Ed., Cambridge University Press, 2004.
2. B.E.A. Saleh and M.C.Teich, Fundamentals of Photonics, 2nd Ed., Wiley, 2007.
3. A. Ghatak and K. Thyagarajan, Optical Electronics, Cambridge University Press, 2009.
4. A. Yariv and P. Yeh, Photonics, 6th Ed., Oxford University Press, 2007.
5. O. Svelto and D. C. Hanna, Principles of Lasers, Springer, 1998.
6. R.W. Boyd, Nonlinear Optics, 3rd Ed., Academic Press, 2007
7. A. Yariv and P. Yeh, Photonics: Optical Electronics in Modern Communications, 6th Ed., Oxford University Press, 2006.

Course Name: **Physics of Semiconductor Devices**
Course Code: **PH-371**
Course Type: **Open Elective-I**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- An ability to understand the principles of semiconductors
- An understanding of concepts of semiconductor devices.
- The broad education necessary to understand semiconductor devices
- A knowledge of concepts / technologies based on semiconductor devices

Unit Number	Course Content	Lectures
UNIT-1	Idea of atomic structure, crystalline structure, Bonding in semiconductors, crystal structure of semiconductors, Miller indices, crystal structure, Semiconductor materials, Elemental and compound semiconductors, Band model of semiconductors, Carrier concentration in energy bands, Fermi level and energy distribution of carriers inside band, extrinsic semiconductors, concept of effective mass, heavily doped semiconductors	**8L**
UNIT-2	Doping mechanism, ion implantation, doping by diffusion, Fick's law of diffusion, diffusion profiles, diffusion constant and diffusion length	**7L**
UNIT-3	Drift and diffusion of charge carriers in semiconductors, Variation of mobility with temperature and doping level, conductivity, Hall effect, Einsteins relations, Temperature dependence of carrier concentration and resistivity in semiconductors,	**7L**
UNIT-4	P-n junction formation, constancy of Fermi level across junction, abrupt junctions, graded junctions and diffused junctions, current conduction across p-n junction, temperature dependence of I-V characteristic of junction, breakdown in p-n junctions.	**7L**
UNIT-5	deposition techniques, etching and ion milling, sputtering, thermal evaporation, electron beam evaporation, flash evaporation, laser ablation, chemical vapour deposition (CVD), molecular beam epitaxy (MBE), metal oxide chemical vapour deposition (MOCVD).	**7L**

Course Outcomes

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

CO1: Describe the concepts of semiconductor devices.

CO2: Identify the applications of semiconductor devices.

CO3: Write down the concepts related to semiconductor devices.

CO4: Learn and to apply concepts learnt in semiconductor devices in Industry and in real life.

Books and References:

1. Introduction to Semiconductor Materials and Devices: by M.S.Tyagi, John Wiley & Sons.
2. Physics of Semiconductor Devices: by S. M. Sze, Wiley Eastern Limited.
3. The Science and Engineering or Microelectronics fabrication: by Stephen A Campbell, Oxford Univ Press.
4. Electronic Materials Science: by James W Mayer & S S Lau, Macmillan publishing Co.
5. Semiconductor Devices An Introduction: by Jasprit Singh, McGraw Hill.

Course Name: **Nuclear Technology**

Course Code: **PH-380**

Course Type: **Open Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- An ability to learn nuclear technology
- An understanding of concepts of nuclear science and engineering .
- To impart education necessary to understand nuclear science and engineering
- To make students understand the use of nuclear technologies.

Unit Number	Course Content	Lectures
UNIT-1	Review of nuclear physics: general nuclear properties, models of nuclear structure, nuclea reactions,nuclear decays and fundamental interactions; Nuclear radiation: radioactivity radiation dosimetry, dosimetry units and measurement; radiation protection and control applications of radiation: medical applications, industrial radiography, neutron activation analysis, instrument sterilization, nuclear dating;	8L
UNIT-2	Nuclear fission: nuclear energy, fission products, fissile materials, chain reactions, moderators neutron thermalization, reactor physics, criticality & design; nuclear power engineering; energy transport and conversion in reactor systems, nuclear reactor safety;	7L
UNIT-3	Nuclear fusion: controlled fusion, nuclear fusion reactions, fusion reactor concepts, magnetic confinement, tokamak, inertial confinement by lasers;	7L
UNIT-4	Nuclear waste management: components and material flow sheets for nuclear fuel cycle waste characteristics, sources of radioactive wastes, compositions, radioactivity and heat generation; waste treatment and disposal technologies; safety assessment of waste disposal;	7L
UNIT-5	Particle accelerators and detectors: interactions of charged particles, gamma rays and neutrons with matter, electrostatic accelerators, cyclotron, synchrotron, linear accelerators colliding beam accelerators, gas-filler counters, scintillation detectors, and semiconductor based particle detectors.	7L

Course Outcomes

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

CO1: Understand nuclear technologies.

CO2: Identify the applications of nuclear techniques.

CO3: Use the concepts of nuclear technologies in useful applications.

Books and References

1. K. S. Krane, Introductory Nuclear Physics, John Wiley, 1987.
2. R. J. Blin-Stoyle, Nuclear and Particle Physics,Springer, 1991.
3. R. L. Murray, Nuclear Energy, 6th Ed., Butterworth-Heinemann, 2008.
4. J. J. Duderstadt and L. J. Hamilton, Nuclear Reactor Analysis, Wiley, 1976.
5. J. R. Lamarsh and A. J. Baratta, Introduction to Nuclear Engineering, Prentice Hall.

Course Name: **Microwave Physics**
Course Code: **PH-381**
Course Type: **Open Elective-II**

Contact Hours/Week: **3L** Course Credits: **03**

Course Objectives

- An ability to learn microwave physics
- An understanding of concepts microwave devices.
- The broad education necessary to understand microwave technology

Unit Number	Course Content	Lectures
UNIT-01	Introduction to Microwaves: History of Microwaves, Microwave Frequency bands; Applications of Microwaves: Civil and Military, Medical, EMI/ EMC.Mathematical Model of Microwave Transmission: Concept of Mode, Features of TEM, TE and TM Modes, Losses associated with microwave transmission, Concept of Impedance in Microwave transmission.	8L
UNIT-02	Analysis of RF and Microwave Transmission Lines: Coaxial line, Rectangular waveguide, Circular waveguide, Strip line, Micro strip line. Microwave Network Analysis: Equivalent voltages and currents for non- TEM lines, Network parameters for microwave circuits, Scattering Parameters.	7L
UNIT-03	Passive and Active Microwave Devices: Microwave passive components, Directional Coupler, Power Divider, Magic Tee, Attenuator, Resonator, Microwave active components, Diodes, Transistors, Oscillators, Mixers. Microwave Semiconductor Devices, Gunn Diodes, IMPATT diodes, Schottky Barrier diodes, PIN diodes. Microwave Tubes, Klystron, TWT, Magnetron.	7L
UNIT-04	Microwave Design Principles: Impedance transformation, Impedance Matching,Microwave Filter Design, RF and Microwave Amplifier Design, Microwave Power Amplifier Design, Low Noise Amplifier Design, Microwave Mixer Design, Microwave Oscillator Design.	7L
UNIT-05	Microwave Measurements: Power, Frequency and impedance measurement at microwave frequency, Network Analyzer and measurement of scattering parameters, Spectrum Analyzer and measurement of spectrum of a microwave signal.	7L

Course Outcomes

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

CO1: Describe the microwave devices and their applications.

CO2: Identify the applications of microwaves

CO3: Write down the concepts related to microwaves.

CO4: Learn and to apply concepts learnt in microwaves.

Books and References

1. Paul, C., Introduction to Electromagnetic Compatibility, John Wiley & Sons, 1992.
2. Kennedy, G., Electronic Communications Systems, McGraw-Hill, 1970.
3. Ott, H. W., Noise Reduction Techniques in Electronic Systems, John Wiley & Sons, second edition, 1988.