

# **Seventh Semester**

| B. Tech. (7 <sup>th</sup> Semester) Mechanical Engineering |  |           |        |            |            |       |             |
|--|--|-----------|--------|------------|------------|-------|-------------|
| MEO-401A   | SMART MATERIALS  |           |        |            |            |       |             |
| Lecture  | Tutorial   | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3  | 0  | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Purpose</b>   | The purpose of this course is to develop the understanding of various aspects of smart materials, smart structures and their applications.                   |           |        |            |            |       |             |
| Course Outcomes  |  |           |        |            |            |       |             |
| <b>CO1</b>   | Students will be able to recognize the key concepts behind classification and fabrication of smart materials and various functions of intelligent materials. |           |        |            |            |       |             |
| <b>CO2</b>   | Students will be able to categorize the various types of smart structure systems, actuators and sensors.   |           |        |            |            |       |             |
| <b>CO3</b>   | Students will be able to describe the various types of SMA based hybrid composites and smart battery materials.  |           |        |            |            |       |             |
| <b>CO4</b>   | Students will be able to perceive the structure and properties of various types of nanotubes.  |           |        |            |            |       |             |

#### UNIT-I

**Smart materials: key concepts:** Introduction to smart materials, definition of smart materials, define smart materials, basic principles behind smart properties, classification of smart materials according to their production technologies and applications in various industries, approaches to fabrication of smart materials, properties of smart materials, nanoscale and microscale structure property relationship, Intelligent materials, primitive functions of intelligent materials, intelligence inherent in materials, intelligent materials in harmony with humanity, intelligent biological materials, biomimetics.

#### UNIT-II

**Smart materials and structural systems:** Introduction, actuator materials, sensing technologies, sensing technologies, microsensors, intelligent systems, hybrid smart materials, passive sensory smart structures, reactive actuator based smart structures, active sensing and reactive smart structures, smart skins.

#### UNIT-III

**Shape memory alloys:** Phase transition, shape-memory effect, shape memory alloy fiber/metal matrix composites, shape memory alloy fiber/polymer matrix composites, SMA particulate / aluminum matrix composites.

**Smart battery materials:** Introduction, electrochemical concepts involved in a battery, types of batteries, lithium ion batteries, layered oxide cathodes, spinel oxide cathodes, olivine oxide cathodes, carbon anodes.

#### UNIT-IV

**Nanoscale intelligent materials and structures:** Introduction, nanotube geometric structures, structures of carbon nanotubes, structures of non-carbon nanotubes, designations of nanotubes and nanostructured materials, mechanical and physical properties of nanotubes; elastic properties, electrical conductivity,

magnetoresistance, piezo-resistance, electrokinetics of nanotube, piezoelectric properties, electrochemical effects, nanotube power generation, nanotube contact phenomena.

**Text books:**

1. Smart Materials and Structures - M.V. Gandhi and B.S. Thompson, Chapman and Hall pub.
2. Encyclopedia of Smart Materials - Mel Shwartz Vol.1 and 2, John Wiley & Sons, Inc.
3. Nano engineering of Structural, Functional, and Smart Materials - Mark J. Schulz, Ajit D. Kelkar, and Mannur J. Sundaresan , Taylor and Francis Pub.

**Reference books:**

1. Micro and smart systems - Ananthasuresh, Wiley India Ltd.
2. Coursera course Smart Materials: Microscale and Macroscale Approaches - Peter the great St. Petersburg Polytechnic University.

**Note: The paper setter will set the paper as per the question paper template provided.**

| B. Tech. (7 <sup>th</sup> Semester) Mechanical Engineering |   |           |        |            |            |       |             |
|--|---|-----------|--------|------------|------------|-------|-------------|
| MEO-405A   | NON-DESTRUCTIVE TESTING   |           |        |            |            |       |             |
| Lecture  | Tutorial  | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3  | 0   | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Purpose</b>   | The purpose of this course is to make the students understand about different inspection and testing methods of components safely and without damage. |           |        |            |            |       |             |
| Course Outcomes  |   |           |        |            |            |       |             |
| <b>CO1</b>   | Students will be able to learn the fundamental concepts of NDT.   |           |        |            |            |       |             |
| <b>CO2</b>   | Students will be able to describe the different methods of NDE.   |           |        |            |            |       |             |
| <b>CO3</b>   | Students will be able to describe the concept of thermography and eddy current testing.   |           |        |            |            |       |             |
| <b>CO4</b>   | Students will be able to explain the ultrasonic testing and acoustic emissions.   |           |        |            |            |       |             |

#### UNIT-I

**Introduction to NDT:** NDT vs destructive testing, overview of the non-destructive, Testing methods for the detection of manufacturing defects as well as material characterization, relative merits and limitations, various physical characteristics of materials and their applications in NDT, visual inspection – unaided and aided

#### UNIT-II

**Surface NDE methods:** Liquid penetrant testing – principles, types and properties of liquid penetrants, developers, advantages and limitations of various methods, testing procedure, interpretation of results, magnetic particle testing-theory of magnetism, inspection materials magnetization methods, interpretation and evaluation of test indications, principles and methods of demagnetization, residual magnetism.

#### UNIT-III

**Thermography and eddy current testing (ET):** Thermography- principles, contact and non-contact inspection methods, techniques for applying liquid crystals, advantages and limitations – infrared radiation and infrared detectors, instrumentations and methods, applications, eddy current testing-generation of eddy currents, properties of eddy currents, eddy current sensing elements, probes, instrumentation, types of arrangement, applications, advantages, limitations, interpretation/evaluation

#### UNIT-IV

**Ultrasonic testing (UT) and acoustic emission (AE):** Ultrasonic testing-principle, Transducers, transmission and pulse-echo method, straight beam and angle beam, instrumentation, data representation, A/Scan, B-scan, C-scan, phased array ultrasound, time of flight diffraction, acoustic emission technique-principle, AE parameters, applications.

#### Text books:

1. Non-Destructive Testing - Baldev Raj, T.Jayakumar, M.Thavasimuthu Narosa Publishing House.

2. Non-Destructive Testing Techniques - Ravi Prakash, 1<sup>st</sup> revised edition, New Age International Publishers.

**Reference books:**

1. ASM Metals Handbook, Non-Destructive Evaluation and Quality Control, American Society of Metals, Metals Park, Ohio.
2. ASNT, American Society for Non Destructive Testing, Columbus, Ohio, NDT Handbook, Vol. 1, Leak Testing, Vol. 2, Liquid Penetrant Testing, Vol. 3, Infrared and Thermal Testing Vol. 4, Radiographic Testing, Vol. 5, Electromagnetic Testing, Vol. 6, Acoustic Emission Testing, Vol. 7, Ultrasonic Testing.
3. Handbook of Nondestructive evaluation by Charles, J. Hellier, McGraw Hill, New York 2001.
4. Introduction to Non-destructive testing: a training guide by Paul E Mix, Wiley, 2<sup>nd</sup> Edition New Jersey, 2005.

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| B. Tech. (7 <sup>th</sup> Semester) Mechanical Engineering |  |           |        |            |            |       |             |
|--|--|-----------|--------|------------|------------|-------|-------------|
| MEO-407A   | MANUFACTURING COST ESTIMATION  |           |        |            |            |       |             |
| Lecture  | Tutorial   | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3  | 0  | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Purpose</b>   | The purpose of this course is to impart the students with the knowledge of cost estimating function and controls, organizing and staffing for cost estimation and cost estimation of machining, joining and finishing processes. |           |        |            |            |       |             |
| Course Outcomes  |  |           |        |            |            |       |             |
| <b>CO1</b>   | Students will be able to describe cost reduction techniques, cost estimating functions, and establish staff and organization for cost estimation.  |           |        |            |            |       |             |
| <b>CO2</b>   | Students will be able to discuss cost estimating controls and various estimating procedures.   |           |        |            |            |       |             |
| <b>CO3</b>   | Students will be able to estimate the costs for different machining and casting processes.   |           |        |            |            |       |             |
| <b>CO4</b>   | Students will be able to estimate the costs for different joining and surface finishing processes.   |           |        |            |            |       |             |

#### UNIT-I

**The estimating function and costing studies:** Explanation of terms, importance of the life of the product, target cost, product costs, purpose of estimating, types of estimates, a systematic approach to cost reduction, cost reduction examples, team efforts.

**Organizing and staffing for estimating:** Coordinated product cost estimating, cost estimating department, type of organization and cost estimating, qualifications of a cost estimator, development of a cost estimator.

#### UNIT-II

**Cost estimating controls:** Administrative controls, initiating cost requests, estimating methods, controlling the cost estimate, controlling estimate deviations, estimating in a changing cost environment, do's and don'ts of cost estimating.

**Estimating procedures:** Cost estimating analysis, part analysis, preliminary manufacturing plan, facilities, direct material cost, tooling costs, manufacturing time, direct labour costs, factory burden, total manufacturing cost.

#### UNIT-III

**Cost estimation for machining:** Traditional machining operations defined, gathering information, economical machining, cost modeling and calculations, grinding application, milling application, non-traditional machining applications.

**Estimating casting costs:** Casting materials, casting processes, determining material costs, foundry tooling defined, molding costs, core costs, machining and cleaning costs, heat treatment, inspection and shipping costs, foundry burden.

#### **UNIT-IV**

**Estimation of cost:** Joining Costs: Welding, Braze Welding, Brazing, Soldering, Electron Beam Welding, Laser Beam Welding, Plasma Arc Welding, Adhesive Bonding, Fastening, Ultrasonic Welding.

**Estimating surface finishing costs:** Deburring, ultrasonic cleaning, polishing, honing, hybrid finishing processes, painting, electroplating, cost modelling and calculations.

#### **Text books:**

1. Realistic cost estimating for manufacturing. Third Edition - Lembersky, Michael Society of Manufacturing Engineers, 2016.
2. Process Planning and Cost Estimation, Second Edition - R. Kesavan, C. Elanchezian, B. Vijaya Ramanath, New age international publishers.

#### **Reference books:**

1. Process Planning And The Cost Estimation - M. Adithan, New age international publishers.
2. Estimating and Costing for the Metal Manufacturing Industries - Robert Creese (Author), M. Adithan (Author), CRC Press

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| B. Tech. (7 <sup>th</sup> Semester) Mechanical Engineering |   |           |        |            |            |       |             |
|--|---|-----------|--------|------------|------------|-------|-------------|
| MEO-409A   | ERGONOMICS  |           |        |            |            |       |             |
| Lecture  | Tutorial  | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3  | 0   | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Purpose</b>   | The purpose of this course is to make the students aware of the human factor engineering principles and its application to different disciplines. |           |        |            |            |       |             |
| Course Outcomes  |   |           |        |            |            |       |             |
| <b>CO1</b>   | Students will be able to explain the ergonomics fundamentals and anthropometry.   |           |        |            |            |       |             |
| <b>CO 2</b>  | Students will be able to analyse the human posture, relative movements and human behavior and perception.   |           |        |            |            |       |             |
| <b>CO 3</b>  | Students will be able to apply the ergonomics principles in visuals display and product designing.  |           |        |            |            |       |             |
| <b>CO 4</b>  | Students will be able to describe the workstation design and occupational safety.   |           |        |            |            |       |             |

#### UNIT-I

**Discipline approach: ergonomics/ human factors:** Introduction to ergonomics, Fitting task to man their contractual structure, domain, philosophy and objective, mutual task comfort: two way dialogue, communication model, ergonomics/ human factors fundamentals, physiology (work physiology) and stress.

**Human physical dimension concern:** Human body- structure and function, anthropometrics, Anthropometry: body growth and somatotypes, static and dynamic anthropometry, stand posture-erect, Anthropometry landmark: sitting postures, Anthropometry: squatting and cross-legged postures, anthropometric measuring techniques, statistical treatment of data and percentile calculations.

#### UNIT-II

**Posture and movement:** Human body- structure and function, posture and job relation, posture and body supportive devices, chair characteristics, vertical work surface, horizontal work surface, movement, work counter

**Behaviour and perception:** Communication and cognitive issues, psycho-social behaviour aspects, behaviour and stereotype, information processing and perception, cognitive aspects and mental workload, human error and risk perception

#### UNIT-III

**Visual Issues:** Visual performance, visual displays, environments factors, environmental factors influencing human performance

**Ergonomic design process:** Ergonomics design methodology, Ergonomics criteria/check while designing, Design process involving ergonomics check, some checklists for task easiness.

#### **UNIT-IV**

**Performance support and design intervention:** Occupational safety and stress at workplace in view to reduce the potential fatigue, errors, discomforts and unsafe acts workstation design, furniture support, vertical arm reach and design application possibility

**Humanising design:** Design and human compatibility, comfort and adaptability aspects, Design Ergonomics in India: scope for exploration.

#### **Text Books:**

1. Introduction to Ergonomics - R. Bridger-CRC Press, Taylor & Francis Group.
2. Human Factors in Engineering and Design-M. Sanders, E. McCormick, McGraw-Hill International Editions: Psychology Series.
3. An Introduction to Human Factors Engineering-C. Wicknes, S. Gordon, Y. Liu and S. Gordon-Becker, New York.
4. Indian Anthropometric Dimensions for Ergonomic Design Practice-D. Chakrabarti, National Institute of Design, Ahmedabad.

#### **Reference Books:**

1. Handbook of Human Factors and Ergonomics-G. Salvendy, John Wiley & Sons, Inc.
2. Ergonomics for Beginners, A Quick Reference Guide, J. Dul and B. Weerdmeester, CRC Press, Taylor & Francis Group.

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| B. Tech. (7 <sup>th</sup> Semester) Mechanical Engineering |  |           |        |            |            |       |             |
|--|--|-----------|--------|------------|------------|-------|-------------|
| MEO-411A   | AIR AND NOISE POLLUTION  |           |        |            |            |       |             |
| Lecture  | Tutorial   | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3  | 0  | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Purpose</b>   | The objective of this course is to analyze the emissions from automobiles, industries and to describe various techniques of reducing these emissions. Also to understand the concept to control noise pollution. |           |        |            |            |       |             |
| Course Outcomes  |  |           |        |            |            |       |             |
| <b>CO1</b>   | Students will be able to analyze the emissions from industries and various vehicles.   |           |        |            |            |       |             |
| <b>CO2</b>   | Students will be able to understand standards, alternative control strategies and AAQ guidelines.  |           |        |            |            |       |             |
| <b>CO3</b>   | Students will be able to describe various processes for desulfurization, flue control methods for various exhaust gases.   |           |        |            |            |       |             |
| <b>CO4</b>   | Students will be able to explain the characterization of noise, physical sound and various noise barriers.   |           |        |            |            |       |             |

#### UNIT-I

**Introduction:** Concept of unpolluted air, gaseous and vapour pollutants in atmosphere, scales of air pollution, primary and secondary pollutants, ambient air quality, monitoring of pollutants (SO<sub>2</sub>, NO<sub>2</sub>, O<sub>3</sub>, PAN, particulates, hydrocarbons, PAH's) and their health effects, stack monitoring for SO<sub>x</sub>, NO<sub>x</sub>, CO, CO<sub>2</sub>, Hydrocarbons, Fluorides, Ammonia, VOCs, effects of air pollution on vegetation, materials and structures, stack monitoring for thermal power plant, oil refinery industry, fertilizer industry, non-ferrous metal industry. recent techniques of online stack monitoring, emission inventory, trends of AAQ in urban, rural and Industrial areas.

#### UNIT-II

**Air quality:** National and International air emission standards and AAQ guidelines, indoor air quality, averaging time, air pollution system, alternative control strategies, GLC estimates for multiple sources using standard software (e.g., EPA's ISC model), determination of effective stack height.

#### UNIT-III

**Emission Standards and Particulate matter:** Distribution and sources of particulate matter, Hood duct design, particulate collection mechanisms, control systems and their design, flue-gas desulfurization processes, flue gas control methods for NO<sub>x</sub>, emission standards for automobiles, origin of exhaust

emissions from gasoline, diesel, CNG and LPG engines, crankcase and evaporative emissions, emission reduction by fuel changes, emission reduction by engine design changes, catalytic converters, diesel engine emissions.

#### **UNIT-IV**

**Noise:** Characteristics, sources, types of noise, impact of noise.

**Physics of sound-** Speed of sound, sound pressure, frequency, wavelength, RMS sound pressure, sound pressure level, loudness, sound power level and sound energy density, sound propagation, wind and temperature gradient.

**Enclosures and Barriers:** Lead as a noise barrier, plenum barriers, barrier around pipe, wires and rectangular ductwork, high transmission loss ceilings, acoustical foams, nylon in noise reduction, damping compounds.

**Noise measuring equipments:** Sound level meter, octave band analyzer, statistical analyzer and noise average meter.

**Text books:**

1. Rao M.N. and Rao H.V.N., "Air Pollution", Tata McGraw Hill Publishing Company Ltd., New Delhi.
2. Wang L.K., Pereira N.C., Hung Y.T., "Advanced Air and noise pollution control", Volume I and II, Humana Press, New Jersey.

**Reference books:**

1. Ghassemi A., "Pollution Control and Waste Minimization", Marcel Dekker, Inc., New York.
2. Rao C.S., "Environmental Pollution Control Engineering", New Age International (P) Ltd., New Delhi.
3. Singal S.P., "Noise Pollution and Control Strategy", Alpha Science International, New Delhi.
4. Ray T.K., "Air Pollution Control in Industries", Volume I, Tbi, New Delhi.
5. Stern A.C., Bauble R.W., Fox D.L., Turner B., "Fundamentals of Air Pollution, Hardcover", Elsevier Science and Technology Books.
6. Narayanan P., "Environmental Pollution Principles, Analysis and Control", CBS Publishers

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| MEC-401A               | AUTOMATION IN MANUFACTURING   |           |        |            |            |       |             |
|------------------------|---|-----------|--------|------------|------------|-------|-------------|
| Lecture                | Tutorial  | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3                      | 0   | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Purpose</b>         | The purpose of this course is to impart knowledge of production automation, robotics, flexible manufacturing, CNC programming, material handling and automated storage systems. |           |        |            |            |       |             |
| <b>Course Outcomes</b> |   |           |        |            |            |       |             |
| <b>CO1</b>             | Students will be able to explain the role automation in manufacturing and robotics in industry.   |           |        |            |            |       |             |
| <b>CO2</b>             | Students will be able to describe the group technology and flexible manufacturing techniques in the automated production line and manufacturing system.                         |           |        |            |            |       |             |
| <b>CO3</b>             | Students will be able to explain computer aided process planning and shop floor manufacturing activities.   |           |        |            |            |       |             |
| <b>CO4</b>             | Students will be able to develop CNC programs and understand the concept automated guided vehicle and automated storage system in material handling.                            |           |        |            |            |       |             |

#### UNIT-I

**Introduction:** Production system, automation in production system, manual labour in production system, automation principle and strategies, manufacturing industries and products, manufacturing operations, product facilities, product/ production relationship, basic elements of an automation system, advance automation function, level of automation.

**Industrial robotics:** Robot anatomy and related attributes, joint and links, common robot configuration, joint drive system, sensors in robotics, robot control system, end effectors, grippers and tools, applications of industrial robots, material handling, processing operation, assembly and inspection, robot programming.

#### UNIT-II

**Group technology and cellular manufacturing:** Part families, parts classifications and coding, production flow analysis, cellular Manufacturing- composite part concept, machine cell design, applications of group technology, grouping parts and machines by rank order clustering technique, arranging machines in a G.T. cell.

**Flexible manufacturing:** Introduction, FMS components, flexibility in manufacturing – machine, product, routing, operation, types of FMS, FMS layouts, FMS planning and control issues, deadlock in FMS, FMS benefits and applications.

### UNIT- III

**Process planning:** Introduction, manual process planning, computer aided process planning – variant, generative, decision logic decision tables, decision trees, Introduction to artificial intelligence.

**Shop floor control:** Introduction, shop floor control features, major displays, major reports, phases of SFC, order release, order scheduling, order progress, manufacturing control, methodology, applications, shop floor data collections, Types of data collection system, data input techniques, automatic data, collection system.

### UNIT- IV

**CNC basics and part programming:** Introduction, historical, background, basic components of an NC, steps in NC, verifications of numerical control machine tool programs, classification of NC Machine tool, basics of motion control and feedback for NC M/C, NC part programming, part programming methods, modern machining system, automatically programmed tools, DNC, adaptive control.

**Automated guided vehicle and storage system:** Functions of AGV, types of AGV, safety consideration for AGV, design of AGV; Introduction to storage system, storage system performance, storage location strategies, conventional storage method and equipment, automated storage system, fixed aisle automated storage/ retrieval system, carousel storage systems, analysis of storage system, fixed aisle automated storage/ retrieval systems, carousel storage systems.

#### Text Books:

1. CAD/CAM/CIM-P. Radhakrishnan, S. Subramanayan and V.Raju, New Age International (P) Ltd., New Delhi.
2. Computer Integrated Manufacturing- Alavudeen and Venkateshwaran, Prentice- Hall of India Pvt. Ltd., New Delhi.

#### Reference Books:

1. Automation, Production System and Computer Integrated Manufacturing- Mikell P. Groover, Pearson fourth edition.
2. CAD/CAM: Computer Aided Design and Manufacturing-Groover-M.P. and Zimmers E. W., Prentice Hall International, New Delhi, 1992.

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|--|--|-----------|---------|------------|------------|-----------|------------|-------------|
| MEC-403L A   | MECHANICAL ENGINEERING LAB-III   |           |         |            |            |           |            |             |
| Lecture  | Tutorial   | Practical | Credits | Major Test | Minor Test | Practical | Total Time | Time (Hrs.) |
| 0  | 0  | 2         | 1       | 0          | 40         | 60        | 100        | 3           |
| <b>Purpose:</b>  | To provide practical knowledge in the concerned subject that a student opt from the program electives offered in the curriculum. |           |         |            |            |           |            |             |

### COMPUTER AIDED DESIGN PRACTICALS

#### Course Outcomes

- CO1** Students will be able to draw and design 2D models.
- CO 2** Students will be able to draw and design 3D modelling.
- CO 3** Students will be able to assemble the parts.

#### List of experiments:

- 1To study the 2 dimensional drawing, orthographic views, front view, top view and side view.
- 2Introduction to Solid Works and working with sketch mode.
- 3To study the wireframe, surface and solid modelling.
- 4Working with the tools like Pattern, Copy, Rotate, Move and Mirror etc.
- 5Working with creating 3D features (Extrude & Revolve).
- 6Working with the tools like Hole, Round, and Chamfer etc.
- 7 Createthe part drawing of product 1 using any 3D software.
- 8Draw the part drawing of product 2 using any 3D software.
- 9Draw the part drawing of product 3 using any 3D software.
- 10Make assembly by using any 3D software.

**Note:** Product 1, 2 and 3 must be based on MEP-401.

### FINITE ELEMENT ANALYSIS LAB:

#### Course Outcomes

- CO1** Students will be able to apply the basic theory of elasticity to continuum problems
- CO2** Students will be able to formulate Finite Element problems like bar, truss and beam elements for linear static structural analysis
- CO3** Students will be able to formulate 2D and axisymmetric finite elements

**CO4** Students will be able to formulate and solve finite element equations for 1D heat transfer elements

**List of Experiments:**

- 1.To solve problems related to solid mechanics, heat transfer and free vibration by using NASTRAN/SIMULIA/ANSYS/ABAQUS.
- 2.Introduction of GUI of the software in the above mentioned areas realistic problems.
- 3.To analyze beams and frames (bending and torsion problems).
- 4.To analyze plane stress and plane strain problems.
- 5.Problems leading to analysis of axisymmetric solids.
- 6.Problems leading to analysis of three dimensional solids: (a) Heat Transfer problems (b) Modal analysis problem:

**By writing own code for finite element analysis using MATLAB for:**

- 7.Plane stress and Plane strain problems.
- 8.Modal analysis problems.

**Reference Books:**

1. Finite Element Method using MATLAB-Young W Kwon and Hyochoong Bang, CRC Press Washington, USA.
2. Finite Element Method: A Practical Course-G. R. LIU and S. S. Quek, Elsevier Science, Butterworth – Heinemann publication.

**POWER PLANT ENGINEERING LAB:**

**Course Outcomes**

- CO1** Students will be able to explain the constructional features and working of different boilers, accessories, mountings, heat balance sheet preparation and to analyze the quality of steam.
- CO2** Students will be able to describe the functions of different cooling towers and condensers and calculate their efficiencies.
- CO3** Student will be able to calculate the calorific value of fuels using a bomb calorimeter.
- CO4** Student will be able to explain the functioning and use of solar photovoltaic systems and calculate the efficiency of a solar cell.

**List of Experiments:**

1. To study high pressure boilers.
2. To study low pressure boilers.
2. To study about the mountings & accessories of high and low-pressure boilers.
3. To prepare the heat balance sheet for the given boiler.
5. To find the calorific value of a given sample of solid/liquid fuel(s) using a bomb calorimeter.
6. To find power output and efficiency of impulse and reaction steam turbine.
7. To study cooling tower and calculate its efficiency.
8. To study various types of condenser and calculate efficiency.
9. To find the dryness fraction of steam using separating and throttling calorimeters.
10. To study solar photovoltaic systems and calculation of efficiency of a solar cell.

**MECHATRONIC SYSTEMS PRACTICALS**

### **Course Outcomes**

- CO1** Students will be able to control the speed of DC motor and servo motor using 8051 microcontrollers.
- CO2** Students will be able to control the motion of single and double acting cylinder using Pneumatic and Hydraulic training kit.
- CO3** Students will be able to control traffic light signals using PLC and 8051 microcontrollers.
- CO4** Students will be able to perform operations of addition, subtraction, multiplication and division using 8086 Microprocessor.

### **List of Experiments**

- 1 To run a stepper motor at different speeds and directions using 8051 assembly language.
- 2 To control traffic light by interfacing with PLC kit.
- 3 To perform speed control of DC motor with 8051 microcontroller.
- 4 To perform experiment on hydraulic trainer kit.
- 5 To perform experiment on pneumatic trainer kit.
- 6 To study various types of sensors and transducers.
- 7 To control a traffic light system using 8051 Microcontroller
- 8 To perform the 8-bit addition and subtraction using 8086 Microprocessor.
- 9 To perform the 8-bit multiplication and division using 8086 Microprocessor.

## **INDUSTRIAL ROBOTICS PRACTICALS**

### **Course Outcomes**

- CO1** Students will be able to analyze the movement of various positions of robotics arm.
- CO 2** Students will be able to design the robotics systems.
- CO 3** Students will be able to analyze the pneumatic and hydraulic systems.
- CO 4** Students will be able to demonstrate sensors, grippers etc.

### **List of Experiments**

1. Recoding Robot positions (Absolute positions, Delete Positions, Save and load positions and Move the Robot to recorded positions).
2. Demonstration of Cartesian/ cylindrical/ spherical robot.
3. Study of different types of grippers.
4. Study of sensor integration.
5. Study of robotic system design.
6. Setting robot for any one industrial application after industrial visit.
7. Study the major equipment/Software/Components in Robotics Lab, e.g. Robotic Arm components, Arena etc.
8. Study of pneumatic and hydraulic system in Robotics.

## **SOLAR ENERGY ANALYSIS PRACTICALS**

### **Course Outcomes**

**CO 1** Students will be able to analyze the solar based heating concepts and flow of working fluid in collector.

**CO 2** Students will be able to analyze the solar parabolic trough and evacuated tube collector.

**CO 3** Students will be able to know about the solar energy storage by different means and understand the sun-earth relationships for sun tracking.

**CO 4** Students will be able to describe the functioning of solar PV collector power plant.

### **List of Experiments:**

1. To evaluate the system efficiency and heat transfer of evacuated tube collector in different parts of system at different ambient conditions.
2. Evaluation of system thermal efficiency solar collector during charging storing and discharging the PCM.
3. To determine the thermal Performance of the Parabolic Trough collector with different inlet temperature of water and oil.
4. To evaluate the thermal performance of flat plate collector in thermosiphon and forced mode of flow at different radiation level.
5. To find the drying rate and drying time of different fruits and vegetables in flat plate based solar dryer.
6. To determine the efficiency of solar photo voltaic collector with and without sun tracking.

| B. Tech. (7 <sup>th</sup> Semester) Mechanical Engineering |  |           |        |            |            |           |            |             |
|--|--|-----------|--------|------------|------------|-----------|------------|-------------|
| MEC-405LA  | PROJECT-III  |           |        |            |            |           |            |             |
| Lecture  | Tutorial   | Practical | Credit | Major Test | Minor Test | Practical | Total Time | Time (Hrs.) |
| 0  | 0  | 10        | 5      | 0          | 100        | 100       | 200        | 3           |
| <b>Purpose:</b>  | To implement the engineering principles and theories into innovative practical projects for solving real world problems. |           |        |            |            |           |            |             |
| Course Outcomes  |  |           |        |            |            |           |            |             |
| <b>CO1</b>   | Students will be able to apply the theoretical knowledge into practical/software projects.                               |           |        |            |            |           |            |             |
| <b>CO2</b>   | Students will be able to design new products using latest technologies.  |           |        |            |            |           |            |             |

The project work could be done for the problem statement of an industry or practical project in the institute. The students may also opt for the analysis based software projects with proper validation. Participation in any technical event/ competition to fabricate and demonstrate an innovative machine or product could be encouraged under this course.

**Note:** The maximum number of students in a group should not exceed four.

| B. Tech. (7 <sup>th</sup> Semester) Mechanical Engineering |   |           |        |            |            |       |            |
|--|---|-----------|--------|------------|------------|-------|------------|
| MEP-401A   | COMPUTER AIDED DESIGN   |           |        |            |            |       |            |
| Lecture  | Tutorial  | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs) |
| 3  | 0   | 0         | 3      | 75         | 25         | 100   | 3          |
| <b>Purpose</b>   | To apply the computer's technology in designing.  |           |        |            |            |       |            |
| <b>Course Outcomes</b>                                     |   |           |        |            |            |       |            |
| <b>CO1</b>   | To understand the fundamentals of CAD and analyze the CAD hardware.                       |           |        |            |            |       |            |
| <b>CO2</b>   | Students will be able to evaluate the CAD software and various transformation operations. |           |        |            |            |       |            |
| <b>CO3</b>   | Students will be able to analyze the geometric modeling.                                  |           |        |            |            |       |            |
| <b>CO4</b>   | Students will be able to create surface modeling and understand the data exchange.        |           |        |            |            |       |            |

#### UNIT-I

**Fundamentals of CAD:** Introduction, Traditional product cycle, CAD/CAM product cycle, rapid prototypic, design for everything, computer aided design, computer aided engineering, customer relationship management, product lifecycle management,

**CAD hardware:** Introduction, basic structure of computer, input, storage, processing, output, control, microcomputer, minicomputer, mainframes, supercomputer, input out device, LAN, MAN, WAN.

#### UNIT-II

**CAD Software:** Introduction, system software, application software, General CAD process, selection of CAD system, database management system, data structure, database types, function of database management system, advantages of DBMS, database coordinate system.

**Geometric transformations:** Introduction, 2D transformation, translation, rotation, scaling, homogeneous coordinate relationship, reflection transformation, shear transformation, inverse transformation for translation, rotation, scaling, reflection, shear, composite transformation, examples of composite transformation, geometric transformations in engineering design, solved examples.

#### UNIT-III

**Geometric modeling:** Need of geometric modeling, requirements of geometric modeling, wire frame modeling, surface modeling, solid modeling, difference between wireframe, surface and solid modeling, introduction to solid modeling, set theory, representation schemes for solid models, boundary representation, cellular decomposition, feature based modeling, Euler theory, mass property calculation.

**Mathematical representation of 2D entity:** Introduction, parametric representation, of analytic curves, lines, circle, conic section, ellipse, parabola, hyperbola, parametric representation of synthetic curve, Hermite cubic spline curve, Bezier curves, B- spline curve, non-uniform rational, B splines, manipulation of curves.

#### UNIT-IV

**Mathematical representation of surface entity:** Introduction, surface entities, analytic surface, plane surface, tabulated surface, ruled surface, surface of revolution, sweep surface, synthetic surface, Hermite Bicubic surface, Bazier surface, bilinear surface, coons surface

**Data exchange formats:** Introduction, CAD/CAM data exchange, neutral file formats, data exchange format, initial graphics exchange specification, standard triangular language, standard for exchange of product data.

**Text Books:**

1. CAD/CAM – Principle Practice and Manufacturing Management - Chris McMahon and Jimmie Browne, Addison Wesley England, Second Edition, 2000.
2. CAD/CAM Theory and Practice, Mastering CAD/CAM - Ibrahim Zeid, Tata McGraw Hill Publishing Co. Ltd., New Delhi.

**Reference Books:**

1. Mathematical Elements for Computer Graphics - NC-Rogers, D.F. and Adams, McGraw Hill, NY, 1989
2. CAD/CAM/CIM - P. Radhakrishnan, S. Subramanian and V.Raju, New Age International (P) Ltd., New Delhi.
3. CAD/CAM: Computer Aided Design and Manufacturing - Groover M.P. and Zimmers E. W., Prentice Hall International, New Delhi, 1992.
4. CAD/CAM/CAE - Chougule N. K, Scitech publications (INDIA) PVT. LTD.

**Note: The paper setter will set the paper as per the question paper template provided.**

| B. Tech. (7 <sup>th</sup> Semester) Mechanical Engineering |  |           |        |            |            |       |             |
|--|--|-----------|--------|------------|------------|-------|-------------|
| MEP-403A   | FINITE ELEMENT ANALYSIS  |           |        |            |            |       |             |
| Lecture  | Tutorial   | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3  | 0  | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Purpose</b>   | The purpose of this course is to understand the formulation of FEA problems and to describe various methods of FEM. Also to understand the FEM with C1 continuity and FDM.   |           |        |            |            |       |             |
| Course Outcomes  |  |           |        |            |            |       |             |
| <b>CO1</b>   | Students will be able to understand the basic steps in FEM formulation. Also to study various concepts associated and assembly along with the boundary conditions in FEM formulation.  |           |        |            |            |       |             |
| <b>CO2</b>   | Students will be able to analyze how FEM problems are formulated in 1-D elements. Also to discuss shape functions, h and p approximations; and various solvers associated in FEM.  |           |        |            |            |       |             |
| <b>CO3</b>   | Students will be able to study FEM formulation of 2-D elements using various methods like Galerkin approach, Weighted Residual etc. Also to understand the natural coordinates, numerical integration and various other concepts related to 2-D FEM formulation. |           |        |            |            |       |             |
| <b>CO4</b>   | Students will be able to describe the axi-symmetric problems along with plane stress and plane strain problems with regards to solid mechanics. Also to discuss various elements of FEM, FEM with C1 continuity and FDM problems.                                |           |        |            |            |       |             |

#### UNIT-1

**Introduction:** Basic steps in FEM formulation, general applicability of the method, variational functional, Ritz Method.

**Variational FEM:** Derivation of elemental equations, assembly, imposition of boundary conditions, solution of the equations.

#### UNIT-II

**1-D Elements:** Basis functions and shape functions, convergence criteria, h and p approximations, natural coordinates, numerical integration, Gauss elimination based solvers, computer implementation: pre-processor, processor, post-processor.

#### UNIT-III

**Methods of FEA:** Alternate formulation: Weighted Residual Method, Galerkin Method;

**Problems with C1 Continuity:** beam bending, connectivity and assembly of C1 continuity elements.

**2-D Elements (Triangles and Quadrilaterals) and Shape Functions:** Natural Coordinates, Numerical Integration, Elemental Equations, Connectivity and Assembly, Imposition of Boundary Conditions.

Axisymmetric (Heat Conduction) problem, plane strain and plane stress solid mechanics problems, sub-parametric, iso-parametric and super-parametric elements; elements with C1 continuity.

#### UNIT-IV

**Free vibration problems and FDM:** Formulation of eigenvalue problems, FEM formulation, time-dependent problems, combination of Galerkin FEM and FDM (Finite Difference Method), convergence and stability of FD Scheme.

**Text Books:**

1. Finite element analysis-C. S. Krishnamoorthy, Tata McGraw Hill
2. An introduction to Finite element method-J. N Reddy, Tata Mc. Graw Hill
3. Finite Element Method with applications in Engineering-Y. M. Desai, Pearson Education India.

**Reference Books:**

1. Nonlinear Finite Elements for Continua and Structures (Paperback)-Belytschko(shelved 1 time as *finite-elements*)
2. The Finite Element Method for Three-Dimensional Thermomechanical Applications (Hardcover)-Guido Dhondt(shelved 1 time as *finite-elements*)
3. Numerical Solution of Partial Differential Equations by the Finite Element Method (Paperback)-Claes Johnson(shelved 1 time as *finite-elements*)

**Note: The paper setter will set the paper as per the question paper template provided.**

| B. Tech. (7 <sup>th</sup> semester) Mechanical Engineering |   |           |        |            |            |       |             |
|--|---|-----------|--------|------------|------------|-------|-------------|
| MEP-405A POWER PLANT ENGINEERING                           |   |           |        |            |            |       |             |
| Lecture  | Tutorial  | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3  | 0   | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Purpose</b>   | To understand modern aspects of power generation, different power plants, their combinations, operation and components, energy demand and supply and power plant economics. |           |        |            |            |       |             |
| Course Outcomes  |   |           |        |            |            |       |             |
| <b>CO1</b>   | Students will be able to analyze the economics of power generation and describe the variety of power plants.  |           |        |            |            |       |             |
| <b>CO2</b>   | Students will be able to analyze steam power cycles and understand the coal handling process in detail.   |           |        |            |            |       |             |
| <b>CO3</b>   | Students will be able to understand about the operation & advancements of Solar, Diesel and Gas turbine power plants.   |           |        |            |            |       |             |
| <b>CO4</b>   | Students will be able to describe the role of nuclear energy in power generation and various combinations of power plants and their operation.                              |           |        |            |            |       |             |

#### UNIT-I

**Economics of power generation:** Introduction to economics of power generation, different terms and definitions, hydrology, rainfall, runoff, hydrographs, flow duration curves, cost analysis, power plant locations, selection of power plant equipment, factors affecting economics of generation and distribution of power, performance and operating characteristics of power plants, economic load sharing, tariff for electrical energy.

**Different types of power plants:** Recent developments in power plants, geothermal power plants, tidal power plants, windmills, solar power plants, hydroelectric power plant: site selection, classification, estimation of power availability, selection of water turbines, advantages and disadvantages of hydro power plants.

#### UNIT-II

**Analysis of steam cycle:** The ideal Rankine cycle, externally irreversible Rankine cycle, superheat, reheat, regeneration, internally irreversible Rankine cycle, open feed water heaters, closed type feed water heaters with drains cascaded backward and pumped forward, typical layout of steam power plant, efficiency and heat rate.

**Coal handling plant:** Coal Handling: unloading, feeding, crushing, feeding system, conveyor system, stacking system, magnetic separator/ metal detector, bin/chute vibratory system, coal weighment, coal sampling, fire-fighting system, dust suppression system, dust extraction system, mechanical stokers, pulverized fuels and burners, ash handling and disposal.

#### UNIT-III

**Solar Power Plants:** Introduction; solar collectors: flat plate and concentrating; absorber coating; solar pond electric power plant; solar thermal electric conversion systems: low temperature, medium

temperature and high temperature; solar electric power generation: solar photovoltaics, solar cell working and principle; combination of solar and hydropower plants; solar chimney power plant system.

**Diesel engine & gas turbine power plants: Introduction**, Types, layout of diesel engine power plant, different components of diesel power plant, performance characteristics, supercharging, layout and components of gas turbine power plants, gas turbine fuels, material selection for gas turbines.

#### **UNIT-IV**

**Nuclear power plants:** Basic theory and terminology, nuclear fission and fusion processes, fission chain reaction, moderation, fertile materials, nuclear fuels, general components of nuclear reactor, different types of reactors: PWR, BWR, GCR, LMFBR, CANDU-PHW, disposal of nuclear waste and related issues.

**Power plant combinations:** Combination of hydro power plants with steam plants, GT-ST Combined Cycle plant, combined cycles with heat recovery boiler, PFBC combined cycle, STIG (steam injected gas turbine) cycle, combined cycles with multi-pressure steam, combined cycle for nuclear power plants.

#### **Text Books:**

1. Power Plant Engineering-Morse, D. Van Nostrand.
2. Power Plant Engineering-PK Nag, McGraw Hill.
3. Power Plant Technology-EI-Wakil, McGraw Hill.

#### **Reference Books:**

1. Power Plant Engineering-P.C. Sharma, SK Kataria & Sons.
2. Power Plant Engineering-Domkundwar, Dhanpat Rai & Co.
3. Power Plant Technology-G.D.Rai, Khanna Publishers.
4. Power Plant Engineering-R.K. Rajput, Laxmi Publications.

**Note: The paper setter will set the paper as per the question paper templates provided.**

| B. Tech (7 <sup>th</sup> Semester) Mechanical Engineering |   |           |        |            |            |       |             |
|---|---|-----------|--------|------------|------------|-------|-------------|
| MEP-407A  | MECHATRONIC SYSTEMS   |           |        |            |            |       |             |
| Lecture   | Tutorial  | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3   | 0   | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Purpose</b>  | The purpose of this course is to provide students with an in-depth knowledge of mechatronics systems. The subject will give knowledge of electronics components to students and assist them to acquire inter disciplinary skills.                 |           |        |            |            |       |             |
| Course Outcomes   |   |           |        |            |            |       |             |
| <b>CO1</b>  | Students will be able to understand Mechatronics systems and their applications. The students will be able to understand different sensors and transducers as well as able to select the transducers as per applications.                         |           |        |            |            |       |             |
| <b>CO2</b>  | Students will be able to describe different types of number systems and Boolean algebra and able to convert number systems from one system to another. The students will be able to explain pin configuration and architecture of microprocessor. |           |        |            |            |       |             |
| <b>CO3</b>  | Students will be able to understand the architecture of microcontroller and structure of PLC. The students will also be able to draw the ladder diagram.  |           |        |            |            |       |             |
| <b>CO4</b>  | Students will be able to understand various types of actuator. The students will also be able to explain the working of DC and servo motor.   |           |        |            |            |       |             |

#### UNIT-I

**Introduction:** Definition of mechatronics, multi-disciplinary scenario, evaluation of mechatronics, objectives, advantages & disadvantages of mechatronics, an overview of mechatronics, microprocessor based controllers, principle of working of automatic camera, automatic washing machine & engine management system.

**Review of sensors and transducers:** Definition and classification of transducers, definition & classification of sensors, performance terminology, working principle and application of displacement, position & proximity, velocity and motion, force, fluid pressure, liquid flow, liquid level, temperature, light sensors, selection of transducers.

#### UNIT-II

**Digital principles:** Introduction, digital number system, range and weight of binary number system, octal and hexadecimal number systems, conversion, BCD number systems, gray code, Boolean algebra, logic states, logic functions, more logic gates, universal gates, exclusive-OR gate, minimization of Boolean expression using Karnaugh map.

**Microprocessor:** 8086 CPU architecture: 8086 Block diagram, description of data registers, address registers; pointer and index registers, PSW, Queue, BIU and EU, 8086 Pin diagram descriptions, 8086 minimum mode and maximum mode CPU module.

#### UNIT-III

**Micro controller:** Introduction of 8051 microcontroller & its block diagram, comparison of microprocessor and microcontroller

**PLC:** Programmable logic controllers, basic structure, input/output processing, ladder diagram timers, internal relays and counters, shift registers, master and jump controls, data handling, analogue input/output, selection of a PLC.

#### **UNIT-IV**

**Actuators:** Definition, classification of actuators, mechanical actuation systems, types of motion, kinematics chains, cams, gear trains, ratchet and pawl, belt and chain drives, bearings, brief survey of electromechanical actuators, drive requirements for cutting movements, requirements of feed drives, calculation of drive requirements on feed motor shaft.

**Motors:** DC motors & Control of DC motors, DC & AC servomotors, stepper motors-types, characteristics, advantages, limitations and applications, mechanical aspects of motor selection.

#### **Text books:**

1. A Textbook of Mechatronics-R. K Rajput, S. Chand & Company, Edition 2010
2. Mechatronics, W. Bolton – Pearson Education Asia - 2<sup>nd</sup> Edition, 2011.

#### **Reference books:**

1. Mechatronics, HMT Ltd., McGraw Hill Education, 2017
2. Mechatronics Principles, Concepts and Application-Nitaigour and Premchand, Mahilik – Tata McGraw Hill – 2003
3. Mechatronics: An Introduction-Robert H. Bishop, CRC Press, 2015
4. Mechatronics: Integrated Mechanical Electronic System- Ramachandran, Vijayaraghavan, Balasundaran- Wiley Publication, 2008

**Note: The paper setter will set the paper as per the question paper template provided.**

| B. Tech. 7 <sup>th</sup> Semester Mechanical Engineering |  |           |        |            |            |       |             |
|--|--|-----------|--------|------------|------------|-------|-------------|
| MEP-409A   | INDUSTRIAL ROBOTICS  |           |        |            |            |       |             |
| Lecture  | Tutorial   | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3  | 0  | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Purpose</b>   | The purpose of this course is to make the students understand about the fundamental of robotics technology, its components and robotics cell design and control. |           |        |            |            |       |             |
| Course Outcomes  |  |           |        |            |            |       |             |
| <b>CO1</b>   | Students will be able to understand the fundamentals of robotics and find its applications.  |           |        |            |            |       |             |
| <b>CO2</b>   | Students will be able to explain the use of different sensors and end effectors in robotics.   |           |        |            |            |       |             |
| <b>CO3</b>   | Students will be able to describe the application of robotics in manufacturing.  |           |        |            |            |       |             |
| <b>CO4</b>   | Students will be able to design and analyze the work cell and robotic motion.  |           |        |            |            |       |             |

#### UNIT-I

**Introduction:** Automation and robotics, robotics in science fiction, a brief history of robotics, the robotics market and the future prospectus,

**Fundamental of robotics:** Robot anatomy, work volume, robot drives systems, control systems, precession of movement, end effectors, robot application.

#### UNIT-II

**Sensors in robotics:** Type of sensors in robotics, exteroceptors or external sensors, force and torque sensors, proximity sensors (position sensors), range sensors, machine vision sensors, velocity sensors. tactile sensor, proximately and range sensors, use of sensor in robotics.

**Robot end effectors:** Types of end effectors, characteristics of end-of-arm tooling, elements of end-of-arm tooling.

#### UNIT-III

**Material transfer and equipments:** General consideration in robot material handling, material transfer applications, machine loading and unloading,

**Grippers:** Tool selection of gripper, gripping mechanism, types of gripper, mechanical gripper, vacuum and magnetic grippers.

#### UNIT-IV

**Robot cell design and control:** Robot cell layouts, multiple robots and machine interface, other considerations in work cell design, work cell control, interlocks, the work cell controller, robot motion analysis and control: introduction to manipulator kinematics, manipulator path control, robot dynamics, configuration of robot control.

#### Text books:

1. Robot Analysis and Control-Asada, H., and J. J. Slotine, Wiley.

2.CAD/CAM: Computer Aided Design and Manufacturing- Groover M.P. and Zimmers E. W., Prentice Hall International, New Delhi.

**Reference Books:**

1. Robotics and Control-R. K. Mittal, I. J. Nagrath, McGraw Hill.
2. Fundamental of Robotics Analysis and Control-Robert J Schilling, Pearson
3. Industrial Automation and Robotics-J K Arora, Laxmi Publications

**Note: The paper setter will set the paper as per the question paper templates provided.**

| B. Tech. (7 <sup>th</sup> Semester) Mechanical Engineering |  |           |        |            |            |       |             |
|--|--|-----------|--------|------------|------------|-------|-------------|
| MEP-411A   | SOLAR ENERGY ANALYSIS  |           |        |            |            |       |             |
| Lecture  | Tutorial   | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3  | 0  | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Purpose</b>   | The purpose of this course is to make the students aware about the importance, availability, use and applications of solar energy.         |           |        |            |            |       |             |
| Course Outcomes  |  |           |        |            |            |       |             |
| <b>CO1</b>   | Students will be able to describe the sun-earth relationships and various solar activities based on sun and earth rotation.                |           |        |            |            |       |             |
| <b>CO 2</b>  | Students will be able to analyze the concentrating collector in solar energy applications and solar energy storage by different means.     |           |        |            |            |       |             |
| <b>CO 3</b>  | Students will be able to apply the solar based heating-cooling concepts in building structures and explain the water heating flow systems. |           |        |            |            |       |             |
| <b>CO 4</b>  | Students will be able to analyze solar power generation, refrigeration and air-conditioning systems.                                       |           |        |            |            |       |             |

#### Unit-I

**Introduction:** Basic Heat transfer principles, availability of solar energy, nature of solar energy, solar energy and environment, sun as the source of radiation, solar radiation: measurement of solar radiation, irradiance, solar constant, insolation, radiosity, emissive power, earth's equator, meridian longitude, sun earth angles, sunrise, sun set and day length, solar time, equation of time, various methods of using solar energy, photo thermal, photovoltaic, photosynthesis, present & future scope of solar energy.

#### Unit-II

**Solar thermal energy:** Stationary collectors, FPC, CPC, ETC, sun tracking, concentrating collectors, PTC, PDR, HFC, Fresnel collectors, solar thermal power plants, solar chimney power plant, solar pond, solar water heater, solar cooker, types- solar disinfection, limitations of solar thermal energy.

**Heat Storage:** Sensible and latent heat storage, chemical energy system, performance calculations.

#### Unit-III

**Flow systems:** Natural and forced flow systems, water heating systems for domestic, industrial and space heating requirements, solar distillation.

**Solar heating and cooling:** Direct, indirect and isolated heating concepts, cooling concepts, load calculation methods, performance evaluation methods.

#### Unit-IV

**Solar thermal power generation:** Introduction, paraboloid concentrating systems, cylindrical concentrating systems, central receiver system.

**Solar refrigeration and air conditioning systems:** Introduction, solar refrigeration and air conditioning systems, solar desiccant cooling.

**Text Books:**

- 1.Solar Thermal Engineering Process - Duffie and Beckman.
- 2.Advanced Solar Energy Technology - H.P. Garg, Kluver.
- 3.Solar Energy- S.P. Sukhatme, TMH.

**Reference Books:**

- 1.Solar Energy- J.S. Hsieh, Pearson College DIV.
- 2.Solar Thermal Engineering- P.J. Lunde, John Wiley & Sons.

**Note: The paper setter will set the paper as per the question paper templates provided.**

| B. Tech. (7 <sup>th</sup> Semester) Mechanical Engineering |  |           |        |            |            |           |       |             |
|--|--|-----------|--------|------------|------------|-----------|-------|-------------|
| MEC-407A   | INDUSTRIAL TRAINING-III  |           |        |            |            |           |       |             |
| Lecture  | Tutorial   | Practical | Credit | Major Test | Minor Test | Practical | Total | Time (Hrs.) |
| 2  | 0  | 0         | --     | --         | 100        | --        | 100   | --          |
| <b>Purpose</b>   | To provide an industrial exposure to the students and enhance their skills and creative capability for conversion of their innovative ideas into physical reality. |           |        |            |            |           |       |             |
| Course Outcomes  |  |           |        |            |            |           |       |             |
| <b>CO 1</b>  | Students will be able to self-improve through continuous professional development and life-long learning.  |           |        |            |            |           |       |             |
| <b>CO 2</b>  | Students will be able to develop social, cultural, global and environmental responsibility as an engineer.   |           |        |            |            |           |       |             |
| <b>CO 3</b>  | Students will be able to weigh all the latest changes in technological world.  |           |        |            |            |           |       |             |

**Note:** MEC-407 is a mandatory non-credit course in which the students will be evaluated for the industrial training undergone for minimum 4 weeks after 6<sup>th</sup> semester and students will be required to get passing marks to qualify.

The candidate has to submit a training report of his/her work/project/assignment completed in the industry during the training period. The evaluation will be made on the basis of training report submitted and viva-voce/presentation.

# **Eighth Semester**

| B. Tech. (8 <sup>th</sup> Semester) Mechanical Engineering |  |           |        |            |            |           |       |             |
|--|--|-----------|--------|------------|------------|-----------|-------|-------------|
| MEC-402L A   | Project-IV   |           |        |            |            |           |       |             |
| Lecture  | Tutorial   | Practical | Credit | Major Test | Minor Test | Practical | Total | Time (Hrs.) |
| 0  | 0  | 10        | 5      | 0          | 100        | 100       | 200   | 3           |
| <b>Purpose</b>   | To implement the engineering principles and theories into innovative practical projects for solving real world problems. |           |        |            |            |           |       |             |
| Course Outcomes  |  |           |        |            |            |           |       |             |
| <b>CO1</b>   | Students will be able to apply the theoretical knowledge into practical/software projects.                               |           |        |            |            |           |       |             |
| <b>CO2</b>   | Students will be able to design new products using latest technologies.  |           |        |            |            |           |       |             |

The project work could be done for the problem statement of an industry or practical project in the institute. The students may also opt for the analysis based software projects with proper validation. Participation in any technical event/ competition to fabricate and demonstrate an innovative machine or product could be encouraged under this course.

**Note:** The maximum number of students in a group should not exceed four.

| B. Tech. (8 <sup>th</sup> Semester) Mechanical Engineering |   |           |        |            |            |       |             |
|--|---|-----------|--------|------------|------------|-------|-------------|
| MEO-402A   | SUPPLY CHAIN MANAGEMENT   |           |        |            |            |       |             |
| Lecture  | Tutorial  | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3  | 0   | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Purpose</b>   | The main objective of the course is to impart students with the knowledge of the performance, driver and metrics, network design, economies and uncertainties in Supply chain management. |           |        |            |            |       |             |
| Course Outcomes  |   |           |        |            |            |       |             |
| <b>CO1</b>   | Students will be able to explain the basics of Supply chain management and its performance.   |           |        |            |            |       |             |
| <b>CO2</b>   | Students will be able to discuss supply chain metrics and the process of designing the supply chain networks.   |           |        |            |            |       |             |
| <b>CO3</b>   | Students will be able to explain various aspects and functions of the supply chain network. Also, they will be able to explain the design process of the Global supply chain network.     |           |        |            |            |       |             |
| <b>CO4</b>   | Students will be able to describe how to manage economies and uncertainties in the supply chain.  |           |        |            |            |       |             |

#### UNIT-I

**Understanding the supply chain:** Introduction, definition, the objective of a supply chain, the importance of supply chain decisions, decision phases in a supply chain, process views of a supply chain, examples of supply chains.

**Supply chain performance:** Achieving strategic fit and scope: Competitive and supply chain strategies, achieving strategic fit, expanding strategic scope, challenges to achieving and maintaining strategic fit.

#### UNIT-II

**Supply chain drivers and metrics:** Financial measures of performance, drivers of supply chain performance, framework for structuring drivers, facilities, inventory, transportation, information, sourcing, pricing.

**Designing the supply chain network:** Designing distribution networks and applications to online sales: the role of distribution in the supply chain, factors influencing distribution network design, design options for a distribution network, online sales and the distribution network, distribution networks in practice.

#### UNIT-III

**Network design in the supply chain:** The role of network design in the supply chain, factors influencing network design decisions, framework for network design decisions, models for facility location and capacity allocation, making network design decisions in practice.

**Designing global supply chain networks:** The impact of globalization on supply chain networks, the offshoring decision: total cost, risk management in global supply chains, discounted cash flows, evaluating network design decisions using decision trees, to onshore or offshore: evaluation of global supply chain

design decisions under uncertainty, making global supply chain design decisions under uncertainty in practice.

#### **UNIT-IV**

**Managing economies of scale in a supply chain:** Cycle inventory, the role of cycle inventory in a supply chain, estimating cycle inventory–related costs in practice, economies of scale to exploit fixed costs, economies of scale to exploit quantity discounts, short-term discounting: trade promotions, managing multi-echelon cycle inventory.

**Managing uncertainty in a supply chain:** Safety inventory, the role of safety inventory in a supply chain, determining the appropriate level of safety inventory, impact of supply uncertainty on safety inventory, impact of aggregation on safety inventory, impact of replenishment policies on safety inventory, managing safety inventory in a multi-echelon supply chain, the role of IT in inventory management, estimating and managing safety inventory in practice.

#### **Text books:**

1. Supply chain Management: Strategy, Planning and Operations - Chopra, S., and Meindl, P., Fifth Edition, Pearson Education (Singapore) Pte. Ltd, 2004.
2. Designing & Managing the Supply Chain: Concepts, Strategies & Case studies - Simchi-Levi, P., Kaminsky, Ravi Shankar, E., Third Edition, Tata McGraw-Hill Edition, 2003.

#### **Reference books:**

1. Purchasing and Supply Chain Management: Text and Cases - Doebler, D.W. and Burt, D.N., McGraw-Hill Publishing Company Limited, New Delhi, 1996.
2. Supply Chain Management for Competitive Advantage - Rangaraj, TMH.

**Note: The paper setter will set the paper as per the question paper template provided.**

| B. Tech. (8 <sup>th</sup> Semester) Mechanical Engineering |  |           |        |            |            |       |             |
|--|--|-----------|--------|------------|------------|-------|-------------|
| MEO-404A   | COMPETITIVE MANUFACTURING SYSTEMS  |           |        |            |            |       |             |
| Lecture  | Tutorial   | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3  | 0  | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Purpose</b>   | The objective of this course is to make the students understand about the concepts of competitive manufacturing management systems.  |           |        |            |            |       |             |
| Course Outcomes  |  |           |        |            |            |       |             |
| <b>CO1</b>   | Students will be able to interpret the tactics, strategies and tools of continuous improvements of products and services.  |           |        |            |            |       |             |
| <b>CO2</b>   | Students will be able to implement the just in time and total quality management philosophy for continuous improvement and identify the elements of lean and wasteless production. |           |        |            |            |       |             |
| <b>CO3</b>   | Students will be able to describe how to reduce the setup time and how to maintain and improve the equipment efficiency.   |           |        |            |            |       |             |
| <b>CO4</b>   | Students will be able to explain the pull-push production system and will be able to know the systems for eliminating defects.   |           |        |            |            |       |             |

#### UNIT-I

**Fundamentals of continuous improvement:** Continuous improvement as tactics and strategy- Incremental improvement: Kaizen, improvement threshold, innovation improvement making the leap, improvement as strategy, finding and implementing improvements-PDCA cycle, value analysis/value engineering, process engineering.

**Basic problem solving and improvement tools:** Check list, histogram, Pareto analysis, scatter diagram, process flow chart, cause and effect analysis, run diagram.

#### UNIT-II

**JIT: value added and waste elimination:** Value added focus- necessary and unnecessary activities, support organization, sources of waste-Toyota's seven wastes, Canon's none wastes, JIT principles- simplification, cleanliness and organization, visibility, cycling time, agility, variation reduction, measurement, Meaning of JIT-philosophy, method, JIT limitations and implementation barriers, social impact of JIT.

**Total quality management (TQM):** Quality, Framework for managing total quality, employee involvement, benchmarking, quality certification, implementing TQM.

**Elements of lean production:** Lot size basics-lot size and setup reduction, kinds of lots, Lot sizing-process and purchase batches, EOQ based methods, transfer batches, Lot size reduction- Effect of lot size reduction on competitive criteria, cases for larger process batches, minimum lot size, small buffer stock, EOQ models for lot sizing.

#### UNIT-III

**Setup time reduction:** Setup reduction methodology-Shingo and SMED, SMED methodology for setup reduction, techniques for setup reduction-separate internal and external activities, improve internal setups, improve external setups.

**Maintaining and improving equipment:** Equipment maintenance-breakdown repair, equipment problems and competitiveness, preventive maintenance, total predictive maintenance, Equipment effectiveness-equipment losses, maintainability, reliability, availability, efficiency, quality rate, preventive maintenance programs, Total productive maintenance-perform TPM preventive maintenance, develop in house quality to restore and redesign equipment, eliminate human error in operation and maintenance, Implementing TPM-program feasibility, master plan, target areas, management support.

#### **UNIT-IV**

**Pull production systems:** Production control systems, Pull systems and Push systems- pull production process, push production process, rules for pull production, process improvement, necessary conditions for pull production systems, pull system as a fixed quantity/reorder point system, conveyance Kanbans, production Kanbans, Signal Kanbans, CONWIP method of pull production.

**Systems for eliminating defects:** Inspection (screening), self-checks and successive checks, requirements for self-checking, successive checkings, automation, cycle time, limits of inspection, source inspection and POKAYOKE: POKAYOKE functions, ideas, continuous improvements, JIDOKA-autonomation, andons.

#### **Text Books:**

1. Competitive Manufacturing Management – John M. Nicholas, TMH.
2. Manufacturing Management – Principles and Concepts, Gibson, Greenhalgh and Kerr, Champan and Hall.

#### **Reference Books:**

1. Production and Operation Management – K.C. Jain, Dreamtech Press.
2. Operations management-William J. Stevenson, McGraw Hill Education.

**Note: The paper setter will set the paper as per the question paper templates provided.**

| B. Tech. 8 <sup>TH</sup> Semester Mechanical Engineering |  |           |        |            |            |       |             |
|--|--|-----------|--------|------------|------------|-------|-------------|
| MEO-406A   | CONCURRENT ENGINEERING   |           |        |            |            |       |             |
| Lecture  | Tutorial   | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3  | 0  | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Purpose</b>   | The objective of this course is to familiarize students with the concepts, approaches and implementation techniques related to concurrent engineering. |           |        |            |            |       |             |
| Course Outcomes  |  |           |        |            |            |       |             |
| <b>CO1</b>   | Students will be able to describe the basic concepts of concurrent engineering and implement concurrent engineering techniques.                        |           |        |            |            |       |             |
| <b>CO2</b>   | Students will be able to identify the concept of life cycle management.  |           |        |            |            |       |             |
| <b>CO3</b>   | Students will be able to analyze reengineering and system engineering approaches and processes.  |           |        |            |            |       |             |
| <b>CO4</b>   | Students will be able to appraise different information modeling systems and product realization taxonomy.   |           |        |            |            |       |             |

#### UNIT – I

**Concurrent engineering concept:** Concurrent engineering definitions, basic principles of CE, components of CE, concurrency and simultaneity, modes of concurrency, modes of cooperation, CE design methodologies, benefits of concurrent engineering.

**Review of CE technique:** Design for manufacture (DFM), design for assembly (DFA), quality function deployment (QFD), rapid prototyping (RP), total design (TD), organizing for CE, CE tool box.

#### UNIT – II

**Life-cycle management:** Introduction, shrinking life-cycle, product development cycle, product-life cycle, life-cycle management, new product introduction, strategic technology insertions, managing continuity, managing revision changes, life-cycle cost drivers, life-cycle management tools, sequential versus concurrent engineering.

#### UNIT – III

**Process-reengineering:** Introduction, understanding and managing change, reengineering approaches work-flow mapping, information flow-charting, process improvement methodology, change management methodology, concurrent process reengineering.

**System engineering:** System engineering process, systems thinking, approaches to system complexity, sharing and collaboration in CE, system integration, management and reporting structure.

#### UNIT – IV

**Information modeling systems:** Information modeling, modeling methodology, foundation of information modeling, concurrent engineering process invariant, enterprise model-class, specification model-class, product model-class, process model-class, cognitive models, merits and demerits.

**Product realization taxonomy:** Development methodology for CPRT, concurrent product realization taxonomy, pull system of product realization, description of parallel tracks, description of 2-T loops, description of 3-T loop.

**Text Books:-**

1. Concurrent Engineering Fundamental, (Vol 1) integrated Product and Process Organization - Biren Prasad.
2. Concurrent Engineering - G.S. SAWHNEYUNIVERSITY SCIENCE PRESS (An Imprint of Laxmi Publications Pvt. Ltd.) An ISO 9001:2008 Company.
3. Concurrent Engineering Fundamentals: Integrated Product Development - Prasad, Prentice hall India

**Reference Books:**

1. Design for Concurrent Engineering - J. Cleetus, CE Research Centre, Morgantown
2. Concurrent Engineering in Product Design and Development - I. Moustapha, New Age International
3. Concurrent Engineering: Automation Tools and Technology - Andrew Kusiak - , Wiley Eastern

**Note: The paper setter will set the paper as per the question paper templates provided.**

| B. Tech. (8 <sup>th</sup> Semester) Mechanical Engineering |  |           |        |            |            |       |             |
|--|--|-----------|--------|------------|------------|-------|-------------|
| MEO-408A   | LUBRICANTS AND LUBRICATION   |           |        |            |            |       |             |
| Lecture  | Tutorial   | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3  | 0  | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Purpose</b>   | The purpose of the course is to make the students aware of the different properties and composition of lubricants and understand the fundamental concepts of hydrodynamic, hydrostatic and extreme pressure lubrication. |           |        |            |            |       |             |
| Course Outcomes  |  |           |        |            |            |       |             |
| <b>CO1</b>   | Students will be able to describe properties and composition of lubricants.  |           |        |            |            |       |             |
| <b>CO2</b>   | Students will be able to understand the basics of hydrodynamic lubrication and analyse the thermal and non-Newtonian effects in hydrodynamic lubrication.  |           |        |            |            |       |             |
| <b>CO3</b>   | Students will be able to explain and analyze the hydrostatic lubrication, and extreme pressure lubrication at different temperature-load combinations.   |           |        |            |            |       |             |
| <b>CO4</b>   | Students will be able to understand and analyze the elastohydrodynamic lubrication.  |           |        |            |            |       |             |

#### UNIT-I

**Physical properties of lubricants:** Introduction, relationship of viscosity with temperature, pressure and shear rate, viscosity index, viscosity measurement, viscosity of mixtures; Viscosity classification, thermal properties of lubricants, temperature characteristics of lubricants, neutralization number, carbon residue, optical properties, additive compatibility and solubility, lubricant impurities and contaminants.

**Lubricants and their composition:** Mineral oil based liquid lubricants – sources, types, synthetic oils – manufacturing of synthetic oils, hydrocarbon synthetic lubricants, silicon analogues of hydrocarbons, organohalogens; new developments in synthetic lubricants, emulsions and aqueous lubricants, greases, grease characteristics, lubricant additives.

#### UNIT-II

**Hydrodynamic lubrication:** Introduction, Reynolds equation, pressure distribution, load capacity, coefficient of friction, lubricant flow; converging diverging wedges, journal bearings, thermal effects in bearings, isoviscous and non-isoviscous thermal analysis, hydrodynamic lubrication with non-Newtonian fluids, squeeze films.

#### UNIT-III

**Hydrostatic lubrication:** Introduction, hydrostatic bearing analysis, general approach, optimization of bearing design, aerostatic bearings, stability.

**Extreme pressure lubrication:** Lubrication mechanisms for low temperature-low load, low temperature - high load, high temperature – medium load and high temperature – high load, boundary and EP lubrication of non-metallic surfaces.

#### UNIT-IV

**Elastohydrodynamic lubrication:** Introduction, contact stresses, geometry of contacting bodies, contact area, pressure, maximum deflection and position of maximum shear stress, EHL of lubricating films,

pressure distribution, film thickness formulae, effect of non-dimensional parameters, lubrication regimes, partial EHL, surface temperature at conjunction.

**Text books:**

1. Engineering Tribology - Gwidon W. Stachowiak, Andrew W. Batchelor, Butter worth, Heinemann.
2. Introduction to Tribology of Bearings - B.C. Majumdar, S. Chand Co.

**Reference books:**

1. Friction and Lubrication - E.P. Bowden and Tabor. D., Heinemann Educational Books Ltd.
2. Engineering Tribology - Ross Beckett, Larsen and Keller Education
3. Fundamentals of Fluid Film Lubrication - Bernard Hamrock, Bo Jacobson, and Steven R. Schmid, Taylor and Francis.

**Note: The paper setter will set the paper as per the question paper template provided.**

| B. Tech. 8 <sup>th</sup> Semester) Mechanical Engineering |   |           |        |            |            |       |             |
|---|---|-----------|--------|------------|------------|-------|-------------|
| MEO-410A  | TOTAL QUALITY MANAGEMENT  |           |        |            |            |       |             |
| Lecture   | Tutorial  | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3   | 0   | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Purpose</b>  | The purpose of this course is to develop an understanding of quality management framework, philosophies, in-depth knowledge of various tools and techniques with their application in the manufacturing and service industry. |           |        |            |            |       |             |
| Course Outcomes   |   |           |        |            |            |       |             |
| <b>CO1</b>  | Students will be able to understand quality management philosophies and frameworks.   |           |        |            |            |       |             |
| <b>CO2</b>  | Students will be able to describe various tools and techniques of quality management.   |           |        |            |            |       |             |
| <b>CO3</b>  | Students will be able to explain the applications of quality tools and techniques in both manufacturing and service industry  |           |        |            |            |       |             |
| <b>CO4</b>  | Students will be able to describe various quality systems like ISO and its standards.   |           |        |            |            |       |             |

#### UNIT-I

**Introduction and philosophies of quality management:** introduction, need for quality, evolution of quality, definitions of quality, dimensions of product and service quality, basic concepts of TQM, TQM framework, benefits, awareness and obstacles, quality, vision, mission and policy statements, contributions of Deming, Juran and Crosby, barriers to TQM, quality statements, customer focus, customer orientation, customer satisfaction, customer complaints, and customer retention, costs of quality.

#### UNIT-II

**Principles of quality management:** Leadership, strategic quality planning, quality councils, employee involvement, motivation, empowerment, team and teamwork, quality circles recognition and reward, performance appraisal, continuous process improvement, PDCA cycle, 5S, Kaizen, supplier partnership, partnering, supplier selection, supplier rating.

**Process capability:** Meaning, significance and measurement, six sigma concepts of process capability.

#### UNIT-III

**Tools and techniques for quality management:** Quality functions development (QFD), benefits, voice of customer, information organization, house of quality (HOQ), building a HOQ, QFD process.

**Failure mode effect analysis (FMEA):** Requirements of reliability, failure rate, FMEA stages, design, process and documentation, seven old (statistical) tools, seven new management tools, bench marking and POKAYOKE.

#### UNIT-IV

**Quality systems organizing and implementation:** Need for ISO: 9000, ISO: 9001-2008 quality system, elements, documentation, quality auditing, QS:9000, ISO: 14000, concepts, requirements and benefits, TQM implementation in manufacturing and service sectors, quality audits, TQM culture.

**Text Books:**

1. Total Quality Management-Dale H.Besterfield, Pearson Education (First Indian Reprints 2004).
2. Total Quality Management-Shridhara Bhat K, Himalaya Publishing House, First Edition 2002.

**Reference Books:**

1. Competitive Manufacturing Management – John M. Nicholas, TMH.
2. Total Quality Management- R Kesavan, C Elanchezian, B Vijaya Ramnath, IK International.
3. Total Quality Management: Principles, Methods, and Applications-Sunil Luthra, Dixit Garg, Ashish Agarwal, Sachin K. Mangla, CRC Press.
4. Total Quality Management-Poornima M. Charantimath, Pearson Pub.

**Note: The paper setter will set the paper as per the question paper template provided.**

| B. Tech. 8 <sup>th</sup> Semester) Mechanical Engineering |   |           |        |            |            |       |             |
|---|---|-----------|--------|------------|------------|-------|-------------|
| MEO-412A  | ENERGY CONSERVATION AND MANAGEMENT  |           |        |            |            |       |             |
| Lecture   | Tutorial  | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3   | 0   | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Objective</b>  | To impart students, the knowledge of various energy management and conservation techniques, building audit and survey procedures for energy management. |           |        |            |            |       |             |
| Course Outcomes   |   |           |        |            |            |       |             |
| <b>CO1</b>  | Students will be able to describe various renewable sources of energy and the technicalities, operating principles and classification of HVAC Systems.  |           |        |            |            |       |             |
| <b>CO2</b>  | Students will be able to describe the methodology of Site and Building Surveys.   |           |        |            |            |       |             |
| <b>CO3</b>  | Students will be able to explain various energy analysis techniques and the principle and classification of Process Energy.                             |           |        |            |            |       |             |
| <b>CO4</b>  | Students will be able to discuss the implementation of various energy management techniques in building designs.  |           |        |            |            |       |             |

#### UNIT-I

**Renewable energy:** Introduction; solar energy; wind energy; energy from water; energy from earth; energy from biomass.

**Heating, venting and air conditioning systems:** General principles; the requirements for human comfort; description of typical systems-dual duct HVAC system; multi zone HVAC systems: variable and volume systems, terminal repeat system, evaporative systems, package system; basic principle governing HVAC system, package system; energy management opportunities in HVAC systems; modeling of heating and cooling loads in buildings; problems.

#### UNIT-II

**Site and building surveys:** Phases involved in surveys: initiation phase, audit and analysis phase, implementation phase; general methodology for building and site energy audit; site survey: methodology, site survey-electrical system, steam and water systems; building survey: methodology, basic energy audit instrumentation, measurement for building surveys.

#### UNIT-III

**Energy analysis techniques:** Introduction; annual energy consumption; normalized performance indicators; time-dependent energy analysis; linear regression; single independent; correlation coefficients; multivariable analysis; CUSUM.

**Process energy:** General principles; process heat; energy saving in: condensate return, steam generation and distribution, automotive fuel control, hot water and water pumping; direct and indirect fired furnaces over process electricity; other process energy forms-compressed air and manufacturing processes; problems.

#### UNIT-IV

**Waste heat recovery:** Introduction, recuperative heat exchangers, heat exchanger theory; number of transfer units (NTU) concept, run-around coils, regenerative heat exchangers, heat pumps, energy efficient heating: thermal comfort, building heat loss; U values, heat loss calculations, heating energy calculations; intermittent heating; radiant heat; radiant heating; low-emissivity glazing.

**Passive solar and low energy building design:** Introduction, passive solar heating, direct gain techniques, indirect gain techniques, isolated gain techniques, thermosiphon systems, passive solar cooling, shading techniques, solar control glazing, advanced fenestration, natural ventilation, thermal mass, night venting, termodeck, building form, building operation.

**Text Book:**

1. Energy Management and Conservation Handbook, Second Edition - Frank Kreith, D. Yogi Goswami.
2. Energy Management, Supply and Conservation, Second Edition - Clive Beggs
3. Energy Management Principles - Criag B. Smith, Published by Pergamon Press.
4. Energy Systems and Developments – Jyoti Parikh, Oxford University Press.

**Reference Books:**

1. Energy, Resources, Demand and Conservation with reference to India – Chaman Kashkari, Tata Mc Graw Hill Co. Ltd.
2. Integrated Renewable Energy for Rural Development–Proceedings of Natural Solar Energy Convention, Calcutta.

**Note: The paper setter will set the paper as per the question paper templates provided.**

| B. Tech. 8 <sup>th</sup> Semester) Mechanical Engineering |  |           |        |            |            |       |             |
|---|--|-----------|--------|------------|------------|-------|-------------|
| MEP-402A  | Non-Conventional Machining   |           |        |            |            |       |             |
| Lecture   | Tutorial   | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3   | 0  | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Purpose</b>  | This course provides comprehensive knowledge about the advanced technologies and different Non-conventional machining processes.   |           |        |            |            |       |             |
| <b>Course Outcomes</b>                                    |  |           |        |            |            |       |             |
| <b>CO 1</b>   | Students will be able to compare conventional and non-conventional machining processes and recognize the need for Non-conventional machining processes.  |           |        |            |            |       |             |
| <b>CO 2</b>   | Students will be able to know about the constructional features, performance parameters, process characteristics, applications, advantages and limitations of USM.   |           |        |            |            |       |             |
| <b>CO 3</b>   | Students will be able to know about the constructional features, performance parameters, process characteristics, applications, advantages and limitations of AJM, WJM and AWJM.   |           |        |            |            |       |             |
| <b>CO 4</b>   | Students will be able to identify the need of chemical and electro-chemical machining processes along with the constructional features, process parameters, process characteristics, applications, advantages and limitations. |           |        |            |            |       |             |
| <b>CO 5</b>   | Students will be able to explain the constructional feature of the equipment, process parameters, process characteristics, applications, advantages and limitations EDM, LBM and EBM.  |           |        |            |            |       |             |

#### UNIT-I

**Introduction to non-conventional machining:** Introduction to non-conventional machining(NCM) processes, characteristics of conventional machining processes, characteristics of non-conventional machining processes, need for development of non-conventional machining processes, comparison of conventional and non-conventional machining processes, , classification of non-conventional machining processes, history of non-conventional processes, advantages of non-conventional machining processes, disadvantages of non-conventional machining processes, applications of non-conventional machining processes.

**Ultrasonic machining (USM):** process principle, equipment, design consideration for tool, tool feed mechanism, abrasive slurry, Liquid media, operation of USM, process parameters, process capabilities, mechanics of cutting in USM applications of USM, advantages of USM, disadvantages of USM, Mechanics of cutting in USM, ultrasonic welding

#### UNIT-II

**Abrasive jet machining (AJM):** process principle, equipment, process parameters, process capabilities, applications of AJM, advantages of AJM, disadvantages of AJM, Mechanics of cutting in AJM.

**Water jet machining (WJM):** process principle, equipment, process parameters, process capabilities, Metal removal rate, applications of WJM, advantages of WJM, disadvantages of WJM.

**Abrasive water jet machining (AWJM):** process principle, equipment, process parameters, process capabilities, Metal removal rate, applications of AWJM, advantages of AWJM, disadvantages of AWJM.

### UNIT-III

**Chemical machining:** Introduction, process principle, five steps of chemical machining, elements of process, Influence of etchant medium, selection of maskant and etchants, chemical blanking, accuracy of chemical blanking, applications of chemical machining, advantages of chemical machining, disadvantages of chemical machining, chemical milling, photochemical machining.

**Electrochemical machining (ECM):** classification of ECM processes, fundamental principles of ECM, elements of ECM process, electro-chemistry of ECM process, process parameters, process characteristics, tool design, accuracy, determination of metal removal rate, evaluation of metal removal rate of an alloy, surface finish and work material characteristics, economic consideration, advantage, limitation and application, basics of electrochemical grinding, deburring and honing.

### UNIT-IV

**Electric discharge machining (EDM):** Principal and metal removal mechanism, generators, electrode feed control, electrode material, tool electrode tool design, EDM wire cutting, surface finish, accuracy and application.

**Laser beam machining(LBM):** Introduction, generation of LASER, Equipment and mechanism of metal removal, LBM parameters and characteristics, Applications, Advantages & limitations.

**Electron beam machining (EBM):** Introduction, Principle, equipment and mechanism of metal removal, applications, advantages and limitations.

#### Text Books:

1. Unconventional Machining processes- T. Jagdeesha, I.K. International Publishing house
2. Advanced Machining processes- V.K. Jain, Allied Publishers private Ltd.
3. Unconventional Manufacturing process- M.K. Singh, New Age International
4. Modern machining processes – P.C. Pandey and M.S. Shan, TMH

#### Reference Books:

1. Non-traditional Manufacturing Processes –G.F. Benedict, Marcel Dekker, Inc.
2. Advanced Method of Machining –J.A. McGeough, Chapman and Hall.
3. Electrochemical Machining of Metals –Ruryantsev & Davydov, Mir Pub.

**Note: The paper setter will set the paper as per the question paper template provided.**

| B. Tech. (8 <sup>th</sup> Semester) Mechanical Engineering |   |           |        |            |            |       |             |
|--|---|-----------|--------|------------|------------|-------|-------------|
| MEP-404A   | AUTOMOBILE ENGINEERING  |           |        |            |            |       |             |
| Lecture  | Tutorial  | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3  | 0   | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Purpose</b>   | The objective of this course is to enable the students to understand various automobiles and their components. Also to describe the steering geometry, components and the mechanism involved in the automobile. |           |        |            |            |       |             |
| Course Outcomes  |   |           |        |            |            |       |             |
| <b>CO1</b>   | Students will be able to understand the basics of the engine cylinder and functions of the clutch.  |           |        |            |            |       |             |
| <b>CO2</b>   | Students will be able to explain the working of the gearbox, transmission, and new safety features etc.   |           |        |            |            |       |             |
| <b>CO3</b>   | Students will be able to describe how the rear axle, brake systems and wheel operate.   |           |        |            |            |       |             |
| <b>CO4</b>   | Students will be able to understand the steering geometry and suspension system.  |           |        |            |            |       |             |

#### UNIT-I

**Introduction:** Classification of automobile engines, use of engines, merits and demerits of vertical and horizontal engines, reasons for using single-cylinder two-stroke air-cooled petrol engine on two-wheelers, reasons for using multi-cylinder diesel engine for commercial vehicles, merits and demerits of two-stroke and four-stroke cycle engines, advantages of a multi-cylinder engine for the same power.

**Clutch:** Introduction, function of a clutch, main parts of a clutch, clutch types, clutch actuating mechanism, clutch construction, driven member-(friction or clutch disc), automatic transmission devices, troubleshooting/service procedures.

#### UNIT-II

**Gear box:** Introduction, type of gear boxes, three speed gearbox, merits and demerits of gear boxes, gear shifting mechanisms, epicyclic gearbox, gear reduction, overdrive, Maruti 800 gear box, five-speed gearbox, six speed gearbox.

**Propeller shaft, universal joint and other features:** Introduction, drive mechanism from gearbox to final drive in cars, propeller shaft (constructional features), shaft, universal joints, centre bearing in propeller shaft drive, propeller shaft, problems, ABS, GPS vehicle tracking, autonomous emergency braking (AEB), automatic transmission, electronic stability control (ESC), forward collision warning.

#### UNIT-III

**Rear axle assembly:** Introduction, purpose of the final drive, final drive requirements, the final drive, the differential, axle housing, maintenance of rear axle, troubleshooting in differentials.

**Brake system:** Introduction, functions of a brake, requirements of a brake system, brake actuating mechanism, leading and trailing shoes, classification of brakes, tandem master cylinder, drum brakes, self-energized brakes, disc brakes, floating-caliper brakes, power brakes, air-hydraulic brakes, air brake system, emergency and parking brakes.

**Wheel and tyre:** Introduction, types of automobile wheels, tyres, types of tyres, tyre tread, tyre selection, tyre service parameters, tyre maintenance.

#### **UNIT-IV**

**Suspension system:** Introduction, brief history, need for a good suspension system, stages in suspension system, elements of a suspension system, suspension systems, suspension system maintenance and troubleshooting, inspection and service of suspension system (general), troubleshooting of suspension systems.

**Steering and front axle:** Function of the steering system, steering gears, steering mechanisms used in some Indian vehicles, steering linkage, steering wheel and column, front axle, steering heads, steering geometry, wheel alignment, adjusting steering angles, Ackerman linkage, power Steering, under steering and over steering, steering lock, turning radius.

#### **Text Books:**

1. Automobile Engineering -By K.M. Gupta, Umesh Publications.
2. Automobile Engineering- Sudheer kumar, University Science Press.
3. Automobile Engineering- K.K Jain, Tata McGraw-Hill Publishing Company Limited.

#### **Reference Books:**

1. The Motor Vehicle - By Newton, Steeds and Garrett Basic.
2. Automobile Engineering - By Kirpal Singh, Standard Publication.

**Note: The paper setter will set the paper as per the question paper template provided.**

| B. Tech. (8 <sup>th</sup> Semester) Mechanical Engineering |  |           |        |            |            |       |             |
|--|--|-----------|--------|------------|------------|-------|-------------|
| MEP-406A   | PRODUCT DESIGN AND MANUFACTURING   |           |        |            |            |       |             |
| Lecture  | Tutorial   | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3  | 0  | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Purpose</b>   | The objective of the course is to understand the importance of design factors, manufacturing, assembly and environmental guidelines, prototyping and patenting requirements in product design, manufacturing, development and economics. |           |        |            |            |       |             |
| Course Outcomes  |  |           |        |            |            |       |             |
| <b>CO1</b>   | Students will be able to describe the concept of product design, design considerations, design practiced by the industry, production and marketing, and aesthetics.  |           |        |            |            |       |             |
| <b>CO2</b>   | Students will be able to explain and apply manufacturing, assembly and environmental guidelines in product design, manufacturing and development.  |           |        |            |            |       |             |
| <b>CO3</b>   | Students will be able to apply the value engineering concepts in product designing and will be able to understand the application of prototyping in product design.  |           |        |            |            |       |             |
| <b>CO4</b>   | Students will be able to explain the patenting, and intellectual property. They will also be able to understand the manufacturing and economic aspects related to a product.   |           |        |            |            |       |             |

#### UNIT-I

**Introduction:** Introduction to product design, design by evolution and innovation, essential factors of product design, production consumption cycle, flow and value addition in production consumption cycle, morphology of design (the seven phases)

**Product design practice and industry:** Product strategies, time to market, analysis of the product, the three s's, designer and his role, myth and reality, basic design considerations, problems faced by industrial designer, role of aesthetics in product design.

#### UNIT-II

**Design for manufacture and assembly:** Overview and motivation, basic method: design guidelines: design for assembly, design for piece part production, advanced method: manufacturing cost analysis, cost driver modeling, critique for design for assembly method.

**Design for the environment:** Environmental objectives, basic DFE methods, design guidelines, life cycle assessment, techniques to reduce environmental impact.

#### UNIT-III

**Value engineering:** Value, nature and measurement of value, maximum value, normal degree of value, importance of value, value analysis job plan, creativity, steps to problem solving and value analysis, value analysis tests, value engineering idea generation checklist, cost reduction through value engineering-case study, materials and process selection in value engineering.

**Prototyping:** Prototyping essentials, types of prototypes, uses of prototypes, reverse engineering, rapid prototyping techniques, scale, dimensional analysis, and similitude, basic method: physical prototype design and planning- guidelines for prototype design, sample prototype application, 3-D printing.

#### **UNIT-IV**

**Patents and intellectual property:** What is intellectual property? Overview of patents, utility patents, invention disclosure.

**Product development economics:** Elements of economic analysis, base case financial model, sensitive analysis, project trade-offs, influence of qualitative factors on project success, qualitative analysis.

**Text Books:**

1. Product Design and Development-Karl T. Ulrich and Steven D Eppinger, TMH.
2. Product Design and Engineering-A. K. Chitale and Gupta, PHI.

**Reference Books:**

1. Product Design and Process Engineering-Niebel and Draper, McGraw-Hill.
2. Product Design-Techniques in Reverse Engineering and New Product Development- Kevin Otto and Kristin Wood, Pearsons.

**Note: The paper setter will set the paper as per the question paper templates provided.**

| B. Tech. (8 <sup>th</sup> Semester) Mechanical Engineering |   |           |        |            |            |       |             |
|--|---|-----------|--------|------------|------------|-------|-------------|
| MEP-408A   | WELDING TECHNOLOGY  |           |        |            |            |       |             |
| Lecture  | Tutorial  | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3  | 0   | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Purpose</b>   | To expand the student's knowledge base and practical aspects in various areas of welding processes.   |           |        |            |            |       |             |
| Course Outcomes  |   |           |        |            |            |       |             |
| <b>CO 1</b>  | Students will be able to explain the applications of welding and allied processes in various industries.  |           |        |            |            |       |             |
| <b>CO 2</b>  | Students will be able to select arc welding power source and process parameters based on particular applications.                               |           |        |            |            |       |             |
| <b>CO 3</b>  | Students will be able to describe working of various gas welding equipment and will be able to suggest weld positions based on the application. |           |        |            |            |       |             |
| <b>CO 4</b>  | Students will be able to test weld for different defects and learn about the performance of TIG welding of aluminium and MIG welding of steels. |           |        |            |            |       |             |

#### UNIT-I

**Introduction to welding technology:** History of metal-working, early developments in welding, development of modern welding, functions of welding in industries, application of welding in different industries

**Welding and allied processes:** Fusion welding, electric resistance welding, solid phase welding, braze welding, thermal cutting, thermal spraying, welding compared to riveting and casting.

#### UNIT-II

**Arc welding process and equipment:** Working principle of arc welding processes, static characteristics curves, open circuit voltage, current rating and duty cycles, classes of insulation, power factor.

Different types of AC and DC power sources, arc welding transformers; methods to control welding current in welding transformers, arc welding generators, arc welding rectifiers comparison of power source, factors for selection of power sources.

Special power sources; universal type, multi-operator type, solid state power source, inverter based multi-process power source units.

#### UNIT-III

**Gas welding process and equipment:** Working principle of gas welding process, gases used, welding flames, setup and equipment, gas cylinders, handling fuel and oxygen cylinders, pressure regulators, hoses, welding torch; selection of welding torch tip size, torch lighters, lighting equal pressure type torch, lighting injector type welding torch, torch adjustments, shutting off torch, torch position and movements, puddling, types of oxy-acetylene welds made without the use of welding rod and with the use of welding rod, selection of welding rod size, welding positions, trolleys, filler rod and fluxes, protective equipment and clothing.

#### UNIT-IV

**Inspection and testing welds:** Non-destructive tests, destructive tests, visual inspection, magnetic particle inspection, liquid particle inspection, ultrasonic inspection, X-ray inspection, eddy current inspection, inspecting welds using pneumatic and hydraulic pressure, bend tests, impact tests, laboratory methods of testing welds

**TIG welding of aluminum and magnesium:** TIG equipment for aluminium, clean the parts using caustic cleaners and scouring pads, heat transfer in aluminium, aluminium arcing, balling tungsten, welding machine settings, striking the arc, aluminium weld procedure, square wave welders, TIG welding magnesium, TIG welding aluminium cylinder heads, weld fixture.

**MIG welding of steel and stainless steel:** Metal transfer modes, wire size, starting to MIG weld, aircraft seat welding, stress relieving, MIG welding tips, MIG welding stainless steel, backside protection, MIG welding titanium

**Text books:**

1. Welding Principle and Practices- Edward R. Bohnart, McGraw-Hill Publications.
2. Modern Arc Welding Technology -S.V. Nadkarni, Oxford and IBH Publishing Pvt. Ltd.
3. Modern Welding - Althouse, Goodheart Willcox co. Inc.
4. Performance Welding Handbook - Robert Finch, MBI publishing company.
5. Welding Processes and Technology - O.P. Khanna, Dhanpat rai publications
6. Welding Science and Technology- Ibrahim Khan, New Age International Publishers.
7. Welding Processes and Technology - R.S. Parmar, Khanna Publishers

**Reference books:**

1. Welding - A.C. Davies, Cambridge University Press.

**Note: The paper setter will set the paper as per the question paper template provided.**

| B. Tech. (8 <sup>th</sup> Semester) Mechanical Engineering |   |           |        |            |            |       |             |
|--|---|-----------|--------|------------|------------|-------|-------------|
| MEP-410A DESIGN OF PRESSURE VESSELS AND PIPING             |   |           |        |            |            |       |             |
| Lecture  | Tutorial  | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3  | 0   | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Purpose</b>   | The course aims to impart basic knowledge of design of pressure vessels and piping system. It is also aimed to introduce various standards used for the pressure vessel design. |           |        |            |            |       |             |
| Course Outcomes  |   |           |        |            |            |       |             |
| <b>CO1</b>   | Students will be able to analyze thin plates and shells for various types of stresses.  |           |        |            |            |       |             |
| <b>CO 2</b>  | Students will be able to design shells, end closures and tall cylinder columns of pressure vessels.   |           |        |            |            |       |             |
| <b>CO 3</b>  | Students will be able to explain the buckling and fracture in the pressure vessel.  |           |        |            |            |       |             |
| <b>CO 4</b>  | Students will be able to design piping systems and explain the piping code, behavior and support.   |           |        |            |            |       |             |

#### Unit-I

**Stresses in pressure vessels:** General theory of membrane stresses in vessel under internal pressure and its application to shells (cylindrical, conical and spherical) and end closures, bending of circular plates and determination of stresses in simply supported and clamped circular plate, thermal stresses, stress concentration in plate having circular hole due to bi-axial loading, excessive elastic deformation, plastic instability, brittle rupture and creep, theory of reinforced opening and reinforcement limits.

#### Unit-II

**Design of vessels:** Design of tall cylindrical self-supporting process columns, supports for short vertical vessels, stress concentration: at a variable thickness transition section in a cylindrical vessel, about a circular hole, elliptical openings, theory of reinforcement, pressure vessel design.

#### Unit-III

**Buckling and fracture analysis in vessels:** Buckling phenomenon, elastic buckling of circular ring and cylinders under external pressure, collapse of thick walled cylinders or tubes under external pressure, effect of supports on elastic buckling of cylinders, buckling under combined external pressure and axial loading, control and significance of fracture mechanics in vessels, FEM application

#### UNIT-IV

**piping design:** Flow diagram, Piping layout and piping stress analysis; Flexibility factor and stress intensification factor; Design of piping system as per B 31.1 piping code. Piping components - bends, tees, bellows and valves. Types of piping supports and their behaviour; Introduction to piping Codes and Standards.

#### Text Book:

- 1.Theory and Design of Pressure Vessels-John F. Harvey, CBS Publishers and Distributors, 1987.
- 2.American Standard Code for Pressure Piping, B 31.1", ASME.

3. Pressure Vessel Design Handbook-Henry H Bednar, CBS publishers and distributors
4. Chemical Process Equipment, Selection and Design-Stanley M Wales, Butterworths, Series in Chemical Engineering, 1988. Elsevier.
5. Pressure Vessels: ASME Code Simplified-J. Phillip Ellenberger, ASME.
6. Fundamentals of Piping Design-Smith P, Elsevier.

**Reference Books:**

1. Pressure Vessels, Design Hand Book-Henry H. Bedner, CBS Publishers and Distributors, 1987.
2. Chemical Process Equipment, Selection and Design-Butterworths series in Chemical Engineering", Stanley, M. Wales, 1988
3. Pressure Vessel Design-Harvey J F, CBS Publication.
4. Process Equipment Design-Brownell L. E and Young. E. D, Wiley Eastern Ltd., India
5. ASME Pressure Vessel and Boiler Code-Section VIII Div. 1, 2, and 3", ASME.

**Note: The paper setter will set the paper as per the question paper template provided.**

| B. Tech (8 <sup>th</sup> Semester) Mechanical Engineering |  |           |        |            |            |       |             |
|---|--|-----------|--------|------------|------------|-------|-------------|
| MEP-412A  | QUALITY AND RELIABILITY ENGINEERING  |           |        |            |            |       |             |
| Lecture   | Tutorial   | Practical | Credit | Major Test | Minor Test | Total | Time (Hrs.) |
| 3   | 0  | 0         | 3      | 75         | 25         | 100   | 3           |
| <b>Purpose</b>  | The purpose of this course is to provide students with an in-depth knowledge of quality and reliability. The course addresses the principles and techniques of Statistical Quality Control and their practical uses as well as give insight to modern reliability engineering tools. |           |        |            |            |       |             |
| Course Outcomes   |  |           |        |            |            |       |             |
| <b>CO1</b>  | Students will be able to understand the concept of quality value and engineering and application of statistical methods for quality control. The student will also be able to solve the problems related with dispersion of data.  |           |        |            |            |       |             |
| <b>CO2</b>  | Students will be able to understand different control charts and will solve the problems on control charts. They will also understand various sampling plans and design sampling plans.  |           |        |            |            |       |             |
| <b>CO3</b>  | Students will be able to explain the loss function and tolerance design for online quality control. They will come to know the concept of reliability and will be able to understand the mathematical derivations of different failure rates.  |           |        |            |            |       |             |
| <b>CO4</b>  | Students will be able to describe various hazard models and solve problems for finding reliability of complex systems.   |           |        |            |            |       |             |

#### UNIT-I

**Quality value and engineering:** Quality systems, quality engineering in product design and production process, system design, parameter design, tolerance design, statistical methods for quality control and improvement, mean, median, mode, standard deviation, calculating area, Normal distribution tables, finding the Z score, Central limit theorem.

#### UNIT-II

**Variation in process:** Control charts for variables: X-bar and R charts, Control charts for attributes P, C and U-Chart, Establishing and interpreting control charts process capability, Quality rating, Short run SPC.

Acceptance sampling by variables and attributes, single, double, sequential and continuous sampling plans, design of various sampling plan.

#### UNIT-III

**Loss function, tolerance design:** N type, L type, S type; determination of tolerance for these types, online quality control – variable characteristics, attribute characteristics, parameter design.

**Concept and definition of reliability:** Reliability Parameters: Reliability as a function of time, failure rate as a function of time, Bath-tub curve, constant failure rate, increasing failure rate, mean time to failure (MTTF), MTTF as a function of failure rate, mean time between failure (MTBF), mean down time (MDT), maintainability & availability

#### UNIT-IV

**Brief discussion on hazard models:**Constant hazard model, linearly increasing hazard model, nonlinear hazard model and Weibull distribution, Advantages of weibull distribution, System reliability models: series system, parallel system, series-parallel system

**Complex system:**Reliability of series, parallel & standby systems & complex systems & reliability prediction and system effectiveness, reliability testing

**Text books:**

1. Reliability Engineering, (3rdEdition) - LS Srinath, Affiliated East West Pvt Ltd, 1991..
2. Reliability Engineering- E.Bala Guruswamy, Tata McGraw Hill, 1994.
3. Statistical Quality Control- M. Mahajan, Dhanpat Rai & Co., 2018.
4. Statistical Process Control- Eugene Grant, Richard Leavenworth, McGraw Hill.

**Reference books:**

1. Introduction to Reliability Engineering- Lewis E. E., John Wiley & Sons - 1987
2. Reliability Based Design-Rao S. S., McGraw Hill - 1992
3. Practical Reliability Engineering- O'connor P. D. T., John Wiley & Sons Ltd. - 2003
4. Statistical Quality Control-Eugene G. L., McGraw-Hill - 1996

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