# COURSE STRUCTURE (R20)
# AND
# DETAILED SYLLABUS
# (III YEAR)

## MECHANICAL ENGINEERING

**For**
**B.Tech, Four Year Degree Course**
**(Applicable for the batches admitted from 2020-21)**


**LENDI INSTITUTE OF ENGINEERING AND TECHNOLOGY**
An Autonomous Institution
Approved by AICTE & Permanently Affiliated to JNTUK, Kakinada
Accredited by NAAC with "A" Grade and NBA (CSE, ECE, EEE & ME)
Jonnada (Village), Denkada (Mandal), Vizianagaram Dist – 535 005
Phone No. 08922-241111, 241112
E-Mail: lendi_2008@yahoo.com
Website: www.lendi.org

## III Year - I Semester

| S No | Code | Course Title | Category | Hours | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | | L | T | P | |
| 1 | R20MEC-PC3101 | Design of Machine Members | PC | 3 | 0 | 0 | 3 |
| 2 | R20MEC-PC3102 | Metal Cutting & Machine Tools | PC | 3 | 0 | 0 | 3 |
| 3 | R20MEC-PC3103 | IC Engines & Turbo Machinery | PC | 3 | 0 | 0 | 3 |
| 4 | | **OPEN ELECTIVE -I** | OE | 3 | 0 | 0 | 3 |
| | R20ECE-OE3101.1 | 1) Mechatronics | | | | | |
| | R20EEE-OE3101.2 | 2) Green Energy systems | | | | | |
| | R20CSE-OE3101.3 | 3) Data Base Management System | | | | | |
| | R20BSH-OE3101.4 | 4) Statistical Quality Control | | | | | |
| 5 | | **PROFESSIONAL ELECTIVE -I** | PEC | 3 | 0 | 0 | 3 |
| | R20MEC-PE3101.1 | 1) Nuclear and Advanced Power Generation Technologies | | | | | |
| | R20MEC-PE3101.2 | 2) Automobile Engineering | | | | | |
| | R20MEC-PE3101.3 | 3) Mechanical Behaviour of Materials | | | | | |
| | R20MEC-PE3101.4 | 4) Advanced Machining Process | | | | | |
| 6 | R20MEC-PC3104 | Metal Cutting & Machine Tools lab | PC Lab | 0 | 0 | 3 | 1.5 |
| 7 | R20MEC-PC3105 | Thermal Engineering Lab | PC Lab | 0 | 0 | 3 | 1.5 |
| 8 | R20CSE-SC3101 | Python (Skill Development Course) | **SC*** | **1** | **0** | **2** | **2** |
| 9 | R20BSH-MC3101 | 3D Printing Technology | MC | 2 | 0 | 0 | 0 |
| **10** | **Summer Internship 2 Months (Mandatory) after second year (to be evaluated during III-I Semester)** | | | 0 | 0 | 0 | 1.5 |
| | | **Total credits** | | | | | **21.5** |
| **11** | ***Honors Course -2/Minor Course-2** | | | | | | |

| Category | CREDITS |
|---|---|
| Professional core Courses | 12 |
| Professional Elective courses | 3 |
| Open Elective Course/Job oriented elective | 3 |
| **Skill advanced course/ soft skill course*** | 2 |
| Summer Internship | 1.5 |
| **TOTAL CREDITS** | **21.5** |

****The Eligible students who opted the courses for B.Tech with Honors/Minor only***
*Note: L-Lecture, T-Tutorial, P-Practical, C-Credits*

## III Year - II Semester

| S No | Code | Course Title | Category | Hours | | | Credits |
|---|---|---|---|---|---|---|---|
| | | | | L | T | P | |
| 1 | R20MEC-PC3201 | Design of Power Transmission Elements | PC | 3 | 1 | 0 | 3 |
| 2 | R20MEC-PC3202 | Heat Transfer | PC | 3 | 0 | 0 | 3 |
| 3 | R20MEC-PC3203 | Mechanical Measurements and Metrology | PC | 3 | 0 | 0 | 3 |
| 4 | | **PROFESSIONAL ELECTIVE -II** | PEC | 3 | 0 | 0 | 3 |
| | R20MEC-PE3201.1 | 1) CAD/CAM | | | | | |
| | R20MEC-PE3201.2 | 2) Composite Materials | | | | | |
| | R20MEC-PE3201.3 | 3) Production Planning and Control | | | | | |
| | R20MEC-PE3201.4 | 4) Refrigeration and Air Conditioning | | | | | |
| 5 | | **OPEN ELECTIVE -II** | OE | 3 | 0 | 0 | 3 |
| | R20CSE-OE3201.1 | 1) Internet of Things(IOT) | | | | | |
| | R20EEE-OE3201.2 | 2)Non-Conventional Energy Sources | | | | | |
| | R20BSH-OE3201.3 | 3) Operations Research | | | | | |
| | R20ECE-OE3201.4 | 4) Image Processing | | | | | |
| 6 | R20MEC-PC3204 | CAE Lab | PC LAB | 0 | 0 | 3 | 1.5 |
| 7 | R20MEC-PC3205 | Heat Transfer Lab | PC LAB | 0 | 0 | 3 | 1.5 |
| 8 | R20MEC-PC3206 | Mechanical Measurements and Metrology Lab | PC LAB | 0 | 0 | 3 | 1.5 |
| 9 | R20CSE-SC3201 | JAVA(Skill Development Course) | **SC*** | **1** | **0** | **2** | **2** |
| 10 | R20BSH-MC3201 | Entrepreneurship & Incubation | MC | 2 | 0 | 0 | 0 |
| **Total credits** | | | | | | | **21.5** |
| 11 | ***Honors Course -3/Minor Course-3** | | | | | | |
| 12 | **Industrial/Research Internship (Mandatory) 2 Months during summer vacation ( After third Year & Evaluated in IV-I Semester)** | | | | | | |

| Category | CREDITS |
|---|---|
| Professional core courses | 13.5 |
| Professional Elective courses | 3 |
| Open Elective Course/Job oriented elective | 3 |
| **Skill advanced course/ soft skill course*** | 2 |
| Mandatory course (AICTE) | 0 |
| Industrial/Research Internship (Mandatory) 2 Months | - |
| **TOTAL CREDITS** | **21.5** |

**The Eligible students who opted the courses for B.Tech with Honors/Minor only*
*Note: L-Lecture, T-Tutorial, P-Practical, C-Credits*

## III YEAR –I SEMESTER

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20MEC-PC3101 | Design of Machine Members | 3 | 0 | 0 | 3 |

**Course Objectives:**
The objectives of the course are to

1. understand the significance of design in mechanical engineering and the steps involved indesigning.
2. select the proper materials to different machine elements based on their physical and mechanical properties.
3. explain the criteria for different types of failure modes.
4. learn the design procedure of different machine elements.

**Course outcomes:**
At the end of the course, the student will be able to

1. ***understand*** the design procedure to engineering problems with technical and manufacturingconstraints. (L2)
2. ***apply*** the theories of failures on machine elements under the action of loads**.**(L3)
3. ***analyze*** the bolted, riveted and welded joints under static and fatigue loads. (L4)
4. ***design*** the impended loads for the keys, cotters and knuckle joints to ensure safe design. (L4)
5. ***analyze*** the stresses induced in shafts and couplings (L4)

**UNIT – I**

**INTRODUCTION:** General considerations in the design of Engineering Materials and their properties–selection–Manufacturing consideration in design, tolerances and fits–BIS codes of steels- safety and reliability in design.

**STRESSES IN MACHINE MEMBERS:** Simple stresses–combined stresses–torsional and bending stresses–impact stresses–stress strain relation–various theories of failure–factor of safety– design for strength and rigidity–preferred numbers. The concept of stiffness in tension, bending, torsion and combined situations–static strength design based on fracture toughness.

**Applications:** In design of Automobiles, Mechanical Components etc..

**Learning Outcomes:**

At the end of this unit, the student will be able to

- ***understand*** the basic design considerations (L2)

- ***explain*** the stresses in different machine members (L2)

**UNIT – II**

**STRENGTH OF MACHINE ELEMENTS:** Stress concentration–theoretical stress concentration factor– fatigue stress concentration factor notch sensitivity–design for fluctuating stresses– endurance limit–estimation of endurance strength–Goodman's line– Soderberg's line– modified Goodman's line.

**Applications:** In design of Automobiles, Mechanical Components etc..

**Learning Outcomes:**

At the end of this unit, the student will be able to

- ***identify*** various stresses for the cause of fracture (L3)
- ***explain*** the factors considered for safe design (Understand)

**UNIT – III**

**Riveted joints**– Introduction- Methods of Riveting- Caulking and Fullering -Material of Rivets- Types of Rivet Heads. Types of Riveted Joints-Lap Joint- Butt Joint-Important Terms Used inRiveted Joints- Failures of a Riveted Joint- Strength of a Riveted Joint- Efficiency of a Riveted Joint-Eccentric Loaded Riveted Joint.

**Welded joints** – design of joints with initial stresses – eccentric loading

- **Bolted joints**–Design of bolts with pre-stresses–design of joints under eccentric loading–locking devices– both of uniform strength.

**Applications:** In construction of bridges, Assembles of automobiles etc

**Learning Outcomes:**

At the end of this unit, the student will be able to

- ***explain*** the types of welded, riveted and bolted joints(Understand)
- ***understand*** the procedure for design of bolts(Understand)
- ***identify*** various stresses induced in design of weld joints(Apply)

**UNIT – IV**

**KEYS:** Design of keys-Introduction-Types of Keys-Sunk Keys- Saddle Keys-Strength ofSunk Key-stresses in the key

**PINNED JOINTS: cotters-** cotter joints-spigot and socket, sleeve and cotter, jib andcotter joints-Knuckle Joint- introduction-design

**Applications:** In Automobile Industry etc

**Learning Outcomes:**

At the end of this unit, the student will be able to

- ***explain*** about design of keys and cotters used in machine members(Understand)
- ***determine*** the stresses induced in keys and cotters (Analyze)

**UNIT–V**

**SHAFTS:** Design of solid and hollow shafts for strength and rigidity–design of shafts for combinedbending and axial loads.

**SHAFTCOUPLING:** Introduction- Requirements of a Good Shaft Coupling-Types ofShafts Couplings- Advantages and limitations.

**Rigid couplings**–muff Clamp or Compression Coupling and flange couplings

**Flexible Coupling**- Bushed Pin Flexible Coupling.

**Applications:** In heavy Trucks, four wheelers, etc

**Learning Outcomes:**

At the end of this unit, the student will be able to

- ***understand*** the concept of tolerances in the design of shafts (Understand)
- ***explain*** the types of loads to be considered in design of shafts(Understand)
- ***identify*** the loads and stresses induced in couplings(Apply)

**Note: Design data book is NOT Permitted for**

**examinationTextbooks:**

1. Machine Design/V. Bandari/ TMH Publishers
2. Machine design/NC Pandya & CSShah / Charotar Publishing House Pvt. Limited
3. Design data book of Engineers

**References:**

1. Design of Machine Elements /V.M.Faires / McMillan
2. Machine design/ Schaum Series/ McGraw Hill Professional
3. Machine Design/ Shigley,J.E/ McGraw Hill.
4. Design data handbook/K.Mahadevan & K.Balaveera Reddy/CBS publishers.
5. Design of machine elements-Spotts /Pearson Publications
6. Machine Design–Norton/Pearson publishers

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20MEC-PC3102 | Metal Cutting & Machine Tools | 3 | 0 | 0 | 3 |

**Course Objectives:**

The objectives of the course are to

- Explain the parameters in metal cutting operation.
- Understand Types of lathes, Lathe operations, Work holders, Tool holders, Lathe attachments& Automatic Lathes
- Differentiate between Boring, reaming and tapping.
- Provide insight into Finishing processes and Abrasives, Bonds, Lapping, Honing andBroaching Operations
- Familiarize with the principles of jigs and fixtures and types of clamping and work holdingdevices.

**Course Outcomes:**

At the end of the course, the student will be able to

1. ***calculate*** the cutting forces and tool life(L3)
2. ***classify*** the different lathe operations(L2)
3. ***understand*** the boring, tapping and drilling operations.(L2)
4. ***illustrate*** milling, shaping and slotting operations.(L2)
5. ***explain*** types of grinding machines and work holding devices.(L2)

**UNIT-I**

**Metal Cutting:** Single and multi-point cutting tools, orthogonal and oblique cutting, chip formation, tool wear and tool life, Tool Angles, cutting tool materials, cutting fluids, chip formation and types of chips – built up edge and its effects, chip thickness ratio, chip breakers, Merchant's force diagram and numerical on Merchant Force Diagram

**Learning Outcomes:**

At the end of this unit, the student will be able to

- ***differentiate*** orthogonal and oblique cutting(L2)
- ***classify*** types of chips, cutting tool materials and cutting fluids.(L2)
- ***calculate*** cutting force and tool life(L3)
- ***explain*** the geometry of single point cutting tool, speed and feed finding techniques.(L2)

**Applications:**

- Machining of Metals, Plastics and Glasses in the Mechanical Workshops

**UNIT-II**

**Lathe and Lathe Operations:** Principles of working, specifications, types of lathes, operations performed, work holders and tool holders. Taper turning operations, machining Time calculations. Turret and capstan lathes - Principle of working, collet chucks, Automatic lathes,single spindle and multi–Spindle Automatic lathes.

**Learning Outcomes:**

At the end of this unit, the student will be able to

- ***Explain*** types of lathes and boring machines.(L2)
- ***Elucidate*** the taper turning attachments.(L2)

**Applications:**
Wood turning, turning, facing, grooving, parting, threading, drilling, boring, knurling operationsin machine tool industry

**UNIT-III**
**Drilling and Drilling Machines:** Principles of working, specifications, types, and operationsperformed-nomenclature of twist drill

**Boring and Boring Machines-** Principles of working, specifications, types, and operationsperformed-tool holding devices-nomenclature of boring tools

**Taping and Taps:** Principles of working, specifications, types, and operations performed-toolholding devices-nomenclature of taps.

**Learning Outcomes:**

At the end of this unit, the student will be able to

- ***explain*** the working Principles of drilling, boring and taping machines.(L2)
- ***understand*** the tool geometry of twist drill and taps(L2)

**Applications:**
- Accurate holes in the work pieces
- Metalworking and woodworking industries.

**UNIT-IV**

**Milling operations and Milling machines-**

Principles of working, specifications, classifications of milling machines, milling operations,types and geometry of milling cutters, methods of indexing, and accessories to milling machines. **Shaping, Slotting and planning machines-**

Principles of working- principal parts, specification, classification, and operations performed.

**Learning Outcomes:**

At the end of this unit, the student will be able to

- ***Understand*** the parts of the milling, shaping, slotting, and planning machine. (L2)
- ***Compare*** tool geometry for milling, shaping, slotting, and planning operations. (L2)

**Applications:**

- Gears, straight/flat surfaces, cutting keys and accurate flat surfaces.
- used to machine flat surfaces, produce irregular surfaces

**UNIT-V**
**Grinding and grinding machines**:

Grinding process, types of grinding machines, grinding process parameters, and honing, lapping,other finishing processes.

**Jigs and Fixtures:** Classification of Jigs & Fixtures, types of clamping and work holdingdevices, typical examples of jigs and fixtures, 3-2-1 principle of location and clamping.

**Learning Outcomes:**

At the end of this unit, the student will be able to

- ***understand*** the basic principles of abrasive processes.(L2)
- ***explain*** the designation of the grinding wheel and the significance of the various codes.(L2)
- ***classify*** types of grinding machines, jigs and fixtures and their applications. (L2)
- ***explain*** the design principles of jigs and fixtures. (L2)

**Applications:**

- Finishing operations on flat and cylindrical objects.
- Work holding devices in machining and cutting operations

**Textbooks**


1. P.N.Rao, Manufacturing Technology: Metal Cutting and n,(Volume2),3/e, Tata McGraw-HillEducation.
2. R.K.Jainand S.C.Gupta, Production Technology,17/e, Khanna Publishers.


**Reference books**
``


1. Kalpakjian S and Schmid SR, Manufacturing Engineering and Technology 7/e, Pearson.
2. Milton C. Shaw, Metal Cutting Principles, 2/e, Oxford.
3. Hindustan Machine Tools, Production Technology, TMH.
4. V.K.Jain, Advanced Machining Process,12/e, Allied Publications.
5. AB.Chattopadhyay, Machining and Machine Tools,2/e ,Wiley.
6. Halmi A Yousuf & Hassan, Machine Technology: Machine Tools and Operations, CRC Press Taylor and `Francis Group.

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20MEC-PC3103 | IC Engines & Turbo Machinery | 3 | 0 | 0 | 3 |

**Course Objectives:**
The objectives of the course are to

- Understand the concepts of internal combustion engines.
- Studythestagesofcombustioninsparkignitionenginesanddieselengines.
- Learn the process of carburetion, injection, ignition, cooling, lubrication and governingsystems.
- Impart knowledge about various engine performance characteristics and its testing.
- Summarize the effects of volatility on the operation of I.C. Engines.
- Explain the principle of operation of turbomachines.

**Course outcomes:**
At the end of the course, the student will be able to

1. ***Develop*** the concepts of principle of operation, working of IC Engines and carburetor (L3)
2. ***Analyze*** the combustion phenomena in SI and CI engines and factors influencing combustionprocess. (L4)
3. ***Outline*** the need and working of injection, ignition, cooling, lubrication and governingsystems. (L2)
4. ***evaluate*** various engine performance characteristics with load and speed test on I.C. Engines.(L5)
5. ***explain*** the principle of operation and power and efficiencies of turbomachines.(L2)

**UNIT-I**

**Introduction to I.C Engines:** Engine classification, Two and four stroke engines, SI and CI engines, Valve timing diagram. Effect of valve timing and engine speed on volumetric efficiency. Fuel-air cycles and actual cycle: Reasons for deviation of actual cycle from air standard cycles,

**SI Engines: Carburetion:** Properties of air-petrol mixtures, mixture requirement, simple carburetor, limitation of simple carburetor, Nozzle lip, venturi depression, calculation of fueljet and venture throat diameter for given air fuel ratio.

**Gasoline injection system:** Disadvantages of carburetor, Type of injection system, components of injection system, electronic gasoline fuel injection system, multi-point fuelinjection system, working, advantages and disadvantages.

**Application:** SI Engines

**Learning Outcomes:**
At the end of the course, the student will be able to

- ***understand*** the various types of IC engines(L2)
- ***identify*** the specifications of carburetor for engine requirements (L3)
- ***explain*** the injection systems in SI engine(L2)

**UNIT-II**

**CI Engine:** Combustion in CI engines, Ignition delay, Knock and its control, Fuel injection in CI engines, Requirements, Types of injection systems, Fuel pumps, Fuel injectors, Exhaust emissions from SI engine and CI engine and its control.

**Fuels:** Fuels for SI and CI engine, Important qualities of SI and CI engine fuels, Rating of SI

engine and CI engine fuels, Additives, Volatility of liquid fuels, ASTM distillation curve, effect of volatility on engine performance-cold starting, hot starting, vapour lock, acceleration, carburetor icing, and crank case dilution.

**Application:** CI engines, selection of fuel quality

**Learning Outcomes:**

At the end of this unit, the student will be able to

- ***explain*** the combustion problems occurring in CI engines. (L2)
- ***summarize*** the effect of volatility on the operation of I.C. Engines.(L2)
- ***understand*** the fuels quality requirement for IC engines(L2)

**UNIT-III**

**Ignition System:** Battery and magneto ignition system and their comparative study, spark plug heat range, electronic ignition system, firing order, Ignition timing, centrifugal and vacuum ignition advance.

**Cooling System:** Cooling requirement, air cooling, liquid cooling, type of liquid cooling system, advantage and disadvantage of air cooling and water-cooling system, Anti-freeze mixture.

**Lubrication System:** Function of lubricating system, Classification of lubricating system, mist lubrication system, dry sump lubrication, wet sump lubrication-splash, and modified and full pressure system

**Governing**: Necessity of governing, methods of governing-hit and miss governing,

**Learning Outcomes:**

At the end of this unit, the student will be able to

- ***compare*** different lubrication systems for IC engines (L2)
- ***explain*** different cooling systems, ignition systems for IC engines(L2)

**UNIT-IV**

**Testing and Performance:** Performance parameters, measurements of brake power, indicated power, measurement friction power-Willan's line method, Morse test, motoring test, measurement fuel consumption, and measurements of air consumption, exhaust gas calorimeter. Calculation of various performance parameter, heat balance sheet and heat balance diagram. Performance curves of S.I. and C.I. Engine at full throttle variable speed operation and at constant speed variable load operation.

**Application:** Stationary engines, Engines for automobiles.

**Learning Outcomes:**

At the end of this unit, the student will be able to

- ***explain*** the measurement of power output of I.C. Engines.(L2)
- ***solve*** the exercises to find performance parameters(L3)
- ***analyze*** various engine performance characteristics with load and speed test on I.C.Engines.(L4)

**UNIT-V**

**Turbo Compressors:** Introduction, classifications of Centrifugal compressors – components, working, velocity diagrams, calculations of power and efficiencies. Slip factor, surging and choking, power and efficiencies.

**Axial Flow Compressor:** Construction and working, velocity diagram, calculation of

power and efficiencies. Degree of reaction, work done factor, stalling, comparison of centrifugal and axial flow compressor.

**Application:** Aerospace industry**,** Power plants

**Learning Outcomes:**

At the end of this unit, the student will be able to

- ***explain*** the principle of operation of turbomachines(L2)
- ***compare*** centrifugal and axial flow compressors.(L2)

**TEXTBOOKS**


1. I.C Engine, by V. Ganeshan, Tata McGraw Hill Publishers
2. A Course in International Combustion Engines, by Mathur &Sharma, Dhanpat Rai &Sons.
3. Yahya, S.H, Turbines, Compressor and Fans, Tata McGraw Hill


**REFERENCES**


1. Fundamentals of Internal Combustion Engine by Gill, Smith, Ziurs, Oxford & IBHPublishing CO.
2. Internal combustion engine fundamentals by John B.Heywood, Tata McGraw HillPub, 1988.
3. Earl Logan, Jr, Hand book of Turbo machinery, Marcel Dekker Inc.
4. Shepherd, D.G, Principles of Turbomachinery, Macmillan.

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20ECE-OE3101.1 | Mechatronics<br>(**Open Elective–I**) | 3 | 0 | 0 | 3 |

**Course Objectives:**

- To introduce the integrative nature of Mechatronics.
- To describe the different components and devices of mechatronics systems
- To describe various applications and future trends of mechatronics systems

**Course Outcomes:**

At the end of the course, the student will be able to

1. Describe Mechatronics design process and mechatronics system devices (L2)
2. Illustrate Solid state electronic devices and its applications in various mechatronics systems (L2)
3. Identify the different types of electro mechanical systems and its applications (L4)
4. Analyze different types of Digital electronics and systems and its applications(L4)
5. Design of mechatronics systems for future trends. (L3)

**Unit I**

Mechatronics systems – elements & levels of mechatronics system, Mechatronics design process, system, measurement systems, control systems, microprocessor-based controllers, advantages and disadvantages of mechatronics systems. Sensors and transducers, types, displacement, position, proximity, velocity, motion, force, acceleration, torque, fluid pressure, liquid flow, liquid level, temperature and light sensors.

**Learning Outcomes:**

- Different examples for mechatronics systems (L1)
- Advantages of mechatronics systems(L2)
- Application of different types of Sensors and transducers (L1)

**Unit II**

Solid state electronic devices - PN junction diode, BJT, FET, DIAC, TRIAC and LEDs. Analog signal conditioning, operational amplifiers, noise reduction, filtering.

**Learning Outcomes:**

- Different examples for Solid state electronic devices (L1)
- Different types of amplifiers and its applications (L1)

**Unit III**

Hydraulic and pneumatic actuating systems - Fluid systems, Hydraulic systems, and pneumatic systems, components, control valves, electro-pneumatic, hydro-pneumatic, electro-hydraulic servo systems. Mechanical actuating systems and electrical actuating systems – basic principles and elements.

**Learning Outcomes:**

- Know about electro-pneumatic, hydro-pneumatic systems (L2)
- Applications of Mechanical actuating systems and electrical actuating systems (L4)

**Unit IV**

Digital electronics and systems, digital logic control, micro processors and micro controllers, programming, process controllers, programmable logic controllers, PLCs versus computers, application of PLCs for control. Dynamic models and analogies, System response. Process Controllers – Digital Controllers, Programmable Logic Controllers

**Learning Outcomes:**

- Know about Digital electronics and systems (L2)
- Know about comparison of PLCs and computers (L2)
- Distinguish between Process Controllers and Programmable Logic Controllers (L4)

**Unit V**

System and interfacing and data acquisition – Data Acquisition Systems, Analog to Digital and Digital to Analog conversions; Digital Signal Processing – data flow in DSPs, block diagrams, typical layouts, Interfacing motor drives. Design of mechatronics systems & future trends.

**Learning Outcomes:**

- How to interface the systems for the purpose of data acquisition (L2)
- Different types of ADC and DAC converters (L4)
- Design of mechatronics systems for furure trends (L3)

**Text Books:**


1. MECHATRONICS Integrated Mechanical Electronics Systems/KP Ramachandran, GK Vijaya Raghavan & MS Balasundaram/WILEY India Edition


**References:**


1.Mechatronics /Smaili A, Mrad F/ Oxford Higher Education, Oxford University Press

2. Mechatronics Source Book / Newton C Braga/Thomson Publications,Chennai.

3. Mechatronics – N. Shanmugam / Anuradha Agencies Publishers.

4. Mechatronics System Design / Devdas shetty/Richard/Thomson.

5. Mechatronics/M.D.Singh/J.G.Joshi/PHI.

6. Mechatronics – Electronic Control Systems in Mechanical and Electrical Engg. 4th Edition / W. Bolton/ Pearson.

7.Mechatronics – Principles and Application / Godfrey C. Onwubolu/Elsevier, Indian print

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20EEE-OE3101.2 | Green Energy systems<br>**(Open Elective–I)** | 3 | 0 | 0 | 3 |

**Course objectives:**

- Understand the link between energy, environment and sustainable development
- Familiarize with energy ecosystems and its impact on environment
- Classify energy conversion system in solar and wind energy systems.
- Learn basics of various types of renewable and clean energy technologies
- Explain about Hydropower, Nuclear fission and fusion-Geothermal energy (L2)

**Course Outcome:**

After completion of the course, the student will be able to:

1. Understand the relationship between energy, environment and sustainable development (L2).
2. To know about energy ecosystems and its impact on environment (L2)
3. Classify energy conversion system in solar and wind energy systems (L4).
4. Learn basics of various types of ocean and bio-energy technologies(L2)
5. Understand about Hydropower, Nuclear fission and fusion-Geothermal energy (L2)

**Unit I**

**Energy Sources:**

Introduction to the nexus between energy, environment and sustainable development, Energy sources over view and classification, sun as the source of energy, fossil fuel reserves and resources - overview of global/ India's energy scenario. Energy consumption models – Specific Energy Consumption

**Learning Outcomes:**

- Understand about different sources of energy (L2).
- Know about global/India's energy scenario (L2).

**Unit II**

**Ecology and Environment:**

Concept and theories of ecosystems, - energy flow in major man-made ecosystems- agricultural, industrial and urban ecosystems - sources of pollution from energy technologies and its impact on atmosphere - air, water, soil, and environment - environmental laws on pollution control, The environmental protection act :Effluent standards and ambient air quality, innovation and sustainability, eco-restoration: phyto-remediation.

**Learning Outcomes:**

- Familiarize with the ecology and environmental concepts (L2).
- To know about environmental protection act. (L2)

**Unit III**

**Solar and Wind Energy:**

**Solar Energy**: Solar radiation: measurements and prediction. Indian's solar energy potential and challenges, solar energy conversion principles and technologies: Photosynthesis, Photovoltaic conversion and Photo thermal energy conversion.

**Wind Energy**: Atmospheric circulations, atmospheric boundary layers, classification, factors influencing wind, wind shear, turbulence, wind energy basics and power Content, wind speed monitoring, Betz limit, wind energy conversion system: classification, characteristics and applications.

**Learning Outcomes:**

- Understand the basic principles of solar energy conversion (L2).
- Classify the wind energy conversion systems. (L4)

**Unit IV**

**Ocean and Bio-Energy:**

**Ocean Energy**: Ocean energy resources-ocean energy conversion principles and technologies: ocean thermal, ocean wave & ocean tide

**Bioenergy**Biomass as energy resources; bio-energy potential and challenges, Classification and estimation of biomass; Source and characteristics of biofuels: Biodiesel, Bioethanol, Biogas. Types of biomass energy conversion systems - waste to energy conversion technologies.

**Learning Outcomes:**

- Understand the ocean energy conversion principles and technologies(L2).
- To know about bio-energy potential and challenges (L2).

**Unit V**

**Other Energy Sources and Systems:**

Hydropower, Nuclear fission and fusion-Geothermal energy: Origin, types of geothermal energy sites, site selection, geothermal power plants; hydrogen energy, Magneto-hydro-dynamic (MHD) energy conversion – Radioisotope Thermoelectric Generator (RTG), Bio-solar cells, battery & super capacitor, energy transmission and conversions.

**Learning Outcomes:**

- Understand about geothermal power plants (L2).
- Understand about MHD energy conversion (L2)

**Textbooks:**


1. Energy and Environment Set: Mathematics of Decision Making, Loulou, Richard; Waaub, Jean-Philippe; Zaccour, Georges (Eds.).
2. Energy and the Challenge of Sustainability, World Energy assessment, UNDP, N York.
3. Solar Energy: principles of Thermal Collection and Storage, S.P. Sukhatme, Tata McGraw-Hill
4. Geothermal Energy: From Theoretical Models to Exploration and Development by Ingrid Sober and Kurt Bucher, Springer.
5. Ocean Energy: Tide and Tidal Power by R. H. Charlier and Charles W. Finkl, Springer.


**Reference Books:**


1. Energy and the Environment, Ristinen, Robert A. Kraushaar, Jack J. AKraushaar, Jack P. Ristinen, Robert A., 2nd Edition, John Wiley.
2. D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor and Francis, Philadelphia.
3. Wind Energy Conversion Systems, L.L. Freris, Prentice Hal.

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20CSE-OE3101.3 | Data Base Management System (**Open Elective–I**) | 3 | 0 | 0 | 3 |

**Course objectives:**

1. Learn the fundamental concepts of database systems.
2. Enable students to design ER diagram for any customized applications
3. Learn simple and Complex queries using SQL
4. Learn schema refinement techniques (Normalization).
5. Knowledge about transaction and recovery techniques.

**Course Outcomes:**

1. Understand File System Vs Databases.
2. Design and implement ER-model and Relational models.
3. Construct simple and Complex queries using SQL.
4. Analyze schema refinement techniques.
5. Design and build database system for a given real world problem

**Unit-I**

**Introduction-**Database system, Characteristics (Database Vs File System), Database Users (Actors on Scene, Workers behind the scene), and Advantages of Data base systems, Database applications. Brief introduction of different Data Models; Concepts of Schema, Instance and data independence; Three tier schema architecture for data independence; Database system structure, environment, Centralized and Client Server architecture for the database.

**Learning outcomes: Student will be able to**

1. Distinguish between Database System and File System (L2)
2. Categorize different kinds of data models (L2)

**Unit-II**

**Relational Model:** Introduction to relational model, concepts of domain, attribute, tuple, relation, importance of null values, constraints (Domain, Key constraints, integrity constraints) and their importance , Relational algebra, Relational Calculus.

**Entity Relationship Model:**

Introduction, Representation of entities, attributes, entity set, relationship, relationship set, constraints, sub classes, super class, inheritance, specialization, generalization using ER Diagrams.

**Learning Outcomes: Student Will Be Able To**

1. Develop E-R model for the given problem (L6)
2. Knowledge about integrity constraints in relational model (L1)

**Unit-III**

**Schema Refinement (Normalization):** Purpose of Normalization or schema refinement, concept of functional dependency, normal forms based on functional dependency(1NF, 2NF and 3NF), concept of surrogate key, Boyce-codd normal form(BCNF), Lossless join and dependency preserving decomposition, Fourth normal form(4NF).

**Learning Outcomes: Student will be able to**

1. Differentiate between various normal forms based on functional dependency (L2)
2. Apply Normalization techniques to eliminate redundancy (L3)

## Unit-IV

**Transaction And Recovery:** Transaction State, Implementation of Atomicityand Durability, Concurrent Executions, Serializability, Deadlocks in transactions, Recoverability, Implementation of Isolation, Testing for Serializability, Failure Classification, Storage, Recovery and Atomicity, Recovery algorithm.

### Learning Outcomes: Student will be able to

1. Summarize transaction properties and recoverability (L2)

## UNIT-V

**File Organization and Indexing**, File Types, File Operations ,Cluster Indexes, Primary and Secondary Indexes , Index data Structures, Hash Based Indexing: Tree based Indexing, Indexes and Performance Tuning

### Learning Outcomes: Student will be able to

1. Understand basic concepts of File Organization and Indexing (L2)

## Text Books:


1. Database Management Systems, 3/e, Raghurama Krishnan, Johannes Gehrke,TMH
2. Database System Concepts,5/e, Silberschatz, Korth, TMH
3. Introduction to Database Systems, 8/e C J Date, PEA..


## Reference Books:


1. Database Management System, 6/e Ramez Elmasri, Shamkant B. Navathe, PEA
2. Database Principles Fundamentals of Design Implementation and Management,Carlos Coronel, Steven Morris, Peter Robb, Cengage Learning.

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20CSE-OE3101.4 | Statistical Quality Control<br>(**Open Elective–I**) | 3 | 0 | 0 | 3 |

**Course Objectives**

- Provide the concept of Quality and various techniques associated with quality control(L2)
- Enhance the complexity of statistical analysis and interpretation.(L2)
- Identify various statistical tools of quality monitoring. (L1)
- Analyze the acceptance sampling plans. (L3)
- Demonstrate the application of the control charts. (L2)

**Course Outcomes:**

1. Comprehend the importance of quality & role of statistical quality control.(L2)
2. Build knowledge of theoretical and practical aspects of process capability.(L3)
3. Analyse the philosophy of statistical process control to interpret results. (L3)
4. Develop an understanding on quality control charts philosophies and frameworks.(L3)
5. Identify accepting sampling plans to meet producer and consumer requirements.(L4)

## UNIT-I

**Introduction To Quality Control:** Concept of quality-quality characteristics. Quality control, History of quality control, Inspection and quality control, Quality design ,Quality policy and objectives, Economics of quality, Quality function deployment(QFD).

**Learning Outcomes:**

After completion of this unit student will be able to

- Comprehend various terms associated with quality control(L2)
- Elucidate the concept of QFD.(L2)

**Application:**

Identify Manufacturing and write about their quality control techniques used in theorganisation.

## UNIT-II

**Process Capability:** Foundation of process capability, Natural Tolerance limits, Process capability index and Analysis –process performance index.

**Learning Outcomes:**

After completion of this unit student will be able to

- Demonstrate the process capability with an example(L2)
- Illustrate the process performance index(L2)

**Application:**

Observe and study Process capability index in manufacturing company.

## UNIT- III

**Statistical Process Control:** Statistical basis of the Control Charts-principles, choices of control limits, significance of control limits, sample size and sampling frequency, rational subgroups, analysis of pattern on control charts.

**Learning Outcomes:**

After completion of this unit student will be able to

- Recognize statistical concepts related to control charts.(L2)
- Analyzeassignablecausesforvariationsinspecificationsofmanufacturedcomponents.(L4)

**Application:**

Identify assignable causes Quality control in machine shop by analyzing reasons.

**UNIT-IV**

**Control charts for variables and attributes:** Control limits for X and R-Charts, Type I and Type II errors, p chart, c chart construction. Simple Numerical Problems.

**Learning Outcomes:**

After completion of this unit student will be able to

- Construct control charts for variables and attributes(L3)
- Identify type I and type II errors(L3)

**Application:**

Construct control charts related to manufacturing process in an industry.

**UNIT-V**

**Acceptance Sampling:** Fundamental concept in acceptance sampling, Need of acceptance sampling, operating characteristics curve. Producer risk and consumer risk in sampling plans. Acceptance plans, single sampling plan, double sampling plan –exercises.

**Learning Outcomes:**

After completion of this unit student will be able to

- Describe the concepts of acceptance sampling(L2)
- Choose appropriate acceptance sampling plan to minimize producer risk and consumer risk.(L5)

**Application:**

Selection of sampling plan to minimize risk in manufacturing units.

**TEXT BOOKS:**


1. Statistical Quality Control. M. S. Mahajan, Dhanpat Rai Publishing Co Pvt Ltd
2. Statistical Quality Control – R.C. Gupta– Khanna Publishers, Delhi


**REFERENCE BOOKS:**


1. Grant,E,L.and Laven Worth,R.S.:Statistical Quality Control, McGrawHill.
2. Introduction to statistical quality control: By D.C. Montgomery 4th Edition, John Wiley &Sons.Inc.
3. Multivariate Q C in Encyclopedia of statistical sciences, Vol. 6: Edited by WL Johnson,S Kotz, John Wiley,N.Y.
4. Quality Control and Industrial Statistical: By A J Duncan, 5th Edition, Irwin, Homewood, Ille.
5. Principle of Quality Control: By Jery Banks, John Wiley.

**WEBLINKS**

1. https://nptel.ac.in/courses/112/107/112107259/- Inspection and Quality control manufacturing.
2. http://www2.ing.unipi.it/lanzetta/stat/Chapter20.pdf
3. https://www.youtube.com/watch?v=qb3mvJ1gb9g
4. https://freevideolectures.com/course/4539/nptel-operations-management/49?_cf_chl_managed _tk_=pmd

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20MEC-PE3101.1 | Nuclear and Advanced Power Generation Technology (**Professional Elective–I**) | 3 | 0 | 0 | 3 |

**Course Objective:**

The objectives of the course are to

- To Familiarize students with various areas of power generation
- To Acquaint students with the operation of power plant
- To educate students with safety & environmental concepts
- Learn about equipment, plant structure and operating principles of various types of powerplants
- Learn various cutting-edge technologies in power plants

**Course Outcomes:**

At the end of the course, the student will be able to

1. ***understand*** the types of sources available to generate power (L2).
2. ***describe*** the nuclear power plant main components & its operation (L1).
3. ***analyze*** the methods to improve the performance of gas turbines (L4).
4. ***explain*** the methods to improve the performance with combined cycle power plant (L1).
5. ***learn*** advance technologies in power generation (L1).

**UNIT-I**

**Nuclear Power Station:** Introduction, Nuclear power station in India, India's 3-Stage Programme for Nuclear power development**,** Nuclear Fuel –Nuclear Fission, Chain Reaction, Breeding and Fertile Materials-Nuclear Reactor – Components-Operation.
**Types of Reactors:** Different types of Reactors, Pressurized Water Reactor, Heavy water-cooled and Moderated CANDU (Canadian-Deuterium Uranium) Boiling Water Reactor, Gas Cooled Reactor.

**Applications:** Nuclear power plant

**Learning Outcomes**
At the end of this unit, the student will be able to

1. ***classify*** types of power plants based on their applications (L4).
2. ***identify*** different types of reactors used in a power plant (L1).

**UNIT-II**

**Nuclear Materials:** Introduction, Fuels, Cladding and Structural Materials coolants, Moderating and Reflecting Materials, Control Rod Materials, Shielding Materials
**Nuclear Waste & its Disposal:** Introduction, Radiation Hazards, Types of Nuclear waste,Effect of Nuclear Radiation, Radioactive waste disposal system, Gas disposal system **Applications:** Nuclear waste Management, Nuclear power plant

**Learning Outcomes**
At the end of this unit, the student will be able to

1. ***summarize*** the importance of materials used in nuclear power plant (L2).
2. ***explain*** the need for disposing the nuclear waste (L2).

**UNIT-III**

**Gas Turbine Plant:** Introduction - Classification - Construction - Layout with Auxiliaries - Principles of Working Closed and Open Cycle Gas Turbines. Regeneration, reheating, intercooling, components of Gas turbine plant-compressor, combustion chamber, Turbine, Gas turbine.

**Applications:** Gas Power plants, Aircraft engine

**Learning Outcomes:**
At the end of this unit, the student will be able to
1. ***classify*** various types of gas turbine plants along with their schematic layout (L4).
2. ***analyze*** the effect adding on auxiliaries to the plants (L4).

**UNIT- IV**

**Combined cycle (CC) Power Plants:** Limitations of steam turbine (ST) and gas turbine power plants (GT), Combined Brayton and Rankine cycle and GT-ST Plants; Advantages of CC Plants, storage type hydro-electric plant in combination with steam plant, run-of-river plant in combination with steam plant, pump storage plant in combination with steam or nuclear power plant, co- ordination of hydro-electric and gas turbine stations, co-ordination of hydro-electric and nuclear power stations, co-ordination of different types of power plants.
**Applications:** combined cycle power plants

**Learning Outcomes**
At the end of this unit, the student will be able to
1. ***illustrate*** the different combinations of various power plants (L3)
2. ***analyze*** the effect of various combinations of power plants in enhancing the efficacy (L4).

**UNIT- V**
**Futuristic Technologies:** Fuel cells; MHD-Steam Power plant, Thermo electric steam plant,Thermo ionic steam plant

**Applications:** Conventional and un-conventional energy sources

**Learning Outcomes**
At the end of this unit, the student will be able to
1. ***illustrate*** the futuristic technologies in power generation (L3).
2. ***describe*** the various energy conversion systems (L1).

**TEXTBOOS**

1. P.K.Nag, Power Plant Engineering,3/e, TMH.
2. Aroraand S.Domkundwar, A course in Power Plant Engineering, Dhanpat Rai&Co (P)Ltd.


**REFERENCEBOOKS**

1. Rajput, A Textbook of Power Plant Engineering,4/e, Laxmi Publications.
2. Ramalingam, Power plant Engineering, Scietech Publishers.
3. P.C. Sharma, Power Plant Engineering, S.K. Kataria Publications.

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20MEC-PE3101.2 | Automobile Engineering<br>(**Professional Elective–I**) | 3 | 0 | 0 | 3 |

**Course Objectives**

The objectives of the course are

- To understand the power transmission systems
- To understand steering geometry and classification of steering gear mechanisms.
- To create awareness on suspension system, braking system, and electrical system.
- To follow the safety standards and emissions controlling methods.

**Course Outcomes**

After completing the course, the student will be able to

- ***illustrate*** the construction features of automobile engines and parts.[ L2]
- ***analyze*** parts/modules in transmission system. [ L4]
- ***explain*** types of steering mechanisms.[ L2]
- ***outline*** the working /features of suspension, braking and electrical systems. [L2]
- ***analyze*** the methods for emission control of engine. [ L4]

**UNIT-I**

**Introduction To Automobile and Engine Construction :** Layout of four wheeler automobile - Chassis and body - –Power unit – power transmission – rear wheel drive, front wheel drive, 4 wheel drive – types of automobile engines, engine construction details, turbo charging and super charging- valve mechanisms-types– engine lubrication, splash and pressure lubrication systems, oil filters– crank case ventilation –cooling system –types

**Applications:** Automobile vehicles

**Learning Outcomes:**

At the end of this unit the student will be able to

- ***identify*** different types of automobiles.(L3)
- ***explain*** various parts of the engine.(L2)
- ***explain*** the lubrication and cooling system in IC Engines.(L2)

**UNIT-II**

**Transmissionsystem:**Clutches-Function-Types-Singleplate,Multipleplate, Cone clutch and Diaphragm Clutch – Fluid coupling - Gearbox - Sliding - Constant - Synchromesh - Overdrive– Torque converter-Continuously variable transmission-Universal joint-Propeller shaft- Drive types- Differential - rear axles– types – wheels and tyres.

**Applications:** Automobile vehicles, Marine Engines, Aerospace vehicles

**Learning Outcomes:**

At the end of this unit the student will be able to

- ***explain*** clutch functionality and transmission systems.(L2)
- ***understand*** the functionality of differential.(L2)
- ***explain*** the rear axle assembly. (L2)

**UNIT-III**

**STEERING SYSTEM:** Steering geometry – camber, castor, king pin rake, combined angle toe in, center point steering. types of steering mechanism – Ackerman steering mechanism, Davis steering mechanism, steering gears – types, steering linkages**.**

**Application:** Automobile vehicles, Marine Engines, Aerospace vehicles

**Learning Outcomes:**

At the end of this unit the student will be able to

- Explain types of steering mechanisms.[ Level 2]
- Illustrate the steering geometry.(L2)

**UNIT-IV**

**SUSPENSION SYSTEM:** Objects of suspension systems – rigid axle suspension system, torsion bar, shock absorber, Independent suspension system.

**BRAKING SYSTEM:** Mechanical brake system, hydraulic brake system, master cylinder, wheel cylinder tandem master cylinder, pneumatic and vacuum brakes.

**ELECTRICAL SYSTEM: W**iring diagram of 4-wheeler and 2-wheeler, battery construction-ignition types– current regulator - voltage regulator - current - voltage regulator – bendix drive , solenoid switch, Charging circuit, horn circuit, wiper circuit.

**Applications:** Automobile vehicles

**Learning Outcomes:**

At the end of this unit the student will be able to

- ***explain*** the various electrical components in automobile.(L3)
- ***Illustrate*** the components of braking systems.(L3)

**UNIT-V**

**Automobile safety and Emission control:** Safety and security - Seat belts - Air bags - Electronic Control Unit (ECU) - Anti lock brake system (ABS) - Active Suspension System(ASS) - Electronic Brake Distribution (EBD) – Electronic Stability Program(ESP)- Traction Control System (TCS) - Global Positioning System (GPS) - Types of pollutants, mechanism of formation, exhaust gas treatment-thermal and catalytic converters-use of alternative fuels for emission control – National and International pollution standards

**Applications:** Automobile vehicles

**Learning Outcomes:**

At the end of this unit the student will be able to

- Identify the safety systems in automobile.(L2)
- Understand the emission controlling methods.(L3)

**Textbooks:**


1. Kirpal Singh, Automobile Engineering,Vol.1&2, Standard Publications.
2. Automobile engineering by R B Gupta , Satya Prakashan publications (P) Ltd.
3. Richard Stone, Jeffrey K.Ball, Automotive Engineering Fundamentals" SAEInternational.
4. Automobile engineering by R K Rajput-Laxmi publications (P) Ltd.

**Reference Books:**


1. William.H.Crouse,AutomotiveMechanics,10/e Edition, McGraw-Hill.
2. David A. Corolla , Automotive Engineering: Power train, Chassis System and VehicleBody, Butterworth-Heinemann Publishing Ltd.
3. Bosch , Automotive Hand Book, 6/e SAE Publications year.
4. K. Newton and W. Steeds, The motor vehicle, 13/e Butterworth-HeinemannPublishing Ltd.

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20MEC-PE3101.3 | Mechanical Behaviour of Materials (**Professional Elective–I**) | 3 | 0 | 0 | 3 |

**Course objectives:**

The objectives of the course are to

- Explain the structure of material over the effects of mechanical properties.
- Familiarize the defects inside the structure and their effects on the mechanicalproperties.
- Impart knowledge about strengthening mechanisms of materials.
- Analyze mechanisms of failures of materials (fracture, fatigue and creep) and theirrelationship with the different types of stress.
- Familiarize the metallurgical factors affecting creep.

**Course Outcomes:**

At the end of the course, the student will be able to

1. ***analyze*** the structure of the materials and failure modes(L4).
2. ***Explain*** the grain size and solid solution strengthening(L2)
3. ***understand*** different types of fractures of materials (L2).
4. ***determinate*** of fatigue behavior of materials(L5)
5. ***understand*** the creep behavior in different materials (L2)

**UNIT– I**

**Elastic and plastic behavior**: Elastic behavior of materials–Hooke's law, plastic behavior: dislocation theory – Burger's vectors and dislocation loops, dislocations in FCC, HCP and BCC lattice, stress fields and energies of dislocations, forces on and between dislocations, slip and twinning.

**Application**: In construction purposes, analysis of various structures like bridges, columns, pillars, beams etc

**Learning outcomes:**

At the end of this unit ,the student will be able to

- ***explain*** the elastic behavior of engineering materials (L2).
- ***Explain*** the dislocation theory(L2)
- ***understand*** the forces in between dislocations(L5).

**UNIT–II**

**Strengthening mechanisms**: Cold Working, Grain Size Strengthening, Solid Solution Strengthening, Martensitic Strengthening, Precipitation Strengthening, Dispersion, Strengthening, Fibre Strengthening, Examples. Yield Point Phenomenon, Strain aging and Dynamic strain aging.

**Application**: In construction of stronger bridges and structures it is necessary to have a strong frame that can support high tensile or compression load and resist plastic deformation.

**Learning outcomes:**

At the end of this unit, the student will be able to

- ***describe*** various strengthening mechanisms(L2)
- ***discuss*** grain size and solid solution strengthening (L2).
- ***Compare*** strain aging and dynamic strain aging (L2).

**UNIT–III**

**Fracture and fracture mechanics:** Types of Fracture, Basic Mechanism of Ductile andBrittle Fracture, Griffith's Theory of Brittle Fracture, Ductile to Brittle Transition Temperature (DBTT).Fracture Mechanics-Introduction, Modes of Fracture, Stress Intensity Factor,Strain Energy Release Rate, Fracture Toughness.

**Application:** prediction of failure in applied loads, residual loads and Size, shape, locationorientation of crack

**Learning outcomes:**

At the end of this unit, the student will be able to

- ***explain*** the basic mechanism of ductile and brittle fracture (L2).
- ***understand*** the Application of griffith'stheory (L3).
- ***Predict*** factors effecting on DBTT(L2).
- ***Classify*** various modes of fracture(L2).

**UNIT-IV**

**Fatigue behavior and testing:** Stress Cycles, S-N Curves, Effect of Mean Stress, Factors Affecting Fatigue, Structural Changes Accompanying Fatigue, and Cumulative Damage. **Application:** Analysis of Fatigue behavior of fibers in fiber composites as the load bearers arefiber's, Analysis of plastic behavior in metals etc.

**Learning outcomes:**

At the end of this unit, the student will be able to

- ***explain*** the S-N curves for different materials(L2)
- ***analyze*** fatigue behavior of fiber's in fiber composites (L4)

**UNIT-V**

**Creep behavior and testing's:** Creep Curve, Stages In Creep Curve And Explanation, Structural Changes During Creep, Creep Mechanisms, Metallurgical Factors Affecting Creep, High Temperature Alloys, Stress Rupture Testing, Creep Testing Machines.

**Applications:** Stress relaxation in bolts and cable wires, Size must be precise in turbine rotors of jet engines.

**Learning outcomes:**

At the end of this unit, the student will be able to

- ***explain*** the stages in creep curve (L2).
- ***predict*** the metallurgical factors affecting creep(L2).
- ***illustrate*** the working of creep testing machines(L2).

**Textbooks:**


1. Dieter,G.E.," Mechanical Metallurgy",McGraw-Hill,SIEdition.
2. Davis.H.E.,Troxell G.E., Hauck. G.E.W.," The Testing Of Engineering Materials", McGraw-Hill.


**References:**


1. Wulff, The Structure and Properties of Materials, Vol.III" Mechanical Behavior ofMaterials",John Wiley and Sons.
2. Honey Combe R.W.K., "Plastic Deformation of Materials", Edward Arnold Publishers,.
3. Suryanarayana, A. V.K., "Testing of Metallic Materials", Prentice Hall India.

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20MEC-PE3101.4 | Advanced Machining Processes (**Professional Elective–I**) | 3 | 0 | 0 | 3 |

**Course Objectives**

The objectives of the course are to

- Understand idea about nontraditional machining processes
- Illustrate about ultrasonic machining in mechanical processes
- Explain concepts for electrical discharge machining
- Distinguish between chemical machining and electro chemical machining process
- Discuss the working of high energy machining processes

**Course Outcomes**

At the end of the course, the student will be able to

1. ***understand*** the modern manufacturing process with respect to process capability andeconomics(L2)
2. ***explain*** the principles and process parameters of the process based on the mechanicalenergy.(L2)
3. ***illustrate*** the electrical discharge machining processes and applications (L2)
4. ***compare*** the chemical and electrical machining processes(L2)
5. ***describe*** the working principles of high energy machining process(L2)

**UNIT- I**

**Introduction:** Need of Non-Traditional Machining Processes–Classification Based on Energy, Mechanism, source of energy, transfer media and process – Process selection Based on Physical Parameters, shapes to be machined, process capability and economics – Over view of all processes.

**Application:** pharmaceutical industries and fabrication of CNT

**Learning outcomes:**

After completion of this unit, student will be able to

- ***classify*** the non-traditional Machining Processes(L2)
- ***understand*** the source of energy in nontraditional machining process(L2)
- ***explain*** Physical Parameters in nontraditional machining process(L2)

**UNIT-II**

**Mechanical Processes:**

**Ultrasonic Machining**: Principle – Transducer types – Concentrators – Abrasive Slurry– Process Parameters –Tool Feed Mechanism –Advantages and Limitations -Applications. Abrasive Jet Machining: Process- Principle – Process Variables – Material Removal Rate – Advantages and Limitations – Applications. Water Jet Machining: Principle –Process Variables–Advantages and Limitations – Practical Applications–Abrasive water jet machining process.

**Application:**

- Machining very precise and intricate shaped articles.
- Drilling the round holes of any shape.
- Grinding the brittle materials.
- Profiling the holes.

**Learning outcomes:**

After completion of this unit, student will be able to

- ***understand*** the working principle of Ultrasonic Machining(L2)

- ***explain*** working principle for Abrasive Jet Machining(L2)
- ***illustrate*** the working principle of Abrasive water Jet Machining(L2)

**UNIT- III**

**Electrical Discharge Machining:** Electrical Discharge Machining: Mechanism of metal removal–Dielectric Fluid–Flushing methods–Electrode Materials–Spark Erosion Generators – Electrode Feed System – Material Removal Rate – Process Parameters – Tool Electrode Design – Tool wear Characteristics of Spark Eroded Surfaces-Advantages and Limitations – Practical Applications. Electrical Discharge Wire Cut and Grinding: Principle –Wire Feed System–Advantages and Limitations–Practical applications

**Application:** Die making and Mold making

**Learning outcomes:**

After completion of this unit, student will be able to

- ***understand*** the process of Electrical Discharge Machining(L2)
- ***explain*** flushing methods of electrical discharge machining(L2)
- ***elucidate*** advantages, limitations and applications of electrical discharge machine(L2)
- ***illustrate*** working principle Electrical Discharge Wire Cut and Grinding(L2)

**UNIT-IV**

**Chemical And Electro Chemical Machining:** Chemical Machining: fundamentals, Principle

–classification and selection of Etchant - chemical milling, Engraving, Blanking – Advantagesandlimitations–Applications.ElectroChemicalMachining:Electro-chemistryoftheprocess-Electrolytes–ElectrolyteandtheirProperties– MaterialRemovalRate– ToolMaterial–ToolFeedSystem–DesignForElectrolyteFlow– ProcessVariables–Advantages and Limitations – Applications – Electro Chemical Grinding: Honing, cutting off, Deburringand turning.

**Application:** Machining of complex profiles like turbine wheels, turbine and jet blades.

**Learning outcomes:**

After completion of this unit, student will be able to

- ***understand*** the process parameters about Chemical Machining process(L2)
- ***explain*** classification of chemical machining processes and their Applications(L2)
- ***elucidate*** Electrolyte and their Properties of electro chemical machining(L1)
- ***compare*** the features of the finishing processes.(L2)

**UNIT-V**

**High Energy Machining Process:**

**Electron Beam Machining:** Principle –Generation and control of electron beam-Advantagesand Limitations – Applications.

**Plasma Arc Machining**: Principle –Gas mixture– Types of Torches–Process Parameters–Advantages and Limitations –Applications.

**Laser Beam Machining (LBM)-**Principle, Laser system, Construction and operation ofLBM, Laser materials Advantages and disadvantages of LBM.

**Application:**

- custom cosmetic aircraft interior components,
- rocket engines components, combustor liners

**Learning outcomes:**

After completion of this unit, student will be able to

- ***understand*** the process parameters about Electron Beam Machining(L2)

- ***explain*** the applications of laser beam machining(L2)
- ***elucidate*** the process parameters of Laser Beam Machining(L2)

**TEXTBOOKS**

1.P.C Pandey And H.S.Shan,“ Modern Machining Process”,Tata McGraw–Hill Publishing Company Limited, New Delhi.
2.V.K.Jain,“Advanced Machining Process”, Allied Publishers Pvt Limited

**REFERENCES**

1.Amithaba Bhattacharyya, “New Technology”, The Institution Of Engineers, India 2.HMT Bangalore,“ Production Technology”, Tata McGraw–Hill Publishing Company
Limited, New Delhi.
3.Hassan El– Hofy“ Advanced machining Processes” MC Graw-Hill.

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20MEC-PC3014 | Metal Cutting and Machine Tools Lab | 0 | 0 | 3 | 1.5 |

**Course objectives:**

The objectives of the course are to

- Explain the devices used for turning, slotting, shaping etc...
- Illustrate the operating parameters of milling machines
- Explain the working of different types of lathe operations

**Course outcomes:**

After completion of this course the student may be able to

1. ***explain*** the lathe working principle and can perform various operations to preparedifferent shapes of products (L2)**.**
2. ***experiment*** with drilling machines and can perform various operations to preparedifferent shapes of products (L3)**.**
3. ***make*** use of shaper, slotting and planning machine and can perform various operationsto prepare different shapes of products (L3)**.**
4. ***explain*** the surface grinding machine and can perform various operations to preparedifferent shapes of products (L2)**.**
5. ***experiment*** with a milling machine, with understanding working principle and canperform various operations to prepare different shapes of products(L3)**.**

**List of Experiments**

1. Facing and Centre Drill Operations on Lathe Machine
2. The Step Turning And Taper Turning Operations on Lathe Machine
3. Thread Cutting And Knurling Operations on Lathe Machine
4. Drilling And Tapping Operations on Radial Drilling Machine Using Aluminum Specimen
5. Make A Rectangular "V" Block on Shaping Machine
6. Make Slots In The Given Hollow Cylinder With Slotting Machine
7. Make A Spur gear on Milling Machine By Using Given Wooden Piece
8. Grind The Surface Of MS Flat Plate on Surface Grinding Machine
9. Perform Straight Slots on Planning Machine Using Wooden Specimen
10. Grind The Single Point Cutting Tool on Tool End Cutter Machine
11. Cutting force measurement using Tool Dynamometer

**Note : Any 10 Experiment from above list**

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20MEC-PC3105 | Thermal Engineering Lab | 0 | 0 | 3 | 1.5 |

**Course objective:**

To provide hands-on experience in operating various types of internal combustion engines andunderstand their functioning and performance.

**Course Outcomes:**

After completion of this lab the student will be able to

1. ***Draw*** the valve and port timing diagram of SI engine & CI engine(L2)
2. ***conduct*** performance test on IC engines & Reciprocating compressors.(L3)
3. ***analyze*** the heat energy distribution using heat balance sheet for twin cylinder C.I engine.(L4)
4. ***calculate*** the frictional power of an IC Engine. (L3)
5. ***find*** the Economical speed of the engine. (L3)

**LISTOFEXPERIMENTS:**

1. Draw the Valve timing diagram of4-Stroke CI engine.
2. Draw the port timing diagram of 2-stroke SI engine.
3. Find different performance parameters of twin cylinder 4-Stroke CI engine withhydraulic dynamometer loading by conducting load test on it.
4. Find FP by conducting Retardation test on the four stroke CI engine.
5. Prepare the heat balance sheet on twin cylinder 4-Stroke CI engine with hydraulicdynamometer loading.
6. Find FP by conducting motoring test on 4-StrokeSI engine.
7. Find different performance parameters of variable compression ratio engine byconducting load test on it.
8. Find different performance parameters of two stage reciprocating air compressor byconducting load test on it.
9. Calculate the economical speed by conducting Economical speed test on 4-stroke multicylinder SI engine.
10. Find FP by conducting Morse test on 4-stroke multi cylinder SI engine.

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20MEC-MC3101 | 3D Printing Technology | 2 | 0 | 0 | 0 |

**Course Objectives:**

This course will enable students to

1. To exploit technology used in 3D prinitng.
2. To understand importance of 3D printing in advance manufacturing process.
3. To acquire knowledge, techniques and skills to select relevant 3D Printing process.
4. To explore the potential of 3D Prinitng in different industrial sectors.

**Course Outcomes**

Upon completion of this course, students will be able to

1. ***know*** the importance of 3D printing in Manufacturing (l1)
2. ***understand*** the liquid-based 3D printing system(L2)
3. ***illustrate*** the solid-based 3D printing system (L2)
4. ***explain*** the powder based 3D printing system (L2)
5. ***elucidate*** the **a**pplication 3D printing in medical field (L2)

**UNIT – I**

**INTRODUCTION**

3D Printing, Generic 3D Printing Process, Benefits of 3D Printing, Distinction Between 3D Printing and CNC Machining, Classification of 3D Printing Processes, Metal Systems, Hybrid Systems, Milestones in 3D Printing Development, 3D Printing around the World.

**Learning outcomes:**

At the end of the unit, the student will be able to:

1. ***distinguish*** between 3D printing and CNC Machining (L1)
2. ***classify*** the various 3D printing Processes

**UNIT-II**

**LIQUID-BASED 3D PRINTING SYSTEM**: Stereo lithography Apparatus (SLA): models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages.

**Learning outcomes:**

At the end of the unit, the student will be able to:

1.***understand*** the Basic Principle of Liquid based system.(L2)
2.***explain*** the working process of Stereo lithography .(L2)

**UNIT-III**

**SOLID-BASED 3D PRINTING SYSTEMS**:- Models and specifications, process, working principle, applications, advantages and disadvantages, case studies. Fused deposition modelling (FDM) - models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

**Learning outcomes:**

At the end of the unit, the student will be able to:

1.***elucidate*** the Basic Principle of Solid based systems.(L2)
2.***explain*** the working process of Fused deposition modelling. (L2)

**UNIT – IV**

**POWDER BASED 3D PRINTING SYSTEMS**: Selective laser sintering (SLS): models and specifications, process, working principle, applications, advantages, disadvantages and case studies.

**Learning outcomes:**

At the end of the unit, the student will be able to:

1.***illustrate*** the working principle of 3D printing machine.(L2)
2.***explain*** the working principle of Selective laser sintering.(L2)
3.***explain*** the working principle of Three dimensional printing.(L2)

**UNIT-V**

**MEDICAL APPLICATIONS & FUTURE DIRECTION FOR 3D PRINTING** - Use of 3D Printing to Support Medical Applications, Limitations of 3D Printing for Medical Applications, Further Development of Medical 3D Printing Applications. Use of Multiple Materials in 3D Printing - Discrete Multiple Material Processes, Blended Multiple Material Processes, Commercial Applications Using Multiple Materials, Business Opportunities and Future Directions

**Learning outcomes:**

At the end of the unit, the student will be able to:

1. ***apply*** knowledge of 3D printing for real-life applications.(L2)
2. ***select*** the suitable types of materials used in 3D printing.(L2)

**TEXT BOOK(S):**

1. Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing, Ian Gibson, David W Rosen, Brent Stucker, Springer, 2nd Edition.
2. 3D Printing and Additive Manufacturing: Principles & Applications, Chua Chee Kai, Leong Kah Fai, World Scientific, 4th Edition.

**REFERENCE(S):**

1. Rapid Prototyping: Laser-based and Other Technologies, Patri K. Venuvinod and Weiyin Ma, Springer.
2. Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling, D.T. Pham, S.S. Dimov, Springer.
3. Rapid Prototyping: Principles and Applications in Manufacturing, Rafiq Noorani, John Wiley & Sons.
4. Additive Manufacturing, Second Edition, Amit Bandyopadhyay Susmita Bose, CRC Press Taylor & Francis Group.
5. Additive Manufacturing: Principles, Technologies and Applications, C.P Paul, A.N Junoop, McGrawHill.
6. J.D. Majumdar and I. Manna, Laser-assisted fabrication of materials, Springer Series in Material Science.
7. L. Lu, J. Fuh and Y. S. Wong, Laser-induced materials and processes for rapid prototyping, Kluwer Academic Press.
8. Zhiqiang Fan and Frank Liou, Numerical modeling of the additive manufacturing (AM) processes of titanium alloy, lnTech.

**Online resources:**

1. https://www.nist.gov/additive-manufacturing
2. https://www.metal-am.com/
3. http://additivemanufacturing.com/basics/
4. https://www.3dprintingindustry.com/
5. https://www.thingiverse.com/
6. https://reprap.org/wiki/RepRap

## III YEAR –II SEMESTER

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20MEC-PC3201 | Design of Power Transmission Elements | 3 | 0 | 0 | 3 |

**Course Objectives:**

The objectives of the course are

- To understand the different bearings and their life prediction
- To learn to design curved beams having different cross sections like rectangular,circular, trapezoidal and T-section.
- To design the crane hooks and C-clamps
- To learn the design of main parts of I.C Engine.
- To design the power transmission elements.

**Course Outcomes:**

At the end of the course, student will be able to

1. ***choose*** the suitable bearing depending upon the application and predict life of thatbearing. . (L5)
2. **examine**thecurvedbeamsundertheactionofaxialloadsfordifferentcrosssections.(L4)
3. ***evaluate*** different I.C Engine parts under the action of forces. (L4)
4. ***analyze*** the power transmission using power screws (L4)
5. ***analyze*** the load concentration factor, dynamic load factor, surface compressive strength,bending strength of spur & helical gear drives(L4)

### Unit-I

**Bearings:** Classification of bearings- applications, types of journal bearings – lubrication – bearing modulus – full and partial bearings – clearance ratio – power losses in bearings, bearing materials – journal bearing design – ball and roller bearings design – static and dynamic loading of ball, bearing life.

**Application:** Bearings used in automobiles, turbofans, pumps etc.

**Learning outcomes:**

At the end of the unit, student will be able to

- Identify different types of bearings and its applications. (L3)
- Examine the power losses in bearings due to friction. (L4)
- Analyze the bearing parameters of journal and anti frictional bearing.(L4)
- Determine bearing life and reliability.(L5)

### Unit-II

**Design of Curved Beams:** Introduction, stresses in curved beams, expression for radius of neutral axis for rectangular, circular, trapezoidal and t-section, design of crane hooks, c – clamps.

**Application:** crane hooks, anchor chain links, I-bolts etc.

**Learning outcomes:**

At the end of the unit, student will be able to

- Determine stresses in curved beams for different cross sections.(L5)
- Distinguish various types of threads for different applications.(L4)

### Unit-III

**Internal Combustion Engine Parts:** Construction design and proportions of piston, forces acting on piston, cylinder, cylinder liners. Connecting Rod: Thrust in connecting rod – stress due to whipping action on connecting rod ends–cranks and crankshafts, strength and proportions of overhung and centre cranks–crankpins, crankshafts.

**Application:** All automobile engines.

**Learning outcomes:**

At the end of the unit, student will be able to

- Analyze the automobile components like piston, cylinder, cylinder liners, connecting rodand crankshaft under the action of various forces.(L4)
- Explain the stresses in connecting rod and crankshaft for different loading.(L2)

## Unit-IV

**Design of Power Screws:** Design of screw, square ACME, buttress screws, design of nut, compound screw, differential screw, ball screw, design of screw jack - possible failures of screws and nuts

**Application:** Bolts and nuts, etc.

**Learning outcomes:**

At the end of the unit, student will be able to

- Examine the possible failures of different threads.(L2)
- Design of various power screws.(L4)

## Unit-V

**Spur & Helical Gear Drives:** Spur gears- helical gears – load concentration factor – dynamic load factor, surface compressive strength –bending strength – design analysis of spur gears – estimation of centre Distance, module and face width, check for plastic deformation, check for dynamic and wear considerations.

**Application:** Power Transmissions Systems(Gear box, differential).

**Learning outcomes:**

At the end of the unit , student will be able to

- Analyse load concentration factor and dynamic load factor for gears.(L4)
- Explain the possible for dynamic and wear considerations under loads.(L2)
- Design analysis of spur and helical gears(L4)

**Note: Design data book is permitted for examination**

## Text Books


1. Machine Design/V.Bandari/TMH Publishers
2. Machine Design/NCPandya & CSShaw/ Charotar publishers
3. Design data book/Jalaluddin.


## References


1. Machine Design:An integrated Approach/R.L. Norton/Pearson Education.
2. Design of machine elements/Spots/Pearson Publications
3. Data Books:(i) P.S.G. College of Technology(ii)Mahadevan
4. Mech. Engg. Design/JE Shigley /Tata McGraw Hill education.

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20MEC-PC3202 | Heat Transfer | 3 | 0 | 0 | 3 |

**Course Objectives**

The objectives of the course are

- To impart the basic laws of conduction , convection and radiation heat transfer and theirapplications.
- To familiarize the convective heat transfer concepts.
- To make conversant with the heat transfer analysis related to thermal systems like heatexchangers, evaporator, and condenser.
- To explain basics of radiation heat transfer.

**Course Outcomes**

After completing the course, the student will be able to

- ***understand*** the modes of heat transfer and Steady state conduction (L2)
- ***compute*** the effectiveness and efficiency in extended surfaces. (L3)
- ***analyze*** heat transfer coefficients for forced convections by using empirical relations. (L4)
- ***analyze*** heat transfer coefficients for natural convections, regimes of boiling and mode ofcondensation heat transfer. (L4)
- ***analyze*** heat exchanger performance and radiation heat transfer between black body & graybody surfaces. (L4)

**UNIT-I**

**Introduction:** Modes and mechanisms of heat transfer – basic laws of heat transfer –General discussion about applications of heat transfer.

**Conduction Heat Transfer:** Fourier rate equation – general heat conduction equation in cartesian, cylindrical and Spherical coordinates. Steady, unsteady and periodic heat transfer – initial and boundary conditions.

**One Dimensional Steady State Conduction Heat Transfer:** Homogeneous slabs, hollow cylinders and spheres – overall heat transfer coefficient – electrical analogy – critical radius of insulation.

**Applications:** Heat transfer in cooking utensils, iron boxes, water geysers ,heat transfer through metals

**Learning Outcomes:**

At the end of this unit the student will be able to

- ***identify*** the phenomenon related to different modes of heat transfer(L1)
- ***compare*** different types of conduction heat transfer(L2)
- ***apply*** concept of thermal resistance and its importance in practical problems(L3)

**UNIT-II**

**Extended surface (Fins):** heat Transfer – long fin, fin with insulated tip and short fin, application toerror measurement of temperature.

**One Dimensional Transient Conduction Heat Transfer:** Systems with negligible internal resistance significance of biot and fourier numbers - chart solutions of transient conduction systems.

**Applications:** Radiator used in automobile, Air-cooled I.C. engines, Condensers of Air Conditioners, Electric transformers, Reciprocating air compressors, Electric motors,Heating or cooling of the engines, Heat transfer in buildings in day, Cooling or heating of foods

**Learning Outcomes :**
At the end of this unit the student will be able to

- ***design*** a Fins for a given application(L3)
- ***calculate*** time to reach particular temperature or vise verse, temperature, time history of anylocation in the bodies. (L3)

**UNIT-III**

**Convection:** Basic concepts of convection–heat transfer coefficients - types of convection – forcedconvection and free convection. Significance of non dimensional numbers
**Forced Convection:**
**External Flows:** Concepts about hydrodynamic and thermal boundary layer and use of empirical correlations for convective heat transfer -flat plates and cylinders.
**Internal Flows:** Concepts about hydrodynamic and thermal entry lengths – division of internal flow based on this –use of empirical relations for convective heat transfer- horizontal pipe flow and annulus flow.

**Application:** chimneys fitted in factories, heat transfer in liquids and gases, heat transfer in cooling towers and cooling jackets for reactors.

**Learning Outcomes :**At the end of this unit the student will be able to

- ***apply*** the convective heat transfer principles(L3)
- ***apply*** fluid friction concept to solve convective heat transfer problems.(L3)

**UNIT-IV**

**Free Convection:** Development of hydrodynamic and thermal boundary layer along a vertical plate – use of empirical relations for convective heat transfer- plates and cylinders in horizontal and vertical orientation.

**Boiling**: Different regimes of boiling-nucleate, transition and film boiling.
**Condensation**: film wise and drop wise condensation.

**Application:** free air cooling without the aid of fans; Refrigerant boiling and condensing in Air conditioners and refrigerators, boiling of fluids in chemical industries ,industrial kettles.

**Learning Outcomes:** At the end of this unit the student will be able to

- ***understand*** the natural convection heat transfer(L2)
- ***understand*** the regimes of boiling. (L2)
- ***understand*** the condensation heat transfer(L2)

**UNIT-V**

**Heat Exchangers**: Types of heat exchangers- parallel flow- counter flow- cross flow heat exchangers- overall heat transfer coefficient-LMTD and NTU methods-fouling in heat exchangers.
**Radiation**: Radiation heat transfer – thermal radiation – laws of radiation - Black and Gray bodies – shape factor-radiation exchange between surfaces.

**Applications:** Heat exchangers are used in many engineering applications, such as refrigeration, heating and air-conditioning systems, power plants, chemical processing systems, food processing systems, automobile radiators, and waste heat recovery units.

Heat transfer through vacuum, electromagnetic radiation, heat transfer from campfire, Heat radiated from I.C. Engine, solar radiation.

**Learning Outcomes:** At the end of this unit the student will be able to

- ***explain*** the working of different types of heat exchangers(L2)
- ***calculate*** the rate of heat transfer in heat exchangers(L3)
- ***find out*** the surface area required for a given application(L3)
- ***calculate*** the radiation heat transfer between two bodies(L2)

**Text Books:**


1. Heat and Mass Transfer-R.KRajput, Publishers-S Chand &CoL td.
2. Heat & Mass Transfer-D.S. Kumar, S.K. Kataria& Sons Publishers.
3. Fundamentals of Engineering Heat and Mass Transfer-R.C.Sachdeva, New Age Publications.
4. P.K. Nag, HeatTransfer, 3/e,Tata McGraw-Hill.
5. Heat and Mass Transfer Databook - C.P. Kothandaramanand S. Subramanyan, New AgePublications


**Reference Books:**


1. Heat Transfer- A Practical Approach- Cengel. A. Yunus, Tata McGraw-Hill.
2. Fundamentals of Heat and MassTransfer-F.P.Incropera and D.P.Dewitt, JohnWiley.
3. Heat Transfer- J.P.Holman, Tata McGraw-Hill.
4. A Textbook of Heat Transfer-S.P. Sukhatme, Universities Press.

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20MEC-PC3203 | Mechanical Measurements and Metrology | 3 | 0 | 0 | 3 |

**Course Objectives:**
The objectives of the course are

1. To learn basic principles of measurement systems, errors occurred in measurement systems andmeasurement of displacement
2. To learn the operating principles and working of different instruments used for temperaturepressure, for level, flow and speed measurement
3. To learn the operating principles and working of different instruments used for force, torque andpower and concepts of control systems
4. To learn Inspection of engineering parts with various precision instruments
5. To know the Principles of measuring instruments and gauges and their uses

**Course Outcomes:**
At the end of the course, the student will be able to:

1. ***understand*** the working principles of measuring devices and errors in measurements (L2)
2. ***explain*** the need for limits, fits and tolerances of work parts and design the inspection gauges
3. ***illustrate*** the different methods of measurement of angles and tapers.(L2)
4. ***infer*** the working of comparators, screw thread and gear teeth measuring instruments.(L2)
5. ***identify*** appropriate transducers and devices for the measurement of pressure, speed, force, torque, humidity, acceleration and vibrations. (L3)

**UNIT-I**

Basic Principles of Measurement-Measurement of Displacement, Temperature, Level & Flow Types, generalized configuration and functional descriptions of measuring instruments - examples, Static &dynamic performance characteristics - sources of error, classification and elimination of error. Types of transducers to measure displacement, Types of transducers to measure temperature, Types of transducers for level measurement, Type of transducer for flow measurement

**Learning outcomes:**
1. Understand the Measurement of Displacement, Temperature, Level & Flow (L2)

**Unit -II**
**Measurement of Pressure, Speed, Force, Torque, Power and Humidity**
Principle and working of various low and high pressure measuring instruments, types of Mechanical and electrical tachometers for speed measurement, principles of seismic instruments-vibrometer and accelerometer, Elastic force meters, load cells and torsion meters. Principle of dynamometer-types of dynamometers, humidity introduction , Principle and working of various humidity measuring instruments

**Learning outcomes:**

- Understand the Measurement of Pressure, Speed, Force, Torque, Power and Humidity (L2)

**Unit –III**

**Systems of Limits and Fits-Measurement of Angles and Tapers**

Introduction, normal size, tolerance limits, deviations, allowance, Fits & their types-unilateral and bilateral tolerance systems, hole & shaft basis systems- Interchangeability and Selective assembly. Class &grade of tolerance, Numerical on limits, fit and tolerance. sine bar - sine plate, rollers and spheres used to determine the tapers. Taylor's principle, Design of GO & NO-GO gauges ,Types of limit gauges, Numerical on limit gauge design

**Learning outcomes:**

Students will be able to

- Analyze the design tolerances and fits for selected product quality.(L4)

1. Understand the International standard system of tolerances(L2)
2. Understand the standards of length, angles,(L2)
3. understand the Measurement Of Angles And Tapers(L2)

**Unit IV**

Comparators-Screw Thread & Gear Teeth Measurement

Comparators – types and their uses in mass production. Flat surface measurement: surface plates - optical flat and autocollimator. Screw thread measurement: errors in screw thread , Measurement of effective diameter, angle of thread and thread pitch, Gear measuring instruments, Gear tooth profile measurement, Measurement of diameter, pitch pressure angle and tooth thickness, Coordinate Measuring Machines- Types of CMM, blue light scanning, white light scanning, Role of CMM, and its applications

**Learning outcomes:**

Students will be able to

1.understand the Measurement of flatness of surfaces(L2)

2.Describe The Different Types Of Interferometry And Their Applications (L2)

3.Choose appropriate method and instruments for inspection of various gear elements and threadelements.(L2)

4.Explain errors in screw threads-concept of virtual effective diameter, measurement ofeffective diameter(L2)

5.Understand the different types of comparators and their uses(L2)

**UNIT-V**

**Applied mechanical measurement:**

Measurement of force, Torque, Pressure, Types of Dynamometers, Absorption dynamometer, Prony brake and Rope brake dynamometer, and Power Measuring Instruments. Use of elastic members, Bridgeman gauge, McLeod gauge, Pirani gauge.

**Learning outcomes:**

Students will be able to

1. Understand the Measurement of force, Torque, Pressure (L2)
2. Understand the different types of Dynamometers (L2)

**Textbook (s)**

1. N V Raghavendra and Krishnamurthy, Engineering Metrology and Measurement, Oxford University Press, Reprint edition, 2018
2. D.S. Kumar, Mechanical Measurement & Control, Metropolitan Book Co. (P) Ltd, 5th reprintedited, 2015
3. R. K. Rajput, Mechanical Measurements and Instrumentation, S.K. Kataria& Sons, 2nd edition,2015

**Reference (s)**

1. R. K. Jain, Mechanical and Industrial Measurements: Process Instrumentation and Control, KhannaPublishers, 12th reprint edition, 2018
2. Beckwith, Thomas G., Marangoni, Roy D., Lienhard V, John H., Mechanical Measurements, 6thEdition, Prentice Hall, 10th reprint, 2018
3. I.C. Gupta, Engineering Metrology, Dhanpat Rai and Sons, 10th edition, 2017
4. R. K. Jain, Engineering Metrology, Khanna Publishers, 20th edition, 2017
5. M.Mahajan, A Textbook Of Metrology, Dhanpat Rai & Co, 17th edition, 2017

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20MEC-PE3201.1 | CAD/CAM<br>**( Professional Elective-II)** | 3 | 0 | 0 | 3 |

**Course Objectives:**

The objectives of the course are to

- Familiarize the important elements of CAD/CAM, geometric representation and transformations.
- Introduce the various parametric representations of curves and surfaces in geometric modelling.
- Impart knowledge related to methods and techniques in geometric modeling of solids in CAD.
- Create awareness among the students with numerical control (NC), computernumerical control (CNC) and direct numerical control (DNC) machines.
- Understand the principles and concepts of robotics and various elements of Computer Integrated Manufacturing (CIM).

**Course Outcomes:**

At the end of the course, the student will be able to:

1. ***Apply*** the basics of geometric transformations for image processing.(L3)
2. ***Illustrate*** various geometric modeling methods for building CAD models.(L2)
3. ***understand*** the concepts of parametric representation to curves and surfaces (L2)
4. ***apply*** the coding system for CNC programming.(L3)
5. ***explain*** the significance of Group Technology and Computer Integrated Manufacturing inautomated systems.(L2)

**UNIT-I**

**CAD/CAM:** Introduction, hardware and software, I/O devices, benefits. Graphics standards-Neutral file formats–IGES,STEP.

**2D and 3D geometric transformations:** Translation, scaling, rotation, mirroring, homogeneous transformations, concatenation of transformations, viewing transformations.

**Applications:** Used for image registration and the removal of geometric distortion.

**Learning Outcomes:**

At the end of this unit, the student will be able to

- ***explain*** various input and output devices(L2)
- ***understand*** geometric transformations in 2D and 3D(L2)

**UNIT-II**

**Geometric Modelling:**
**Parametric representation:** Representation of curves, Hermite curves, Spline, Bezier and B- spline curves in two dimensions; Geometric modelling of surfaces: Surface patch, Coons and bicubic patches, Bezier and B-spline surfaces, sweep surfaces, surface of revolution, blending of surfaces.
**Applications:** Used in design engineering and manufacturing for geometric modeling application
(industrial design) and geometric modeling systems(CAD systems).

**Learning Outcomes:**
At the end of this unit, the student will be able to

1. ***explain*** the concepts of parametric representation to curves and surfaces.(L2)
2. ***understand*** the surfaces such as Coons, Bezier and B-spline (L2)

**UNIT-III**

**Geometric Modelling of solids:**
Geometric Modelling of Solids: Wireframe, surface modelling, solidentities, Boolean operations,CSG approach and B-rep of solid modelling, geometric modeling of surfaces.

**Applications:** Used to help design engineers to view the part / object as if it was reallymanufactured. The CAD software can even change the perspective and viewing angles.

**Learning Outcomes:**
At the end of this unit, the student will be able to

1. ***apply*** the concepts of parametric representation to curves and surfaces. (L3)
2. ***develop*** Surfaces Such As Coons, Bezier And B-Spline(L3)
3. ***differentiate*** wireframe, surface and solid modeling(L4)

**UNIT- IV**

**Computer Aided Manufacturing (CAM):**Structure of numerical control (NC) machinetools,designationofaxes,drivesandactuationsystems,feedbackdevices,computernumeri calcontrol(CNC)anddirectnumericalcontrol(DNC),adaptivecontrolsystem,functionsofCNC andDNC systems.
**Part Programming:** Part programming instruction formats, information codes, preparatory functions, miscellaneous functions (G-codes, M-codes). Tool codes and tool length offset, interpolations canned cycles.

**Applications:** Helpingdesignengineerstoviewthepart/objectasifitwasreallymanufactured. The CAD software can even change the perspective and viewing angles

**Learning Outcomes:**
At the end of this unit, the student will be able to

1. ***explain*** about various devices and activation systems.(L2)
2. ***apply***theFundamentalsandusevariouscodesofpartprogramminginCNC.(L3)

**UNIT- V**

**Group Technology:** Part family, coding and classification, production flow analysis, types andadvantages. Computer aided processes planning–importance, types.
**Computerintegratedmanufacturing(CIM):**ElementsofCIM,VirtualReality(VR),Aug mented Reality (AR), Artificial Intelligence (AI) and expert systems in CIM.

**Applications:** Group Technology is used in design standardization, manufacturing cell layouts,process planning, purchasing, and manufacturing technology systems design.

**Learning Outcomes:**
At the end of this unit, the student will be able to

1. Understand the elements of computer integrated manufacturing (L2)
2. Explain the part coding in group technology (L2)

**Textbooks:**


1. P.N. Rao, CAD/CAM: Principles and applications, 3/e, Tata McGraw-Hill, Delhi.
2. Ibrahim Zeid, R.Siva Subramanian, CAD/CAM: Theory and Practice, 2/e, TataMcGraw-Hill, Delhi.


**Reference books:**


1. MikellP.Groover,EmoryW.Zimmers,CAD/CAM,5/e,PearsonPrenticeHallofIndia, Delhi.
2. P.Radhakrishnan,S.Subramanyan&V.Raju,CAD/CAM/CIM,3/e,NewAgeInternati onalP ublishers
3. Computer Aided Manufacturing, 3/e, Tien Chien Chang, Pearson.

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20MEC-PE3201.2 | Composite Materials<br>**( Professional Elective-II)** | 3 | 0 | 0 | 3 |

**Course objectives:**

The objectives of the course are to

- Understand the composite materials and their applications.
- Understand the different manufacturing methods available for composite material.
- Create awareness among the students in preparation of composites like MMCs, PMCs,CMCs.
- Explain the behavior of constituents in the composite materials.
- Build proper background for stress analysis in the design of composite structures.
- Focus on Advances in biodegradable composites.

**Course Outcomes:**

At the end of this course, the student will be able to

1. ***Explain*** the practical applications of composites.(L2)
2. ***illustrate*** the methods of the polymer matrix composites.(L2)
3. ***outline*** the types of metal matrix composite.(L2)
4. ***summarize*** the types of ceramic matrix materials.(L2)
5. ***Illustrate*** the Properties and applications of bio- degradable composites.(L2)

**UNIT-I**

**Introduction to composites:** Fundamentals of composites– Definition –classification– basedonMatrix–basedonstructure–Advantagesandapplicationsofcomposites-Reinforcement – whiskers – glass fiber – carbon fiber - Aramid fiber – ceramic fiber – Properties and applications **Learning Outcomes:**

At the end of this unit, the student will be able to

- Explain the fundamentals of composites.(L2)
- Classify the composites based on matrix and structure.(L2)
- Illustrate the practical applications of composites.(L2)
- Summarize the properties and advantages of rein for cement materials.(L2)

**Applications:**

Space craft: Antenna structures, solar reflectors, Satellite structures, Radar, Rocket engines, etc.

**UNIT–II**

**Polymer matrix composites:** Polymers - Polymer matrix materials – PMC processes – hand layup processes – spray up processes – resin transfer moulding – Pultrusion – Filament winding

– Auto clave based methods - Injection moulding – sheet moulding compound –properties and applications of PMCs.

**Learning Outcomes:**

At the end of this unit, the student will be able to

- Explain the properties of polymer matrix composites.(L2)

- Illustrate the polymer matrix composites. (L2)
- Explain various process used in making the polymer matrix composites.(L2)
- Discuss the auto clave based methods.(L2)

**Applications:**

Aerospace, automobile, sporting goods, medical implants, reciprocating industrial machinery, storage and transportation of corrosive chemicals, and military vehicles and weapons.

**UNIT-III**

**Metal matrix composites:** Metals - types of metal matrix composites – Metallic Matrices. Processing of MMC – Liquid state processes –solid state processes – In situ processes. Properties and applications of MMCs.

**Learning Outcomes:**

At the end of this unit, the student will be able to

- ***outline*** the various types of metal matrix composite.(L2)
- ***explain*** liquid state processes and solid state processes in MMCs preparation. (L2)
- ***explain*** Insitu processes.(L2)
- ***summarize*** the properties and applications of MMCs.(L2)

**Applications:** Aircraft structures, spacecraft structures

**UNIT-IV**

**Ceramic matrix composites:** Processing of CMCs –Sintering - Hot pressing – Infiltration – Lanxide process – In situ chemical reaction techniques – solgel polymer pyrolsis –SHS - Cold isostatic pressing (CIPing) – Hot isostatic pressing (HIPing). Properties andApplications of CCMs.

**Learning Outcomes:**

At the end of this unit, the student will be able to

- ***summarize*** the various types of ceramic matrix materials.(L2)
- ***explain*** the sintering, hot pressing, infilatration and lanxide process.(L2)
- ***compare*** between cold and hot isostatic pressing.(L2)
- ***summarize*** the properties and applications of CCMs.(L2)

**Applications:**

Gas turbines components (combustion chambers, stator vanes and turbine blades), Rocketengines, Components for burners, Flame holders, Hot gas ducts

**UNIT-V**

**Advances in composites:** Advantages of carbon matrix – limitations of carbon matrixcarbonfibre– chemicalvapourdepositionofcarbononcarbonfibreperform.PropertiesandapplicationsofCarbon- carboncomposites.

**Biodegradability:** introduction of biocomposites, classification, processing of biocomposites, applications of biocomposites

**Learning Outcomes:**

At the end of this unit, the student will be able to

- ***elucidate*** the Properties and applications of Carbon-carbon composites.(L2)
- ***explain*** the Advantages and limitations of carbon matrix carbon fibre. (L2)
- ***illustrate*** composites for aerospace applications. (L2)
- ***classify*** the bio- degradable composites. (L2)

**Applications:** Aerospace, Biomedical, Automobile Engineering.

**Textbooks**


1. Chawla K.K, Composite materials,2/e,Springer–Verlag,1998.
2. Materials Science and Engineering: An Introduction – William D Callister Jr
3. Mathews F.L. and Rawlings R.D., Chapman and Hall, Composite Materials: Engineering andScience, 1/e, England,1994.


**References**


1. ASM Handbook Volume 2 Composites
2. HK Shivan and, BVBabu Kiran, Composite Materials, ASIANBOOKS, 2011.
3. A.B.Strong, Fundamentals of Composite Manufacturing, SME,1989.
4. S.C.Sharma, Composite materials, NarosaPublications,2000.
5. Maureen Mitton, Hand Book of Bioplastics & Biocomposites for Engineering applications, JohnWiley publications.

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20MEC-PE3201.3 | Production Planning &Control<br>**( Professional Elective-II)** | 3 | 0 | 0 | 3 |

**Course objectives:**

The objectives of the course are

- To understand the characteristics of production and service systems.
- To Apply principles and techniques in the development of integrated systems
- To understand the challenges faced by the production manager in manufacturing and serviceorganizations
- To Identify different strategies employed in manufacturing and service industries to controlinventory.
- To apply scheduling methodology in mass production and job order production systems
- To Understand the concepts of dispatching and methods of dispatching .

**Course outcome:**

At the end of the course, the student will be able to

1. ***Summarize*** the production planning and control functions.(Level 2)
2. ***Apply*** quantitative techniques for demand forecasting in manufacturing firms. (Level3)
3. ***Compare*** inventory management systems applicable to optimize cost to controldifferent types of inventories. (Level 4)
4. ***Analyze*** factors affecting in preparation of route sheets to make the product. (Level 4)
5. ***Evaluate*** Scheduling methodologies applicable to job order and mass productionsystem. (Level 4)
6. ***Illustrate*** the Dispatching procedure (Level 2)

**UNIT–I**

Introduction: Definition – characteristics of production systems, layouts used, objectives and functions of production planning and control — organization of production planning and control department–internal organization of department.

**Learning outcomes**

After completion of this unit, students will be able to

- Understand the functions of production planning and control (L2)
- Compare the characteristics of the production systems(L2)

**UNIT–II**

Forecasting – importance of forecasting – types of forecasting, their uses– Quantitative Forecasting technique: Least Square Method, Exponential Smoothing Method, Moving Average Method, Seasonal forecasting. Errors in forecasting methods, Qualitative Forecasting technique: opinion survey method, executive opinion method, customer and distributor survey method, marketing trails method, market research method and Delphi method.

**Learning outcomes:**

After completion of this unit, students will be able to

- Explain qualitative and quantitative methods of forecasting (L2)
- Develop regression equation for demand forecasting(L3)

**UNIT–III**

Inventory management – functions of inventories – relevant inventory costs – Selective control methods-ABC analysis –VED analysis –EOQ model–exercises, Inventory control systems–P–Systems and Q-Systems, MRP I, MRP II, ERP, JIT and KANBAN systems

**Learning outcomes:**

After completion of this unit, students will be able to

- ***explain*** the functions of inventories(L2)
- ***illustrate*** the applications of P–Systems and Q-Systems. (L2)

**UNIT–IV**

Routing: Definition – routing procedure – route sheets – bill of material –factors affecting routing procedure, schedule – definition – difference with loading.

Scheduling: Scheduling in mass production system, Line Balancing, Scheduling in jobproduction system, n jobs-2machines, n jobs-3 machine problems.

**Learning outcomes:**

After completion of this unit, students will be able to

- ***understand*** routing procedure (L2)
- ***differentiate*** loading and scheduling. (L4)
- ***explain*** various scheduling methods. (L2)

**UNIT–V**

Dispatching – dispatching procedure – dispatching rules- Mean flow time, mean lateness of the job orders, follow up and controlling aspects ,applications of software modules in production planning and control.

**Learning outcomes:**

After completion of this unit, students will be able to

- ***understand*** the activities of dispatching (L2)
- ***explain*** the dispatching rules (L2)
- ***explain*** the application of software modules in production planning and control(L2)

**Text Books:**


1. Elements of Production Planning and Control/Samuel Eilon / Universal Book Corp.
2. Production and *Operations Management*. R. *Panneerselvam*,. Prentice Hall India Pvt. Ltd.


**References:**


1. Inventory Control Theory and Practice/ MartinK. Starr and David W.Miller/Prentice-Hall
2. Production Planning and Control/ Mukhopadyay/ PHI.
3. Production Control/ Franklin G Moore & Ronald Jablonski/ Mc-Graw Hill
4. Production and Operations Management/Ajay K Garg /Mc Graw Hill

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20MEC-PE3201.4 | Refrigeration and Air conditioning<br>**( Professional Elective-II)** | 3 | 0 | 0 | 3 |

**(Refrigeration and Psychometric tables and charts allowed)**

**Course Objective:**

The students will acquire the knowledge

1. To illustrate the operating cycles and different systems of refrigeration
2. To analyze cooling capacity and coefficient of performance of vapour compression refrigerationsystems and understand the properties of refrigerants
3. To identify VCR system components and calculate coefficient of performance by conducting teston vapour absorption and steam jet refrigeration systems
4. To calculate cooling load for air conditioning systems and identify the requirements of comfortair conditioning
5. To describe different component of refrigeration and air conditioning systems

**Course Outcomes:**

At the end of the course, the student will be able to

1. ***Illustrate*** the operating cycles and different systems of refrigeration (L2)
2. ***Analyze*** coefficient of performance of vapour compression Refrigeration systems (L3)
4. ***calculate*** coefficient of performance by conducting test on vapour absorption and steam jetrefrigeration systems (L3)
5. ***solve*** cooling load for air conditioning systems and the requirements of comfort airconditioning. (L2)
6. ***explain*** different component of refrigeration and air Conditioning systems. (L2)

**UNIT– I**

**Introduction To Refrigeration:** Necessity and applications–unit of refrigeration and C.O.P. – Mechanical refrigeration –types of ideal cycles of refrigeration. Air refrigeration: bell Coleman cycle - open and dense air systems – refrigeration systems used in air craft's and problems**.**

**Application:** Aerospace industries

**Learning Outcomes**

At the end of this unit, the student will be able to

- ***examine*** the applications of refrigeration.(L4)
- ***analyze*** various refrigerating cycles(L4)
- ***evaluate*** the performance of various cycles.(L5)

**UNIT–II**

**Vapour Compression Refrigeration:** Working principle and essential components of the plant – simple vapour compression refrigeration cycle – COP – representation of cycle on T- Sand p-h charts – effect of sub cooling and super heating – cycle analysis – actual cycle influence of various parameters on system performance–use of p-h charts – numerical problems.

**Application:** Industries, Aerospace etc.

**Learning Outcomes:**
At the end of this unit, the student will be able to

- ***explain*** working principle of VCR.(L2)
- ***explain*** representation of cycle on T-S and p-h charts.(L2)
- ***evaluate*** the performance of VCR.(L5)
- ***examine*** various parameters in sub-cooling and superheating.(L4)

**UNIT-III**

**Refrigerants**–Desirable properties–classification- refrigerants used –nomenclature – Ozone depletion– global warming

**VCR System Components:** Compressors–general classification–comparison–advantages and disadvantages. Condensers–classification–working principles evaporators–classification – working principles expansion devices – types – working principles **Application:** Industries, Domestic refrigerators etc.

**Learning Outcomes**
At the end of this unit, the student will be able to

- ***examine*** Desirable properties of refrigerant.(L4)
- ***discuss*** ozone depletion–global warming.(L6)
- ***list out*** various advantages and disadvantages of VCR..(L2)
- ***explain*** working principle of evaporators and expansion devices.(L2)

**UNIT-IV**

**Vapor Absorption System:** Calculation of maximum COP – description and working ofNH3–water system and Li Br–water (Two shell &Four shell) System, principle of operation three fluid absorption system, salient features.
**Steam Jet Refrigeration System:** Working Principle and basic components. Principle and operation of (i) thermoelectric refrigerator (ii) vortex tube.

**Application**: Industries, Domestic refrigerators etc.

**Learning Outcomes**
At the end of this unit, the student will be able to

- ***classify*** various absorption refrigeration cycles. (L4)
- ***explain*** working principle of VAR.(L2)
- ***determine*** the COP of VAR.(L5)
- ***explain*** working principle of steam jet and thermo electric refrigerator and vortextube.(L2)

**UNIT– V**

**Introduction To Air Conditioning:** Psychometric properties & processes – characterization of sensible and latent heat loads — need for ventilation, consideration of infiltration – load concepts of RSHF,GSHF-problems, concept of ESHF and ADP temperature.
**Air Conditioning Systems:** Classification of equipment, cooling, heating ,humidification and dehumidification, filters, grills and registers, fans and blowers.

**Application:** Industries, Domestic Air-conditioning systems etc.

**Learning Outcomes**

At the end of this unit, the student will be able to

- ***examine*** Psychometric properties & processes.(L4)
- ***evaluate*** sensible and latent heat loads.(L5)
- ***evaluate*** RSHF,GSHF, ESHF and ADP temperature(L5)
- ***explain*** working principle of air conditioning systems. (L2)

**Text Books:**


1. ACourseinRefrigerationandAirconditioning/SCArora&Domkundwar/Dhanpatrai
2. Refrigeration and Air Conditioning/CPArora/TMH.


**References:**


1. Refrigeration and Air Conditioning/Manohar Prasad/New Age.
2. Principles of Refrigeration/Dossat /Pearson Education.
3. Basic Refrigeration and Air-Conditioning/Ananthanarayanan/TMH Course

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20CSE-OE3201.1 | **Internet of Things(IOT)**<br>**(OPEN ELECTIVE -II)** | 3 | 0 | 0 | 3 |

**Course Objectives:**
Faculty are going to
1. Introduce the basic terminology and functions of Internet of things.
2. List the connectivity and networking of devices in IoT.
3. Show the development of a Arduino and raspberry Pi based systems.
4. Provide the data processing in a IoT system.
5. List the domains and case studies in extended IoT systems.

**Course Outcome**s:
At the end of the Course, the Student will be able to:
1. Summarize the IoT characteristics, principles and design methodology. (L2)
2. Examine the typical connectivity and networking protocols typically used in a IoT design. (L4)
3. Demonstrate design and development of embedded applications using Arduino and Raspberry Pi platforms. (L3)
4. Recognize the importance of data processing and cloud services for IoT. (L2)
5. Illustrate the different domains and applications of IoT eco-system. (L4)

**UNIT-I**

**Introduction to Internet of Things:** Definition & Characteristics of IoT, Physical design of IoT, Logical Design of IoT, IoT Enabling Technologies, IoT Levels & Deployment Templates, M2M, Difference between IoT and M2M, SDN and NFV for IoT.
**IoT platforms design methodology:** purpose & requirement specification, process specification, domain model specification, information model specification, service specifications, IoT level specification, functional view specification, operational view specification, device & component integration, application development.

**Learning Outcomes:**
At the end of the unit, the student will be able to
1. Explain the Characteristics of IoT. (L2)
2. Explain the physical design and logical design of IoT. (L2)
3. Understand IoT and Machine to machine communication differences and working. (L2)
4. Show the typical IoT design methodology. (L2)

**UNIT-II**

**Networking and Connectivity Technologies:** Connectivity terminology, gateway prefix allotment, impact of mobility on addressing, multihoming, deviations from regular web, IoT identification and data protocols- IPv4, IPv6, MQTT, CoAP, XMPP, AMQP. Connectivity technologies- IEEE 802.15.4, Zigbee, 6LoWPAN, RFID, NFC, Bluetooth, Z-wave.

**Learning Outcomes**:
At the end of the unit, the student will be able to

1. list the challenges and requirements in networking of IoT systems. (L2)
2. analyze the connectivity technologies for device communication. (L4)
3. examine the different networking protocols for IoT requirements. (L4)

**UNIT-III**

**Basics of Arduino and Raspberry Pi:**
Sensor classification, working principle of sensors, criteria to choose a sensor, generation of sensors.
**Arduino:** Introduction to Arduino, Arduino Uno, Arduino Mega, Arduino Nano, Arduino IDE, Steps to Install Arduino IDE, Basic Commands for Arduino, LCD Commands, Serial Communication Commands Programming with Arduino, working with analog Input.

**Raspberry Pi:** Basics of Raspberry Pi, Introduction to Raspberry Pi, Raspberry Pi Components, Installation of Raspbian, Terminal Commands, Installation of Libraries on Raspberry Pi, Getting the Static IP Address of Raspberry Pi, Raspberry Pi Programming- Reading the Digital Input, I2C and SPI programming, Interfacing Raspberry pi-LED, Relay, DC Motor, LCD, DHT11.
**Learning Outcomes:**
At the end of the unit, the student will be able to
1. List the sensors and their classification for IoT. (L2)
2. Practice the basic programming of Arduino platform. (L3)
3. Employ Raspberry pi and python programming to develop simple embedded applications. (L3)

**UNIT-IV**

**Data Processing**: Data acquiring and storage, Organizing the data, Transactions, business processes, Integration and Enterprise systems, cloud computing paradigm for data collection, storage and computing, everything as service and cloud service models, IoT cloud-based services.
**Learning Outcomes:**
At the end of the unit, the student will be able to
1. Summarize the Data collection and storage at node and cloud systems. (L2)
2. Understand the processing of data at different levels of IoT. (L2)

**UNIT-V**

**IoT Case Studies:** Domains-Home automation, Cities, Environment, Energy, Retail, Logistics, Agriculture, Industry, Health & Lifestyle**.** Case Studies- Home Intrusion detection, smart parking, weather monitoring system, Smart Irrigation.
Security and future of IoT Ecosystem:
**Learning Outcomes:**
At the end of the unit, the student will be able to
1. Categorize the domains of IoT development. (L4)
2. Examine the different IoT applications with detailed case study. (L4)

**Text Books**
1. Vijay Madisetti and Arshdeep Bahga, "Internet of Things (A Hands-on-Approach)", 1e, University Press Private Limited-2016.
2. Internet of Things: Architecture, Design Principles and Applications, Rajkamal, McGraw Hill Higher Education.

3. Rajesh Singh, Anita Gehlot, Lovi Raj Gupta, Bhupendra Singh, and Mahendra Swain "Internet of Things with Raspberry Pi and Arduino", CRC Press.
4. Dr Jeeva Jose, "Internet of Things", Khanna Book Publishing Co. (P)LTD, 2018

**Reference Books:**

1. Donald Norris, Internet of things do-it-yourself projects with Arduino, Raspberry Pi, and Beagle Bone Black,1st Edition, McGraw-Hill,2015
2. Getting Started with the Internet of Things Cuno Pfister, Oreilly.
3. Richard Blum, Arduino Programming in 24 Hours, Sams Teach Yourself, Pearson Education,2017
4. Jain, Prof. Satish, Singh, Shashi, Internet of Things and its Applications, 1st Edition, BPB, 2020.

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20CSE-OE3201.2 | **Non-Conventional Energy Sources (OPEN ELECTIVE -II)** | 3 | 0 | 0 | 3 |

**Course Objectives:**

- To study the solar radiation data, extraterrestrial radiation, radiation on earth's surface.
- To study solar thermal collections.
- To study maximum power point techniques in solar Photovoltaic Systems
- To study wind energy conversion systems, Betz coefficient, tip speed ratio and geothermal systems.
- To study basic principle and working of tidal, biomass and fuel cell

**Course Outcomes:** After completion of the course, the student will be able to:

1. Understand the basic concepts of solar radiation, its data on earth's surface (L2).
2. Explain the different types of solar thermal energy collectors (L2).
3. Develop the maximum power point techniques in solar Photovoltaic Systems (L3).
4. Understand the Wind energy conversion systems and the various geothermal resources (L2).
5. Explain the methods of generation of electricity from tidal and chemical resources (L2).

**UNIT–I: Fundamentals of Energy Systems and Solar energy**

Energy conservation principle – Energy scenario (world and India) – various forms of renewable energy - Solar radiation: Outside earth's atmosphere – Earth surface – Analysis of solar radiation data – Geometry –Numerical problems.

**Learning Outcomes:** The students are able to

- Understand solar radiation data, extraterrestrial radiation, and radiation on earth's surface(L2)
- Demonstrate the demand supply gap of energy in Indian, world scenario (L2)
- Understand the need of energy conservation(L2)

**UNIT–II: Solar Thermal Systems**

Liquid flat plate collectors – Numerical problems, Introduction to solar air heaters – Concentrating collectors, solar pond and solar still, solar heating/cooling technique, solar distillation and drying, solar cookers – solar thermal plants.

**Learning Outcomes:** The students are able to

- Explain solar thermal collectors, solar thermal plants(L2)

**UNIT–III: Solar Photovoltaic Systems**

Solar photovoltaic cell, module, array – construction – Efficiency of solar cells – Developing technologies – Cell I-V characteristics – Equivalent circuit of solar cell – Series resistance – Shunt resistance – Applications and systems – Maximum power point techniques: Perturb and observe (P&O) technique – Hill climbing technique.

**Learning Outcomes:** The students are able to

- Construct solar photo voltaic systems. (L3)
- Develop maximum power point techniques in solar PV (L3)

**UNIT–IV: Wind Energy and Geothermal Systems**

Sources of wind energy - Wind patterns – Types of turbines –Horizontal axis and vertical axis

machines - Kinetic energy of wind – Betz coefficient – Tip–speed ratio – Efficiency – Power output of wind turbine – Selection of generator(synchronous, induction).
Geothermal: Classification – Dry rock and hot acquifer – Energy analysis – Geothermal based electric power generation

**Learning Outcomes:** The students are able to

- Explain wind energy conversion systems, wind power generators(L2)
- Understand maximum power point techniques in wind energy systems(L2)
- Explain basic principle and working of geothermal systems (L2)

**UNIT–V: Tidal power systems, Biomass and fuel cells**

Tidal power – Basics – Kinetic energy equation – Turbines for tidal power – Numerical problems – Wave power – Basics – Kinetic energy equation – Wave power devices – Linear generators.
Biomass Energy: Pyrolysis – Direct combustion of heat – Different digesters and sizing.
Fuel cell: Classification of fuel for fuel cells – Fuel cell voltage– Efficiency – V-I characteristics

**Learning Outcomes:** The students are able to

- Explain basic principle and working of tidal power plants and Biomass (L2)
- Understand the concept of converting chemical energy to electrical energy (L2)

**Text Books:**


1. Non-conventional energy source –B. H. khan- TMH-2nd edition.
2. G.D. Rai, 'Non Conventional Energy Sources', Khanna Publishers, New Delhi.


**Reference Books:**


1. Energy Science**:** Principles, Technologies and Impacts, John Andrews and Nick Jelly, Oxford University Press.
2. Renewable Energy- Edited by Godfrey Boyle-oxford university.press,3rd edition,2013.
3. S.P. Sukhatme, Solar Energy: Principles of Thermal Collection And Storage, Tata Mcgraw-Hill
4. Renewable Energy Technologies /Ramesh & Kumar /Narosa.
5. Renewable energy technologies – A practical guide for beginners – Chetong Singh Solanki, PHI.
6. Fuel Cell Technology -Hand Book / Gregor Hoogers / BSP Books Pvt. Ltd.


**Weblinks:**

1. https://nptel.ac.in/courses/103103206

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20CSE-OE3201.3 | Operations Research<br>**(OPEN ELECTIVE -II)** | 3 | 0 | 0 | 3 |

**Course Objectives:**

The objectives of the course are to

- impart the concepts of mathematical modeling for optimization of the resources.
- apply the algorithms to solve the Linear Programming, transportation and assignment problems.
- optimize the channels in waiting lines of manufacturing and service systems.
- determine the best strategy under competitive business environment
- understand Project scheduling and optimizing the duration of the project
- simulate real life probabilistic situations with Montecarlo simulation technique.

**Course Pre-Requisites:**

Basic concepts of statistics: random variables, discrete probability distributions, Poisson and normal Probability distributions.

**Course Outcomes**

After completing the course, the student will be able to

1. ***construct*** mathematical model for allocation problems. (L3 )
2. ***test*** for optimality to arrive optimal solution for transportation and assignment problems(L 4)
3. ***solve*** the problems of waiting lines and scheduling to arrive the optimal decisions. (L3 )
4. ***apply*** the concepts of PERT and CPM for project management. (L3 )
5. ***develop*** simulation model of discrete systems under uncertainties. (L4 )

**UNIT I**

**Introduction to Operations Research (OR):** OR definition - Classification of Models, modeling – Methods of solving OR Models, limitations and applications of OR models.

**Linear Programming(LP):** Problem Formulation, Graphical Method, Special Cases of LP- Degeneracy, Infeasibility and Multiple Optimal Solutions; Simplex Method, Big- M simplex Method, Dual simplex method, application of L.P.P. in manufacturing firms.

**Learning Outcomes:**

At the end of this unit, the student will be able to

- ***understand*** the development of models in Operations Research (L2)
- ***explain*** **the** application areas of operations research in manufacturing and service firms. (L2)
- ***construct*** the mathematical model for allocation problems (L3)
- ***solve*** linear programming problems(L3)

**UNIT II**

**Transportation and Assignment Problems:** Transportation Problem – Formulation; Different Methods of Obtaining Initial Basic Feasible Solution –North West Corner Rule, Least Cost Method, Vogel's Approximation Method; Optimality Method – Modified Distribution (MODI) Method; Special Cases – Unbalanced Transportation Problem, Degenerate Problem. Assignment Problem – Formulation, Hungarian Method for Solving Assignment Problems, Traveling Salesman problem. application of Transportation and Assignment Problems in manufacturing firms.

**Learning Outcomes:**

At the end of the this unit, the student will be able to

- ***develop*** mathematical model for transportation and assignment Problems(L4)
- ***apply*** algorithms to obtain initial basic feasible solution for transportation Problem(L3)
- ***determine*** the optimal solution for Transportation problems. (L3)
- ***test for*** optimality to arrive optimal solution for transportation problem(L4)
- ***apply*** hungarian algorithm to assignment and traveling Salesman problems. (L3)

**UNIT III**

**Game theory:** Optimal solution of two person zero sum games, the max min and min max principle. Games without saddle points, mixed strategies. algebraic method, Reduction by principles of dominance, graphical method for [2x n] and [mx2] game problems.

**Sequencing:** Sequencing the jobs in flow shop scheduling, Solution of Sequencing Problem, Processing of n Jobs through two machines, Processing of n Jobs through three machines, priority rules.

**Learning Outcomes:**

At the end of this unit, the student will be able to

- ***identify*** the optimal strategies in competitive situations (L3)
- ***solve*** pay off matrix games using dominance rules and algebraic method. (L3)
- ***choose*** optimal sequence of jobs for scheduling (L3)

**UNIT IV**

**Network Analysis:** Network Representation, rules for drawing network, Fulkerson's Rule, Determination of Earlier Starting Time and Earliest Finishing Time in the Forward Pass – Latest Starting Time and Latest Finishing Time in Backward Pass, determination of critical path, total float calculation, Time estimates in PERT, Probability of completing the project, project cost, project crashing, Optimum project duration, Project management.

**Learning Outcomes:**

At the end of this unit, the student will be able to

- ***construct*** the network diagram (L3)
- ***compute*** the starting time, finishing times in the forward Pass and backward Passmethods(L2)
- ***identify*** the Critical Path in the project(L3)
- ***find*** the probability of completing the project with PERT (L3)
- ***understand*** the concept of Project management (L2)
- ***determine*** the optimum project duration(L3)

**UNIT V**

**Queuing Theory:** Introduction – Basic queuing process, basic structure of queuing models terminology: arrival Pattern, service channel, population, departure pattern, queue discipline, Kendall's notation. Single Channel model with poisson arrivals, exponential service times with infinite queue length

**Simulation:** Basic concept of simulation, applications of simulation, merits and demerits of simulation, Monte Carlo simulation, simulation of Inventory system, simulation of Queuing system.

**Learning Outcomes:**
At the end of this unit, the student will be able to

- ***understand*** the basic structure of queuing models and characteristics (L2)
- ***explain*** the goals of designing waiting line model (L2)
- ***compute*** parameters of the single channel waiting line (L3)
- ***design*** the discrete event simulation model for waiting line (L4)

**Text books:**


1. Sharma S.D., Operations Research: Theory, Methods and Applications, 15th Edition, Kedar Nath Ram Nath.
2. Prem kumar Gupta and Hira, Operations Research, 3rd Edition, S Chand Company Ltd., New Delhi.


**Reference books:**


1. Hiller F.S., and Liberman G.J., Introduction to Operations Research, 7th Edition, Tata McGraw Hill.
2. Sharma J.K., Operations Research: Theory and Applications, 4th Edition, Laxmi Publications.
3. Taha H.A., Operations Research, 9th Edition, Prentice Hall of India, New Delhi.
4. Pannerselvam R., Operations Research, 2nd Edition, Pentice Hall of India, New Delhi.
5. Sundaresan.V, and Ganapathy Subramanian.K.S, Resource Management Techniques: Operations Research, A.R Publications.

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20CSE-OE3201.4 | Image Processing<br>**(OPEN ELECTIVE -II)** | 3 | 0 | 0 | 3 |

**Course Objectives:**

- To introduce fundamentals of Image Processing.
- To expose various intensity transformations in spatial and frequency domains.
- To impart concepts of wavelets and various coding techniques for image compression.
- To dissimilate various segmentation techniques for images.
- To teach various color models and to introduce the concepts of colour image segmentation.

**Course Outcomes:**

1. Analyze various types of images mathematically
2. Compare image enhancement methods in spatial and frequency domains
3. Demonstrate various segmentation algorithms for given image
4. Justify DCT and wavelet transform techniques for image compression
5. Analyze various colour models for color image processing

**Unit 1**

Digital Image Fundamentals-Elements of visual perception, image sensing and acquisition, image sampling and quantization, basic relationships between pixels – neighbourhood, adjacency, connectivity, distance measures.

**Learning outcomes:**

- Explain mathematical models of various types of images (L2)
- Define image processing parameters such as adjacency and distance measures (L1)

**Unit 2**

Image Enhancements and Filtering- Gray level transformations, histogram equalization and specifications, pixel-domain smoothing filters – linear and order-statistics, pixel-domain sharpening filters – first and second derivative, two-dimensional DFT and its inverse, frequency domain filters – low-pass and high-pass.

**Learning outcomes:**

- Compare image enhancement methods in spatial and frequency domains (L5)
- Apply frequency Domain filtering techniques for image enhancement (L3)

**Unit 3**

Image Segmentation, Detection of discontinuities, edge linking and boundary detection, thresholding – global and adaptive, region-based segmentation.

**Learning outcomes:**

- Describe various Image segmentation techniques (L2)
- Illustrate detection of discontinuities in an image (L2)

**Unit 4**

Wavelets and Multi-resolution image processing- Uncertainty principles of Fourier Transform, Time-frequency localization, continuous wavelet transforms, wavelet bases and multi-resolution analysis, wavelets and Sub-band filter banks.

Image Compression, -Redundancy, inter-pixel and psycho-visual; Loss less compression –predictive, entropy; Lossy compression- predictive and transform coding; Discrete Cosine Transform; Still image compression standards – JPEG and JPEG-2000.

**Learning outcomes:**

- Describe various transform techniques for lossy compression (L2)
- Apply various coding techniques for lossless compression (L3)

**Unit 5**

Colour Image Processing-Colour models–RGB, YUV, HSI; Colour transformations– formulation, colour complements, colour slicing, tone and colour corrections; Colour image smoothing and sharpening; Colour Segmentation.

**Learning outcomes:**

- Describe various colour models for colour image processing (L2)
- Apply various techniques for colour image smoothing, sharpening and segmentation (L3)

**Text Books:**


1. R.C. Gonzalez and R.E. Woods, Digital Image Processing, Second Edition, Pearson Education, 2008.
2. Anil Kumar Jain, Fundamentals of Digital Image Processing, Prentice Hall of India, 2nd edition 2004.
3. Yao wang, JoemOstarmann and Ya – quin Zhang, "Video processing and communication ",1st edition , PHI
4. M. Tekalp ,"Digital video Processing", Prentice Hall International


**References:**


1. Rafael C. Gonzalez, Richard E woods and Steven L. Eddins, "Digital Image processing using MATLAB", Tata McGraw Hill, 2010.
2. Milan Sonka, Vaclav Hlavac, Roger Boule, Image Processing, Analysis, and Machine Vision, Third Edition, Cengage Learning, 2016.
3. S Jayaraman, S Esakkirajan, T Veerakumar, "Digital Image processing", Tata McGraw Hill.

William K. Pratt, "Digital Image Processing", John Wiley, 3rd Edition, 2004

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20MEC-PC3204 | Computer Aided Engineering Lab | 0 | 0 | 3 | 1.5 |

**Course Objectives:**

The students will acquire the knowledge

- To introduce fundamentals of the analysis software, its features and applications.
- To learn basic element types in finite element analysis.
- To know the concept of discretization of continuum, Loading conditions and analysethe structure using preprocessor and post processor conditions

**Course outcomes:**

Upon successful completion of this course student should be able to:

1. Classify the types of Trusses (Plane Truss & Spatial Truss) and Beams (2D & 3D) with various cross sections to determine Stress, Strains and deflections under static, thermal and combined loading.(L2)
2. Determine Plane stress, plane strain conditions & axisymmetric loading on inplane members to predict the failure behavior and finding the SCF.(L3)
3. Analyse connecting rod with tetrahedron and brick elements, performing static analysis on flat & curved shells to determine stresses, strains with different boundary conditions.(L4)
4. Predict the natural frequencies and modes shapes using Modal, Harmonic analysis. Also finding the critical load using Buckling analysis (L5)
5. EvaluatevariouspartprogrammingmethodsusingdifferentNCorCNCpackages. (L4)

1. **DRAFTING:** Development of part drawings for various components in the form of orthographic and isometric representation of dimensioning and tolerances scanning and plotting. Study of script, DXE and IGES files.
2. **PART MODELING:** Generation of various 3D models through protrusion, revolve, shell sweep, creation of various features, study of parent child relation, feature based and boolean based modeling surface and assembly modeling, study of various standard translators, design simple components.
3. a) Determination of deflection and stresses in 2D and 3D trusses and beams.
4. b) Determination of deflections component and principal and Von-mises stresses in plane stress, plane strain and axisymmetric components.
5. a)Determination of stresses in 3D and shell structures (at least one example in each case)
   b) Estimation of natural frequencies and mode shapes, Harmonic response of 2D beam
   c) Steady state heattransfer Analysis of plane and axisymmetric components.
6. a).Study of various post processors used in NC Machines.
   b).Machining of simple components on NC lathe and Mill by transferring NC Code/froma CAM packagethroughRS232.
7. CNC programming for milled components using FANUC Controller
8. Automated CNC Toolpath & G-Code generation using Pro/E/Master CAM

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20MEC-PC3205 | Heat Transfer Lab | 0 | 0 | 3 | 1.5 |

**Course Objectives:**

The students will acquire the knowledge

- To explain basics of radiation heat transfer.
- To Understand different modes of heat transfer
- To Gain knowledge about natural and force convection phenomenon
- To Estimate experimental uncertainty in measurements
- To provide the practical exposure about various heat exchanger methods and todetermine the effectiveness of heat exchangers
- To Acquire practical knowledge about phase change process occurs in boiling andcondensation
- To Apply concept of radiation heat transfer and to calculate Stefan boltzmanconstant for different bodies.

**Course Outcomes**

After completing the course, the student will be able to

1. ***Calculate*** heat transfer through lagged pipe, insulating powder and Drop and Film wisecondensation.(L3)
2. ***Find out*** the Thermal conductivity of a given metal Rod and Determine the overall heat transfercoefficient for a composite slab.(L3)
3. ***Calculate*** the Heat transfer coefficient for Pin Fin, Forced convection, Natural Convection(L3)
4. ***Design*** the Fins and Heat Exchangers(L5)
5. ***test*** for Emissivity, Stefan Boltzmann Constant.(L3)

**LISTOFEXPERIMENTS**

1. Determine the overall heat transfer coefficient across the width of composite wall
2. Determine the thermal conductivity of a metal rod
3. Determinethethermalconductivityofinsulatingpowdermaterialthroughconcen tricsp hereapparatus
4. Determine the thermal conductivity of insulating material through lagged pipeapparatus
5. Determinetheefficiencyandeffectivenessofapinfininnaturalandforcedconvection.
6. Determine the heat transfer coefficient for a vertical cylinder in natural convection
7. Determine the heat transfer coefficient in forced convection of air in a horizontal tube.
8. Determine the heat transfer coefficients on film and drop wise condensation apparatus.
9. Determine the effectiveness of a parallel and counter flow heat exchanger.
10. Determine the emissivity of the test plate surface.
11. Experiment on Stefan-Boltzmann apparatus

| Subject Code | Subject Name | L | T | P | C |
|---|---|---|---|---|---|
| R20MEC-PC3206 | Mechanical Measurements and Metrology Laboratory | 0 | 0 | 3 | 1.5 |

**Course Objectives:** The students will acquire the knowledge:
The Engineering Metrology Lab course is designed for measuring and gauging instruments forinspection of precision linear, geometric forms, angular and surface finish measurements.
The student can learn the measurements with and calibration of instruments.
To study and calibrate displacement, temperature, speed, capacitance and pressure measuringinstruments

**Course Outcomes:**
Upon successful completion of this course student should be able to:
1. ***measure*** length, height, diameter and angles using various instruments (L2)
2. ***measure*** surface roughness with roughness measurement instrument (L2)
3. ***make use of*** resistant temperature detector for temperature measurement (L3)
4. ***demonstrate*** LVDT transducer and rotameter (L3)
5. ***find*** the angle of specimens with sine bar and Vernier bevel protractor (L3)

**List of Experiments:**

1. Measurement of angular displacement using capacitive transducer
2. Study and calibration of a rotameter for flow measurement
3. Study and calibration of LVDT transducer for displacement measurement
4. Calibration of thermistor and RTD
5. Calibration of thermocouple
6. Study and calibration of photo and magnetic speed pickups for the measurement ofspeed
7. Use of gear tooth vernier caliper for tooth thickness inspection and flange micro meter forchecking the chordal thickness of spur gear.
8. Measurements of Surface roughness using Talysurf
9. Measurement of lengths, heights, diameters by vernier calipers, micrometers etc.
10. Performance on angular measurement of given specimen by using Vernier bevelprotractor, sine bar.
11. Thread inspection with two wire/three wire method & tool makers microscope.
12. Use of spirit level in finding the straightness of a bed and flatness of a surface.
13. Measurement of bores by internal micrometers and dial bore indicators.
14. Machine tool alignment test on lathe machine

**Note: Any 12 Experiments form above list**