COURSE STRUCTURE(R20)
AND
DETAILED SYLLABUS
(IV 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)
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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING (MECH)

B. Tech IV-Year Course Structure and Syllabus –R20

IV Year - I Semester							
S. No	**Course Code**	**Course Title**	**Category**	**L**	**T**	**P**	**Credits**
1	R20MEC-PE4101.1 R20MEC-PE4101.2 R20MEC-PE4101.3 R20MEC-PE4101.4	**Professional Elective -3** 1. Finite Elements Analysis 2. CNC and Adaptive Control 3. Non-Destructive Testing Methods 4. Quality Assurance Systems	PEC	3	0	0	3
2	R20MEC-PE4102.1 R20MEC-PE4102.2 R20MEC-PE4102.3 R20MEC-PE4102.4	**Professional Elective -4** 1. Advanced Concepts of Engineering Design 2. Automation In Manufacturing 3. Power Transmission in Hybrid & Electric Vehicles 4. Cryogenic Engineering	PEC	3	0	0	3
3	R20MEC-PE4103.1 R20MEC-PE4103.2 R20MEC-PE4103.3 R20MEC-PE4103.4	**Professional Elective -5** 1. Industrial Hydraulics & Pneumatics 2. Industrial Robotics 3. Gas Dynamics & Jet Propulsion 4. Advanced Materials	PEC	3	0	0	3
4	R20CIT-OE4103 R20EEE-OE4103 R20BSH-OE4103 R20ECE-OE4107	**Open Elective -3** 1. Computer Networks 2. Basics of Utilization of Electrical Energy 3. Optimization Techniques in operation management 4. Fundamentals of Image Processing	OE	3	0	0	3
5	R20ECE-OE4106 R20CSE-OE4103 R20BSH-OE4104 R20EEE-OE4102	**Open Elective -4** 1. Fundamentals of Neural Networks And Fuzzy Techniques 2. Operating System Concepts 3. Supply Chain Management 4. Energy conservation and Auditing	OE	3	0	0	3
6	R20BSH-HM4101	Universal Human Values 2: Understanding Harmony	HM	3	0	0	3
7	R20MEC-SC4101	Computational Fluid Dynamics **(Skill Oriented Course-5)**	SC	1	0	2	2
8	R20MEC-SI4101	**Summer Internship-2 (Evaluation)**	**SI**	0	0	0	3
			Total	**19**	**0**	**2**	**23**
Honors Course -4/ Minor Course-4							

IV Year - II Semester							
S. No	**Course Code**	**Course Title**	**Category**	**L**	**T**	**P**	**Credits**
1	R20MEC-PJ4202	Project Work	PJ	0	0	0	12
			Total	0	0	0	12

Subject Code	Subject Name	L	T	P	C
R20MEC-PE4101.1	Finite Elements Analysis (**Professional Elective –3)**	3	0	0	3

Course Objectives:

The main objectives of this course are to

- Familiarize basic principles of finite element analysis procedure.
- learn the theory and characteristics of finite elements that represent engineering Structures.
- Explain theory and characteristics of finite element structural applications using trusses and beams.
- Apply the finite element solutions to solve 2D problems like triangular, axi – symmetrical solids and quadrilateral elements.
- Explain the finite element solutions to solve heat transfer problems and problems involving dynamics.

Course Outcomes:

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

1. Explain basic principles of finite element analysis, stress-strain relations, and different models for the formulation of finite element equations. (L2)
2. Apply the basics of FEA to relate stresses and strains for structural elements such as bars for calculation of stiffness matrices, load vectors, stress-strain relations, and displacements. (L3)
3. Analyze the applications and characteristics of FEA elements used for trusses and beams, including the calculation of stiffness matrices, load vectors, stress-strains, and displacements in structural systems. (L4)
4. Apply the formulation techniques to solve 2D problems using triangle, axi – Symmetric elements and quadrilateral elements. (L3)
5. Analyze the application of the Finite Element Method in the domains of dynamics, heat transfer, and fluid flow, evaluating its capabilities in solving complex real-world problems across various engineering fields. (L4)

Unit -I

Introduction: Introduction to finite element methods for solving field problems, Stress and equilibrium, Boundary conditions, Strain-Displacement relations, Stress- strain relations for 2D and 3D Elastic problems. Potential energy and equilibrium, The Rayleigh-Ritz method, Formulation of Finite Element Equations.

Application: structural analysis

Learning Outcomes:

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

- **Understand** the numerical methods involved in Finite Element theory.(L2)
- **Understand** the concepts behind variational methods and weighted residual methodsin FEM. (L2)
- **Understand** direct and formal (basic energy and weighted residual) methods for deriving finite element equations. (L2)

Unit-II

One dimensional problems: Discretization process, Types of elements, node numbering, mesh generation, Convergence criteria, interpolation functions, local and global coordinates. Shape function, Element Stiffness Matrix and Load Vector, Assembly of global stiffness matrix and load vector Finite element equations, Treatment of boundary conditions, Temperature effects.

Application: structural analysis

Learning Outcomes:

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

1. Understand the role and significance of shape functions in finite element formulationsand use linear, quadratic, and cubic shape functions for interpolation(L2)
2. Understand the process of meshing and application of boundary conditions.(L2)
3. Develop element characteristic equation procedure and generation of global stiffness equation will be applied.(L3)
4. Apply Suitable boundary conditions to a global structural equation, and reduce it to asolvable form.(L3)
5. Solve axially loaded bar Problems.(L3)

UNIT-III:

Analysis of trusses & beams:

Analysis of Trusses: Finite element modelling, coordinates and stiffness Matrix for plane truss element. assembly of global stiffness matrix and load vector, finite element equations, treatment of boundary conditions, stress, strain and support reaction calculations.

Analysis of Beams: Boundary conditions, Load vector, Hermite shape functions and simple problems.

Application: Building roof and railway bridges and shafts supported in bearing such as axles and line shafts etc.

Learning Outcomes:

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

- **Understand** the use of the basic finite elements for structural applications using truss and beam. (L2)
- **Solve** truss and beam problems. (L3)

UNIT-IV

Two Dimensional Problems: Finite Element Modeling, Constant Strain Triangle (CST) Element Stiffness, Force terms, Stress calculation, Problem modeling and boundary conditions. Plane Stress and plane Strain Problems using CST Element. Problems on isoparametric formulation of 4-noded quadrilateral element.

Numerical Integration: Gaussian quadrature one point, two point and three point formulae,2D integrals.

Application: Plates under bi-axial loading and the bending of plates , pressure vessels, flywheel, turbine discs etc.

Learning Outcomes:

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

- **Implement** the formulation techniques to solve two-dimensional problems using triangle and quadrilateral elements .(L5)
- **Solve** plane stress conditions, axisymmetric and Quadrilateral Element problems.(L3)

UNIT V:

One Dimensional Heat transfer Problems & Dynamic analysis:

One Dimensional Heat transfer Problems: Equilibrium equations, heat conduction in plane walls, heat transfer analysis of fins, finite element formulation, simple problems.

Dynamic analysis: Formulation of finite element model, element consistent and lumped massmatrices, evaluation of eigen values and eigenvectors, free vibration analysis.

Applications:

- Heat transfer involved in the operation of Power plant equipments such as boilers,condensers, air pre-heaters etc., refrigeration and air conditioning systems.
- Dynamic analysis is applied in all kind of structural components like bars, trusses, beams, frames and also machine components like piston rod, connecting

rod, spindle etc.

Learning Outcomes:

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

- **Understand** the application and use of the Finite Element Methods for heat transfer problems. (L2)
- **Solve** heat transfer problems. (L3)
- **Understand** problems involving dynamics using Finite Element Methods.(L2)
- **apply** suitable boundary conditions to a global equation for dynamic problems and solve them Eigen values, Eigen Vectors and vibration analysis for stepped bar and beam elements.(L3)

Text books

1. Chandraputla, Ashok &Belegundu, Introduction to Finite Elements in Engineering, Prentice Hall.3/e
2. S.S. Rao, The Finite Element Methods in Engineering, Elsevier Butterworth – Heinemann, 2/e

Reference books

1. J N Reddy, An introduction to the Finite Element Method, McGraw – Hill, New York,1/e.
2. R D Cook, D S Malkus and M E Plesha, Concepts and Applications of Finite ElementAnalysis, 3rd Edition, John Wiley, New York, 1/e.
3. K J Bathe, Finite Element Procedures in Engineering Analysis, Prentice-Hall, Englewood Cliffs, 1/e.
4. T J R Hughes, the Finite Element Method, Prentice-Hall, Englewood Cliffs, NJ, 3rd Edition.
5. C Zienkiewicz and R L Taylor, the Finite Element Method, 3rd Edition. McGraw-Hill.

Subject Code	Subject Name	L	T	P	C
R20MEC-PE4101.2	CNC and Adaptive Control (**Professional Elective –3)**	3	0	0	3

Course Objectives:

The main objectives of this course are to

- Understand the Role and Applications of NC / CNC.
- Introduce Part Program and its elements
- Explain the Components of CNC machine tool, Drives and controls
- Develop the adaptive control problem and Gain scheduling
- Introduce the deterministic self-tuning regulators
- Introduce the stochastic and predictive self-tuning regulators

Course Outcomes:

By the end of the course the students will be able to

1. Understand the Role, Applications, Benefits of NC/ CNC (L1)
2. Explain the Methods of part Programming and Apply APT and its variations (L2)
3. Explain tool offsets and work offsets. (L2)
4. Apply the principle of gain scheduling controllers (L3)
5. Understand deterministic self-tuning regulators. (L2)

UNIT-I

Numerical Control - Introduction, Role of NC / CNC in CAM, Applications of NC / CNC, Benefits of NC / CNC, Limitations of CNC.

Basic Components of CNC system - Part programming, Machine control unit, Machine tool - Historical developments and their role in control of machine tools, Classification of NC / CNC systems - Based on type of Control (PTP\C\L), method of programming, type of architecture - Hardwired / Soft wired / Open.

Applications: Most commonly used in wide variety of production operation such as metal cutting, automatic drafting ,spot welding, press working, assembly ,inspection etc.

Learning Outcomes:

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

- **explain** the Role, Applications, Benefits of NC/ CNC. (L2)
- **explain** the basic components of CNC system. (L2)
- **classify** the NC / CNC systems, Based on type of Control (PTP\C\L). (L1)

UNIT-II

Part programming - Introduction; Part Program and its elements, Methods of Programming Manual and Computer Assisted Part programming - Custom Macro (Parametric Programming), APT and its variations, Concepts of CAM - Tool path generation and control methods.

Applications: part program is a sequence of instructions, which describe the work, which has to be done on a part, in the form required by a computer under the control of a numerical control computer program. It is the task of preparing a program sheet from a drawing sheet.

Learning Outcomes:

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

- **explain** the Methods of part Programming. (L2)
- **explain** the Concepts of CAM-path generation and control methods.(L2)

UNIT-III

Machine Tool - Components of CNC machine tool, Drives and controls, Automatic Tool Changers, Automatic Pallet Changers, tool offsets and work offsets, high speed and precision machining concepts.

Applications: mostly used in production and manufacturing industry, and also used for

milling and machining centers.

Learning Outcomes:

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

- **understand** the Components of CNC machine tool. (L1)
- **explain** tool offsets and work offsets. (L2)

UNIT-IV

Adaptive Control Systems- Tools - Functions-Adaptive control for Optimization (ACO) for process and system constraints- Adaptive control with constraint (ACC) for maximizing machining parameters- Geometric Adaptive Control (GAC)- Advantages -Applications .

Applications: Essential Elements of CNC Machining , Protects the tool and work piece and machine fromdamage caused by malfunctions.

Learning Outcomes:

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

- **understand** the nature of uncertainties affecting a system. (L1)
- **explain** whether an adaptive control is a good option for a given protection. (L2)

UNIT-V

Development of adaptive control -The role of Index performance (IP) in adaptive systems- Parametric models of dynamical systems - Adaptive Schemes- The adaptive Control Problem- Applications. Gain scheduling: The principle - Design of gain scheduling controllers- Nonlinear transformations -application of gain scheduling - Auto-tuning techniques-Methods based on Relay feedback.

Applications: Adaptive control has been extended to new applications such as drying ovens, active control of vibrations, efficient conditioning, robotics… permitting to control the process or even improve the efficiency that was performed with conventional controls.

Learning Outcomes:

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

- **understand** The role of Index performance (IP) in adaptive systems. (L1)
- **apply** the concept of adaptive Control. (L3)
- **apply** the principle - Design of gain scheduling controllers.(L3)

Text books:

1. Computer aided manufacturing by N.K.TIWARI,P.N.RAO,T.K.KUNDRA
2. Advanced Manufacturing Technology by Rao K V (Author)
3. Introduction to Computer Numerical Control, 5th Edition, James V. Valentino, Queens boroughCommunity College, Joseph Goldenberg, Queens borough Community College.

References:

1. Computer Numerical Control Programming Basics Steve Krar Arthur Gill
2. Reinbold U, Blume C and Dilmann R, Computer Integrated Mfg. Technology & Systems,Marcel Dekker.
3. Petruzella F D, Programmable Logic Controllers, McGraw Hill.

Subject Code	Subject Name	L	T	P	C
R20MEC-PE4101.3	Non-Destructive Testing Methods **(Professional Elective –3)**	3	0	0	3

Course Objectives:

The main objectives of this course are to

- Concepts of various NDE techniques using radiography, ultrasonic's, liquid penetrates, magnetic patches and Eddy currents are dealt with
- Learn basic principles of these methods and select a testing process.
- Understand the advantages and disadvantages of these techniques
- Knowledge on which NDE method to apply under appropriate circumstances
- Classify non-destructive testing equipment.
- Knowledge of all the different types of Non-destructive testing

Course Outcomes:

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

1. Understand non-destructive destructive testing methods and radiographic testing in industries. – (L2)
2. Explain ultrasonic testing and its effectiveness and limitations. – (L2)
3. Illustrate liquid penetrate testing and types of penetrates used in die penetrating testing.(L2)
4. Identify internal flaws of the work piece using magnetic particle testing. – (L3)
5. Apply knowledge of non-destructive testing techniques to test equipment/work pieces invarious industrial/automobile sectors. – (L3)

UNIT-I

INTRODUCTION TO NON-DESTRUCTIVE TESTING: Radiographic test**,** Sources of X and Gamma Rays and their interaction with Matter, Radiographic equipment, RadiographicTechniques, Safety Aspects of Industrial Radiography

Learning outcomes:

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

- **explain** non-destructive testing techniques. (L2)
- **summarize** the basic concepts of Radiographic test.(L2)
- **outline** the concepts of sources of X and Gamma Rays.(L2)
- **explain** the radiographic techniques. (L2)

UNIT-II

ULTRASONIC TEST: Principle of Wave Propagation, Reflection, Refraction, Diffraction, Mode Conversion and Attenuation, Sound Field, Piezo-electric Effect, Ultrasonic Transducers and their Characteristics, Ultrasonic Equipment and Variables Affecting Ultrasonic Test, Ultrasonic Testing, Interpretations and Guidelines for Acceptance, Rejection Effectiveness and Limitations of Ultrasonic Testing.

Learning outcomes:

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

- **explain** the principle of ultrasonic test.(L2)
- **understand** the performance of wave propagation, reflection, refraction,diffraction and sound field in ultrasonic test.(L2)
- **outline** the limitations of ultrasonic testing. (L2)

UNIT-III

LIQUID PENETRANT TEST: Liquid Penetrant Test, Basic Concepts, Liquid Penetrant System, Test Procedure, Effectivenessand Limitations of Liquid Penetrant Testing

EDDY CURRENT TEST: Principle of Eddy Current, Eddy Current TestSystem, Applicationsof Eddy Current Testing Effectiveness of Eddy Current

Testing

Learning outcomes:

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

- **Illustrate** the procedure of Liquid Penetrant, eddy current tests.(L2)
- **Outline** the limitations of Penetrant, eddy current tests.(L2)
- **Explain** the effectiveness of Penetrant, eddy current tests.(L2)

UNIT-IV

MAGNETIC PARTICLE TEST: Magnetic Materials, Magnetization of Materials, Demagnetization of Materials, Principle of Magnetic Particle Test, Magnetic Particle Test Equipment, Magnetic Particle Test Procedure, Standardization and Calibration, Interpretation and Evaluation, Effective Applications and Limitations of the Magnetic Particle Test.

Learning outcomes:

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

- **Illustrate** the procedure of magnetic particle tests.(L2)
- **Outline** the limitations of magnetic particle tests.(L2)
- **Explain** the effectiveness of magnetic particle tests.(L2)

UNIT-V

INDUSTRIAL APPLICATIONS OF NDE: Span of NDE Activities Railways, Nuclear, Non- nuclear and Chemical Industries, Aircraft and Aerospace Industries, Automotive Industries, Offshore Gas and Petroleum Projects, Coal Mining Industry, NDE of pressure vessels, castings, weldedconstructions.

Learning outcomes:

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

- **illustrate** applications of NDE.(L2)
- **explain** the applications of Railways, Nuclear and chemical industries. (L2)
- **outline** the limitations of NDE.(L2)
- **explain** the applications of NDA of pressure vessels, casting and weldingconstructions(L2)

TEXTBOOKS:

1. J Prasad, G C K Nair, Nondestructive test and evaluation of Materials, 2nd edition Tata McGraw-HillEducation Publishers.
2. Josef Kraut krämer, Herbert Kraut krämer, Ultrasonic testing of materials, 3/e,Springer-Verlag,.
3. X. P. V. Maldague, Non destructive evaluation of materials by infrared thermography,1/e,Springer-Verlag.

REFERENCES:

1. GaryL.Workman, Patrick O.Moore, Doron Kishoni, Non-destructive, Hand Book,Ultrasonic Testing, 3/e, Amer Society for Nondestructive.
2. ASTM Standards,Vol3.01, Metals and alloys

Subject Code	Subject Name	L	T	P	C
R20MEC-PE4101.4	Quality Assurance System **(Professional Elective –3)**	3	0	0	3

Course Objectives:

The Objectives of this course are to

- Introduce the concepts of Quality Management.
- Expose with various quality issues in production systems.
- Gain Knowledge on imparting quality as per customer perspective
- Understand the concept of process control
- Get awareness on six sigma problem solving approach
- Understand the importance of Quality assurance system

Course outcomes:

After successful completion of this course, student will be able to

1. Comprehend the importance of Quality & Quality assurance system.(L2)
2. Analyze the causes of variations in the process with Cause and Effect Diagrams.(L4)
3. Construct the control charts for variables and attributes(L4)
4. Identify accepting sampling plans to meet producer and consumer requirements.(L4)
5. Apply the six sigma problem solving approach (L3)

UNIT –I INTRODUCTION

Introduction to quality – Definition of Quality, Dimensions of Quality, Quality Planning, Quality costs, Economics of quality, Definition of Total quality management – history – stages of evolution– objectives –Reliability as a Quality parameter, Reliability calculations, Bath tub curve, Quality function deployment(QFD), significance of Quality assurance system.

Learning Outcomes:

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

- **explain** the concepts of Total Quality Management. (L2)
- **understand** the costs of poor quality (L2)
- **elucidate** the concept of Quality assurance system.(L2)

UNIT- II

PROCESS CAPABILITY: Foundation of process capability, Natural Tolerance limits, Process capability index, Normal probability distribution, significance of process control limits, Cause andEffect Diagrams, Pareto Chart, Quality control tools and Techniques

Learning Outcomes:

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

- **explain** the applicability of Normal probability distribution for process control limits (L2)
- **illustrate** Quality control tools (L2)
- **construct** the Cause and Effect Diagrams for the manufacturing process (L3)
- **Analyze** the process capability ratios (L4)

UNIT -III

STATISTICAL PROCESS CONTROL

Control charts: Statistical basis of the Control Charts-principles, Control limits for mean and range - Charts, analysis of pattern on control charts, Type I and Type II errors, fraction defectives chart, defects chart construction. Simple Numerical Problems.

Learning Outcomes:

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

- **understand** the statistical concepts related to control charts.(L2)
- **analyze the** assignable causes for process deviations. (L4)

- **construct** the control charts for variables and attributes(L3)

UNIT- IV

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:

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

- **describe** the concepts of acceptance sampling(L2)
- **Analyze** appropriate acceptance sampling plan to minimize producer risk and consumer risk.(L4)
- **compare** the sampling plans (L2)

UNIT- V

Six Sigma and Quality Systems

The Concept of Six Sigma, Objectives of Six Sigma, The Frame-Work of Six Sigma Programme, Six Sigma Problem Solving Approach, The DMAIC Model, Six Sigma Metrics: Cost of Poor Quality, Defects Per Million Opportunities , Benefits of Six Sigma.

Need for ISO 9000 and Other Quality Systems, ISO 9000: 2000 Quality System –, QS 9000, ISO 14000 – Concept, Requirements and Benefits.

Learning Outcomes:

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

- **Apply** the six sigma approach to foundry operations (L3)
- **illustrate** the DMAIC Model (L2)
- **explain** the significance of ISO9000 and Other Quality systems. (L2)

TEXTBOOKS:

1. Subburaj Ramaswamy, Total Quality Management,1st edition, Tata Mcgraw Hill PublishingCompany Ltd.,
2. Statistical Quality Control, M.Mahajan, 3rd edition, Dhanpat Rai Publishing Co Pvt Ltd
3. Evans, J R and W M Lindsay, An Introduction to Six Sigma and Process Improvement, 2nd edition, Cengage Learning.

REFERENCE BOOKS:

1. Introduction to statistical quality control: By D.C. Montgomery 6th edition, John Wiley&Sons.Inc.
2. Forrest W. Breyfogle , Implementing Six Sigma, 3rd edition, John Wiley & Sons, Inc.
3. Statistical Quality Control – R.C. Gupta– 9th edition, Khanna Publishers, Delhi
4. Grant,E,L. and Laven Worth, R.S.: Statistical Quality Control, 7th edition, McGraw Hill.

Subject Code	Subject Name	L	T	P	C
R20MEC-PE4102.1	Advanced Concepts of engineering design (**PROFESSIONAL ELECTIVE –4)**	3	0	0	3

Course Objective:

The objectives of the course are

- To understand the design philosophy and the steps involved in designing and the relation of design activity with manufacturing activity.
- To learn the different types of failure modes and criteria.
- To know the concept of product design for manufacturing.
- To understand the economical aspects of optimal product design.

Course outcomes:

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

1. Understand the design philosophy of engineering problems, including the consideration of technical and manufacturing constraints (L2)
2. Apply the theories of failure on machine components under the action of loads (L3)
3. Analyze the strategies for designing a machine component (L4)
4. Analyze the design considerations of components for manufacturing. (L4)
5. Select the engineering design with ergonomics and economical factors (L5)

UNIT I:

Design philosophy: Design process, Problem formation, Introduction to product design, various design models- Shigley model, Asimov model and Norton model, Need analysis, Strength considerations - standardization. Creativity, Creative techniques, Material selections, Notches and stress concentration, design for safety and Reliability.

Learning Outcomes:

After completion of the unit, the student will be able to

- **Understand** the design process and techniques.(L2)
- **Explain** the safety and reliability while designing a component. (L2)

UNIT II:

Failure theories: Static failure theories, Distortion energy theory, Maximum shear stress theory, Coulomb- Mohr's theory, Modified Mohr's theory, Fracture mechanics theory. Fatigue failure theories, Fatigue mechanisms, Fatigue failure models, Fatigue failure criteria, Methods to reduce fatigue, Design for fatigue, Modified Goodman Diagram, Gerber method, Soderberg line, Surface failure models. Lubrication, friction and wear.

Learning Outcomes:

After completion of the unit, the student will be able to

- **Understand** the static failure theories.(L2)
- **Apply** the different methods to reduce fatigue in machine components. (L3)
- **Explain** the lubrication methods in machine components. (L2)

UNIT III:

Product Design:

Introduction, Product strategies, Product value, Product planning, product specifications, concept generation, concept selection, concept testing.

Learning Outcomes:

After completion of the unit, the student will be able to

- **apply** technological strategies for concept generation(L2)
- **analyze** the different methods to reduce fatigue in machine components. (L4)

UNIT IV:

Design for manufacturing:

Introduction, Producibility requirements in design, Pressed components design, Forging design, Casting design, Design process for non metallic parts, Plastics, Rubber, Ceramic, Wood, Glass parts.

Learning Outcomes:

After completion of the unit, the student will be able to

- **Explain** design considerations of components while manufacturing. (L2)
- **Analyze** the design process for non metallic parts. (L4)

UNIT V:

Economic factors influencing design:

Economic analysis, Break-even analysis, Human engineering considerations, Ergonomics, Design of controls, Design of displays. Value engineering, Material and process selection in value engineering, Modern approaches in design.

Learning Outcomes:

After completion of the unit, the student will be able to

- **evaluate** the optimal design based on economical analysis (L5)
- **Apply** ergonomic concepts in engineering design. (L3)

Test Book:

1. Product Design and Manufacturing by A.K. Chitale and R.C. Gupta, Prentice Hall 5thedition .
2. Advanced design concepts for engineers by B.s Dhillon, Taylor and francis group ACRC press book, 1st edition

References:

1. Mechanical Engineering Design by Joseph Shigley and Mischke. Sixth edition, TataMcGraw Hill
2. Machine Design - An Integrated Approach by R.L. Norton, Prentice Hall.
3. Product design and development by Karl T. Ulrich and Steven D. Eppinger. Thirdedition, Tata McGraw Hill.
4. Ray M.S, “elements of engineering design”, Prentice hall Inc 3rd edition
5. Dieter George E, “engineering design - a materials and processing approach”, McGrew hill, international edition, 1st edition

Subject Code	Subject Name	L	T	P	C
R20MEC-PE4102.2	Automation In Manufacturing (**PROFESSIONAL ELECTIVE –4)**	3	0	0	3

Course Objectives

The objectives of the course are to

- Understand the concept of automation and process control systems.
- Classify the automated flow lines and analyze automated flow lines
- Able to balance the operations on assembly line.
- Design automated material handling systems.
- Understand the level of automation in continuous and discrete manufacturing systems.

Course Outcomes

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

1. Understand the characteristics of Automated Systems. (L2)
2. Illustrate operational aspects of flow lines. (L2)
3. Evaluate the methods to balance the assembly line (L5)
4. Compare conventional and automated material transport, storage system. (L3)
5. Explain the control systems, level of automation in continuous and discrete manufacturing industries. (L2)

UNIT I

INTRODUCTION TO AUTOMATION: Automated Manufacturing Systems, Computerized Manufacturing Support Systems, Reasons for Automation, Automation Principles and Strategies, levels of automation, Basic elements of an automated system, Types of production, pneumatic and hydraulic components, circuits, automation in foundry industries, automation in machine tools, mechanical feeding and tool changingand machine tool control. Economical and technological factors for automation. Barriersof automation in manufacturing industries.

Learning outcomes:

After completion of this unit, students will be able to

- **understand** the essential elements of an automated system related to different manufacturing industries.(L2)
- **explain** different types of automation strategies and levels of automation.(L2)

UNIT II

AUTOMATED FLOW LINES: need for automated flow lines, types of flow lines, Methods of part transport, transfer mechanism, buffer storage, factors related to storage requirements, control function, design and fabrication considerations. Analysis of automated flow lines - General terminology and analysis of transfer lines without and with buffer storage, partial automation, down time, implementation of automated flow lines, Automated flow line and automated assembly line, Applications of automated flow lines.

Learning outcomes:

After completion of this unit, students will be able to

- **illustrate** part transfer methods and mechanisms in automated flow lines. (L2)
- **explain** flow lines with/without buffer storage. (L2).

UNIT III

ASSEMBLY LINE BALANCING: Assembly process and systems, assembly line, line balancing methods, ways of improving line balance, flexible assembly lines.

FMS: Types of FMS, components of FMS, Types of flexibility, types of FMS layouts, applications, scope for FMS in manufacturing today, group technology, hierarchy of computer control in FMS, economic justification of FMS planning, scheduling and control

of FMS

Learning outcomes:

After completion of this unit, students will be able to

- **explain** line balancing methods(L2)
- **apply** line balancing methods for improving line efficiency.(L3)
- **explain** the features of flexible assembly line.(L2)
- **evaluate** FMS layouts with economical justification (L5)

UNIT IV

MATERIAL HANDLING SYSTEMS: Introduction to Material Handling, Basic Principles, Material Transport equipment, analysis of material transport systems, Automated Guided Vehicle Systems, Generalized Theories Governing the Mechanical Design Parameters of Handling Systems **storage systems**–storage system performance and location strategies, Conventional storage methods and equipment, , Automated Storage and Retrieval System (ASRS) and Its Types, Applications of ASRS

,Engineering analysis of storage systems. ASRS and Industry 4.0

AUTOMATIC IDENTIFICATION METHODS: Overview of Identification Methods, Barcode technology, Radio frequency identification, other AIDC technologies, benefits of AIDC

Learning outcomes:

After completion of this unit, students will be able to

- **explain** material transport equipment required in automated systems (L2)
- **select** the handling systems for automated systems (L3)
- **compare** conventional and automated storage systems(L2)
- **summarize** various storage methods and equipment(L2)

UNIT V

INDUSTRIAL CONTROL SYSTEMS: Process industries Vs Discrete manufacturing industries, levels of automation in the two industries, variables and parameters in the two industries. Continuous Vs Discrete control –continuous control system, discrete control system

AUTOMATED INSPECTION and ASSEMBLY: Fundamentals, inspection principles, types of inspection methods and equipment, Quality function deployment, Coordinate Measuring Machines, Machine Vision, Automated Assembly Systems, Design for Automated Assembly, and Quantitative Analysis of Assembly Systems, Multi- Station Assembly Machines, Single Station Assembly Machines

Learning outcomes:

After completion of this unit, students will be able to

- **understand** industrial control systems (L2)
- **compare** automation in Continuous and discrete control systems (L2)
- **understand** different types of automated inspection techniques and their applications. (L2)

TEXT BOOKS:

1. M.P. Groover, Automation, Production systems and Computer Integrated Manufacturing,3/e, PHI Learning.
2. Geoffrey Boothroyd, Assembly Automation and Product design,2 edition, Taylor and Francis Publishers.
3. Shivanand HK, Beral MM, Koti V, Flexible Manufacturing Systems, 1 edition, New agepublications

REFERENCE BOOKS:

1. Krishna Kant, Computer based industrial control, 2 edition, Prentice Hall of India.
2. Tiess Chiu chang and A. W. Richard, An introduction to automated process planning systems, 1 edition Tata Mc Graw Hill.
3. Mikell P. Groover and Mitchell Weiss, Roger N. Nagel, Nicholas, G. Odrey, IndustrialRobotics, 2 edition, McGraw Hill.

Subject Code	Subject Name	L	T	P	C
R20MEC-PE4102.3	Power Transmission in Hybrid and Electric Vehicles (**Professional Elective –4)**	3	0	0	3

Course Objectives:

The objectives of the course are to

- provide good foundation on hybrid and electrical vehicles.
- address the underlying concepts and methods behind power transmission in hybrid andelectrical vehicles.
- familiarize energy storage systems for electrical and hybrid transportation.
- Understand specifications of electrical devices
- Understand the design consideration for electrical system body

Course outcomes:

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

1. Explain the history of hybrid and electric vehicles, need and limitations of hybrid and electric vehicles, environmental importance and specifications of these vehicles. (L2)
2. Describe the component and operation of electric and hybrid powertrain topologies and their power flow control strategies. (L2)
3. Identify and describe the function and key components of different electric motors and their speed control and power electronics in an electric vehicles.(L3)
4. Explain the basic principles and types of energy storage systems used in hybrid and electric vehicles (e.g., batteries, ultracapacitors). (L2)
5. Analyze the design considerations for vehicle dynamics, batteries and sizing of components. (L4)

UNIT I

Introduction to Hybrid and Electric Vehicles: History of hybrid and electric vehicles, Need for hybrid and electric vehicles and their limitations. Social and environmental importance of hybrid and electric vehicles, impact of modern drive-trains on energy supplies. Specifications of hybrid and electric vehicles.

Applications: e- mobility vehicles

Learning outcomes:

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

- **summarize** the concepts and recent trends in electrical and hybrid vehicles. (L2)
- **demonstrate** the need for hybrid and electric vehicles and their limitations. (L2)
- **compare** modern drive-trains with conventional drive-trains. (L2)

UNIT II

Hybrid Electric Drive-trains: Basic concept of hybrid traction, introduction to various hybrid drive-train topologies, power flow control in hybrid drive-train topologies.

Electric Drive-trains: Basic concept of electric traction, introduction to various electric drive-train topologies, power flow control in electric drive-train topologies.

Applications: Motor driven wheels etc.

Learning outcomes:

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

- **choose** a suitable drive scheme for developing hybrid and electricvehicles depending on resources.(L1)
- **explain** power flow control in hybrid drive-train topologies. (L2)
- **compare** hybrid electric drive-trains and electric drive-trains. (L2)

UNIT III

Electric Propulsion unit: Introduction to electric components used in hybrid and electric vehicles, Configuration and control of DC Motor drives, Configuration and control of Induction Motor drives, configuration and control of Permanent Magnet Motor drives, Configuration and control of Switch Reluctance Motor drives, drive system efficiency.
Applications: space vehicles, satellites, etc.
Learning outcomes:
At the end of this unit, the students will be able to

- **choose** a suitable drive scheme for developing an hybrid and electric vehicles depending on resources.(L3)
- **explain** power flow control in hybrid drive-train topologies.(L2)
- **clasify** hybrid electric drive-trains and electric drive-trains.(L3)

UNIT IV

Energy Storage: Introduction to Energy Storage Requirements in Hybrid and Electric Vehicles, Battery based energy storage, Fuel Cell based energy storage, Super Capacitor based energy storage, Hybridization of different energy storage devices.
Sizing the drive system: Matching the electric machine and the internal combustion engine (ICE), Sizing the propulsion motor, sizing the power electronics, selecting the energy storage technology.
Applications: Automobile energy storage systems
Learning outcomes:
At the end of this unit, the students will be able to

- **explain** fundamental electrochemistry of battery operation and performance requirements for HEV, PHEV, EREV and full electric vehicles. (L2)
- **summarize** different approaches to estimating state of charge, state of health, power and energy. (L2)
- **analyze** the driven system of electric machines and the internal combustion engine. (L4)

UNIT V

Design Considerations For Electric Vehicles: Various Resistance- Transmission efficiency- Vehicle mass- Electric vehicle chassis and Body design considerations- Heating and cooling systems- Power steering- Tire choice- Wing Mirror, Aerials and Luggage racks.
Applications: Design of electric vehicles
Learning outcomes:
At the end of this unit, the students will be able to

- **design** and develop basic schemes of electric and hybrid electric vehicles. (L3)
- **select** the suitable transmission systems.(L5)

Text Books:

1. Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, 3/e, CRC Press.
2. MehrdadEhsani, YimiGao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electricand Fuel Cell Vehicles: Fundamentals, Theory and Design, 3/e, CRC Press.

References:

1. James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2/e.
2. John G. Hayes, G. Abas Goodarzi, Electric Powertrain: Energy Systems, Power Electronics and Drives for Hybrid, Electric and Fuel Cell Vehicles, 1/e, Wiley-Blackwell, 1/e.
3. Amir Khajepour, M. SaberFallah, AvestaGoodarzi, Electric and Hybrid Vehicles: Technologies, Modeling and Control - A Mechatronic Approach, illustrated edition, John Wiley & Sons, 1st edition.

Subject Code	Subject Name	L	T	P	C
R20MEC-PE4102.4	Cryogenic Engineering (**Professional Elective -4**)	3	0	0	3

Course Objectives:

The objectives of the course are

- To provide the knowledge of evolution of low temperature science
- To provide knowledge on the properties of materials at low temperature
- To familiarize with various gas liquefaction systems
- To provide design aspects of cryogenic storage and transfer lines
- To illustrate the applications of cryogenics in the real life situations

Course outcomes:

After successful completion of this course, student will be able to

1. Understand properties of material at cryogenic temperatures. (L2)
2. Summarize various liquefaction systems available (L2)
3. Analyze on different gas liquefaction systems and cryogenic refrigeration systems(L4)
4. Outline various design aspects of cryogenic storage and transfer lines (L2)
5. Apply different cryogenic condition in real life situations (L3)

UNIT-I

Introduction to Cryogenic Systems, Historical development, Low Temperature properties of Engineering Materials, Mechanical properties- Thermal properties- Electric and magnetic properties

–Cryogenic fluids and their properties. Applications of Cryogenics.

Learning outcomes:

After completion of this unit, the student will be able to

- **understand** material properties at low temperatures (L2)
- **outline the** properties of cryogenic fluids and their applications (L2)
- **explain** the development of cryogenic systems (L2)

UNIT-II

Liquefaction systems for ideal system, Joule Thomson expansion, Adiabatic expansion, LindeHampson Cycle, Claude & Cascaded System, Magnetic Cooling, Stirling Cycle ,Cryo Coolers

Learning outcomes:

After completion of this unit, the student will be able to

- **understand** liquefaction systems available in practice (L2)
- **apply** Linde Hampson cycle for cryogenic fluid generation(L3)
- **outline** the performance of cryo coolers (L3)

UNIT-III

Gas liquefaction systems: Introduction-Production of low temperatures-General Liquefaction systems- Liquefaction systems for Neon. Hydrogen and Helium –Critical components of Liquefaction systems

Cryogenic Refrigeration systems: Ideal Refrigeration systems- Refrigeration using liquids and gasesas refrigerant- Refrigerators using solids as working media

Learning outcomes:

After completion of this unit, the student will be able to

- **summarize** the effect of Critical components of Liquefaction systems (L2)
- **understand** Production of low temperature for Neon. Hydrogen and Helium (L2)
- **illustrate** Liquefaction systems for Neon. Hydrogen and Helium (L2)
- **understand** about Cryogenic Refrigeration systems. (L2)

UNIT-IV

Cryogenic fluid storage and transfer systems: Cryogenic Storage vessels and Transportation, Thermal insulation and their performance at cryogenic temperatures, Super Insulations, Vacuum insulation, Powder insulation, Cryogenic fluid transfer systems.

Learning outcomes:

After completion of this unit, the student will be able to

- **understand** the importance of cryogenic fluid storage.(L2)
- **explain** various types of storage vessels and transportation methods of cryogenic fluid(L2)
- **summarize** the importance of proper thermal insulation in cryogenic storage (L2)

UNIT-V

APPLICATIONS: Space technology, super conductivity, In-Flight air separation and collectionof LOX, Gas industry, Biomedical, Electronics, Cutting Tool technology.

Learning outcomes:

After completion of this unit, the student will be able to

- **understand** various applications of cryogenics (L2)
- **illustrate** the importance of cryogenics in biomedical application (L2)
- **apply** different cryogenic conditions for real life situations (L3)

TEXT BOOK:

1. Fundamentals of Cryogenic Engineering, Mamata Mukhopadhyay, 4th edition, PHI
2. R. B. Scott, Cryogenic Engineering, Van Nostrand Co. , 4th edition

REFERENCES:

1. A.R Jha , Cryogenic Technologies and Applications, 3rd edition , BH
2. Cryogenic Engineering Edit / B.A. Hands/ Academic Press, 2nd edition.
3. Cryogenic Engineering/ R.B.Scottm Vin Nostrand/ Inc. New Jersey, 3rd edition.
4. Experimental Techniques in Low Temperature Physics- O.K. White, Oxford Press, 1st edition .
5. Cryogenic Process Engineering/ K.D. Timmerhaus & TM Flynn/ Plenum Press, 1st edition

Subject Code	Subject Name	L	T	P	C
R20MEC-PE4103.1	Industrial Hydraulics & Pneumatics (**PROFESSIONAL ELECTIVE –5)**	3	0	0	3

Course objective

The objectives of the course are to

- Understand the basic fundamentals of fluid power system
- Explain the working principles of hydraulic actuators and hydraulic motors
- Understand the characteristics of hydraulic circuit elements
- Explain basic concepts of pneumatic system and its components
- Describe the servo systems and its characteristics

Course Outcomes:

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

1. Understand the general concepts associated with Hydraulic systems and its components(L2)
2. Analyze the numerical problems of hydraulic circuits in hydraulic motors (L4)
3. Understand the Hydraulic control elements and working principle of Accumulators &intensifiers (L2)
4. Understand basic concept of pneumatic system and its direction control valves(L2)
5. Evaluate the performance of pneumatic / electro pneumatic system circuit problems(L3)

UNIT – I

Fundamentals of Fluid Power Systems-Introduction-types-advantages-disadvantages & applications-fluid characteristics-terminologies used in fluid power-hydraulic symbols-hydraulic systems and components-sources-pumping theory-gear, vane & piston pumps.

Learning Outcomes

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

- **Understand** Fundamentals of Fluid Power Systems. (L2)
- **Explain** the fluid characteristics (L1)

UNIT-II

Fluid Power Actuators: Introduction-hydraulic actuators-hydraulic cylinders-types, construction, specifications and special types. Hydraulic motors- working principle-selection criteria for various types-hydraulic motors in circuits- formulae-numerical problems

Learning Outcomes

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

- **Describe** construction of hydraulic actuators.(L2)
- **Explain** working principle of hydraulic motors. (L2)
- **Evaluate** the performance of hydraulic motors n circuits (L3)

UNIT-III

Hydraulic control elements-direction control valve-check valve-pressure control valve-relief valve-throttle valve-temperature & pressure compensation-locations of flow control valve. Accumulators & intensifiers-types-working principle

Learning Outcomes

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

- **Understand** hydraulic direction control valves. (L2)
- **Describe** types of Accumulators & intensifiers. (L2)
- **Explain** working principle of Accumulators & intensifiers(L2)

UNIT-IV

Pneumatic systems-Introduction-symbols used-concepts & components -types & specifications of compressors-compressed air behaviour-understanding pneumatic circuits-direction control valves Electro pneumatics- Introduction-Pilot operated solenoid valve-electrical connections to solenoids-electro pneumatic circuit switches-relays-solenoids-P.E converter-concept of latching

Learning Outcomes

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

- **Explain** working of Pneumatic system components. (L2)
- **Explain** direction control valves. (L2)
- **Explain** P.E converter and concept of latching. (L2)

UNIT-V

Applications-servo systems-introduction-closed loop, hydro-mechanical and electro hydraulic– conventional and proportional valves-characteristics of proportional and servo valves- PLC applications in fluid power – selected pneumatic / electro pneumatic circuit problems – failure and trouble shooting in fluid power systems.

Learning Outcomes

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

- **Describe** servo systems. (L2)
- **Explain** characteristics of proportional and servo valves. (L2)
- **Evaluate** the performance of pneumatic / electro pneumatic circuit problems (L3)
- **Explain** failure and trouble shooting in fluid power systems.(L2)

TEXT BOOKS:

1. Introduction to Hydraulics and Pneumatics by S. Ilango and V.Soundararajan, PHI, NewDelhi, 3rd edition
2. Hydraulics and pneumatics by T. Jagadeesha, Dreamtech press, 1st edition

REFERENCE BOOKS:

1. Oil Hydraulic Systems, S.R .Majumdar, McGrawHill Companies, 1st edition
2. Pneumatic Systems: Principles and Maintenance, Majumdar, McGrawHill, 1st edition.
3. Industrial Hydraulics and Pneumatics by P.K Chandrasekara, P.B. Mali, Tech Neo Publications llp, Pune, 1st edition

Subject Code	Subject Name	L	T	P	C
R20MEC-PE4103.2	Industrial Robotics (**Professional Elective –5)**	3	0	0	3

Course Objectives: The goal of the course is to familiarize the students with the concepts andtechniques in robotic engineering, manipulator kinematics, dynamics and control, chose, and incorporate robotic technology in engineering systems.

- Make the students acquainted with the theoretical aspects of Robotics
- Enable the students to acquire practical experience in the field of Robotics
- Understand forward and inverse kinematics of robot manipulator
- Program a Robot for material handling.

Course Outcomes

Upon completion of this course, students will be able to

1. Understand the basic components of robots .(L2)
2. Differentiate types of robot grippers. (L2)
3. Explain the manipulator kinematics. (L2)
4. Illustrate robot actuators and feedback components. (L2)
5. Explain the robot applications in manipulator. (L2)

UNIT-I

Robotics-Introduction-classification with respect to geometrical configuration (Anatomy). Controlled system & chain type: Serial manipulator & Parallel Manipulator. Components of Industrial robotics-precession of movement-resolution, accuracy & repeatability-Dynamic characteristics- speedof motion, load carrying capacity & speed of response-Sensors-Internal sensors: Position sensors, & Velocity sensors. External sensors: Proximity sensors, Tactile Sensors, & Force or Torque sensors.

Learning outcomes:

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

- **classify** robots with respect to geometric configuration.(L2)
- **illustrate** the components of robots.(L2)

UNIT-II

Grippers Mechanical Gripper-Grasping force-Engelberger-g-factors-mechanisms for -actuation, Magnetic gripper, vaccume cup gripper-considerations in gripper selection & design. Industrial robots specifications. Selection based on the Application.

Learning outcomes:

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

- **understand** the mechanisms for grippers. (L2)
- **explain** the factors for gripper selection. (L2)

UNIT-III

Motion Analysis:

Basic Rotation Matrices, Equivalent Axis and Angle, Euler Angles, Composite Rotation Matrices. Homogeneous transformations as applicable to rotation and translation.

Manipulator Kinematics-H notation –H method of Assignment of frames –H Transformation Matrix, joint coordinates and world Manipulation. Coordinates, Forward and inverse kinematics, Industrial Robotic

Learning outcomes:

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

- **understand** the basic Rotation matrices. (L2)
- **explain** the forward and inverse kinematics. (L2)

UNIT-IV

Robot actuators and Feedback components: Actuators: Pneumatic, Hydraulic actuators, electric & stepper motors, comparison of Actuators, Feedback components: position sensors - potentiometers, resolvers, encoders - Velocity sensors, Tactile and Range sensors, Force and Torque sensors - End Effectors and Tools

Learning outcomes:

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

- **compare** the robot actuators. (L2)
- **explain** the sensors used in Robotics. (L2)

UNIT-V

Robot Application in Manufacturing: Material Transfer - Material handling, loading and unloading- Processing spot and continuous arc welding & spray painting Assembly and Inspection. Robotic Programming Methods - Languages: Lead Through Programming, Textual Robotic Languages such as APT, MCL.

Learning outcomes:

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

- **explain** the role of robotics in material handling in industries. (L2)
- **understand** the Robotic Programming methods.(L2)

TEXT BOOK(S):

1. Industrial Robotics / Groover M P /Mc Graw Hill,2nd edition.
2. Introduction to Robotics / John j.Craig / Pearson, 4th edition

REFERENCE(S):

1. Introduction to Industrial Robotics / Ramachandran Nagarajan / Pearson, 1st edition
2. Robot Dynamics and controls / Spony and Vidyasagar / John Wiley, 2nd edition.

Subject Code	Subject Name	L	T	P	C
R20 MEC-PE4103.3	Gas Dynamics and Jet Propulsion (**Professional Elective –5)**	3	0	0	3

Course Objectives:

The Objectives of this course are to

- Understand the concept of Mach number and equations of continuity andmomentum.
- Effect of stagnation properties on nozzle efficiencies.
- Understand frictional flow and its governing equations
- Get awareness on working of Jet engines
- Explain the working of space craft engines

Course outcomes:

After successful completion of this course, student will be able to

1. Explain sonic velocity, mach number and continuity and momentum equations for a control volume (L2)
2. Identify stagnation properties, performance of nozzle and nozzle efficiencies.(L3)
3. Analyze the gas flow in different situations with and without friction (L4).
4. Understand the working of Jet engines (L2)
5. Explain the working of Space craft engines (L2)

UNIT-I

Introduction to gas dynamics: Control volume and system approaches acoustic waves and sonic velocity - Mach number - classification of fluid flow based on Mach number - mach cone- compressibility factor - general features of one dimensional flow of a compressible fluid-Continuity and momentum equations for a control volume.

Learning outcomes:

After completion of this unit, the student will be able to

- **understand** acoustic waves and sonic velocity (L2)
- **Illustrate**the concept of Mach number on gas dynamics (L2)
- **Apply**the continuity and momentum equations for control volume (L3)

UNIT-II

FLOW THROUGH DUCTS Flows through constant area ducts with heat transfer (Rayleigh flow) and Friction (Fanno flow) – variation of flow properties.– Isentropic flow through variable ducts – Nozzle and Diffusers

Applications: Nozzles.

Learning outcomes:

After completion of this unit, the student will be able to

- **Understand**basic properties of gases (L2)
- **apply** governing equations on gas flow (L3)
- **Explain** the working behaviour of nozzle (L2)

UNIT- III

NORMAL AND OBLIQUE SHOCKS Governing equations – Variation of flow parameters across the normal and oblique shocks – Prandtl – Meyer relations –Applications.

Applications: Aero dynamics

Learning outcomes:

After completion of this unit, the student will be able to

- **study** the effect of friction on flow properties (L1)
- **understand** the formation of shock waves and its properties (L2)
- **explain** about fanno line and Rayleigh line (L2)

UNIT- IV

Propulsion: Air craft propulsion: - types of jet engines - energy flow through jet engines, thrust, thrust power and propulsive efficiency turbojet components- diffuser, compressor,

combustion chamber, turbines, exhaust systems.
Applications: Gas turbines
Learning outcomes:
After completion of this unit, the student will be able to

- **Compare** different types of jet engines (L4)
- **Understand** different components in air craft engines(L2)
- **illustrate** the energy flow through jet engines (L2)

UNIT-V

Types of rocket engines – Propellants-feeding systems – Ignition and combustion – Theory of rocket propulsion – Performance study – Staging – Terminal and characteristic velocity – Applications – space flights.
Applications: Aero space applications
Learning outcomes:
After completion of this unit, the student will be able to

- **Illustrate**different air propulsion systems (L2)
- **understand** the working principle of rocket propulsion (L2)
- **Differentiate** fuels used in Air craft and rocket Engines (L3)

Text Books:

1. Gas Dynamics/Ethirajan Rathakrishnan /fourth edition/PHI
2. Fundamentals of compressible flow with aircraft and rocket propulsion/S. M. Yahya /New Age international Publishers

References

1. Gas Dynamics and Jet propulsion/S.L.Soma sundaram
2. Gas Turbines/V.Ganesan/ 3rd edition
3. Turbines, compressors and fans, S.M.Yahya

Course code	Course Title	L	T	P	C
R20MEC-PE4103.4	Advanced Materials **(Professional Elective-5)**	3	0	0	3

Course Objectives

- To understand the mechanics of advanced materials.
- Explain the concepts of anisotropic material behavior, constituent properties and manufacturing processes of different composites.
- Suitability of smart and nano materials for engineering applications.
- Identify appropriate material types for solving real life engineeringproblems

Course Outcomes:

After completing the course, the student will be able to

1. Identify and describe different types of material processing techniques for advanced materials (L2)
2. Understand the suitable material for specific applications (L2)
3. Illustrate the various techniques for preparation and fabrication of advanced materials. (L3)
4. Explain the concept of functionally graded materials and shape memory alloys/composites. (L2)
5. Analyze the various top down and bottom-up methods for synthesis of nanomaterials. (L4).

UNIT-I

INTRODUCTION TO COMPOSITE MATERIALS: Introduction, classification: polymer matrix composites, metal matrix composites, ceramic matrix composites, carbon–carbon composites, fiber- reinforced composites and nature-made composites, and applications.

REINFORCEMENTS: Fibres- glass, silica, kevlar, carbon, boron, silicon carbide, and born carbide fibres.

Learning Outcomes:

After completing the unit, the student will be able to

- **Understand** the application and properties of different composite materials.(L2)
- **Select** the suitable fibers based on their applications. (L1)

UNIT-II

Polymer composites, thermoplastics, thermosetting plastics, manufacturing of PMC, MMC & CCC and their applications.

MANUFACTURING METHODS: Autoclave, tape production, mouldingmethods, filament winding, man layup, pultrusion, RTM.

Learning Outcomes:

After completing the unit, the student will be able to

- **Select** appropriate manufacturing techniques for a given composite structure/ application and describe current areas of technology development for composites processing. (L3)
- **Understand** the various methods for manufacturing of composite materials. (L2)

UNIT-III

MACROMECHANICAL ANALYSIS OF A LAMINA: Introduction, generalized hooke's law, reduction of hooke's law in three dimensions to two dimensions, relationship of compliance and stiffness matrix to engineering elastic constants of an orthotropic lamina, laminate-laminate code.

Learning Outcomes:

After completing the unit, the student will be able to

- **Understand** the laws of composite materials. (L2)
- **Explain** elastic constants of a laminates. (L2)
- **Identify** stiffness and strength of unidirectional laminates, failurecriteria (L3)

UNIT-IV

FUNCTIONALLY GRADED MATERIALS: Types of functionally graded materials-classification-different systems-preparation-properties and applications of functionally graded materials.

SHAPE MEMORY ALLOYS: Introduction-shape memory effect- classification of shape memory alloys-composition-properties and applications of shape memory alloys.

Learning Outcomes:

After completing the unit, the student will be able to

- **Summarize** the functionally graded materials for a givenapplication. (L2)
- **Explain** the concept of shape memory alloys/composites. (L2)

UNIT-V

NANO MATERIALS: Introduction-properties at nano scales-advantages & disadvantages-applications in comparison with bulk materials (nano – structure, wires, tubes, composites). state of art nano advanced- topic delivered by student.

Learning Outcomes:

After completing the unit, the student will be able to

- **Illustrate** the concept of nanomaterials and associated changes in their properties from bulk. (L2)
- **Analyze** the various top down and bottom-up methods for synthesis of nanomaterials. (L3)
- **Explain** the properties and applications of some recently developed nanostructures. (L2)

TEXT BOOKS:

1. Nano material by A.K. Bandyopadyay, New age Publishers, 1st edition
2. Material science and engineering by R Balasubramaniam, 2nd edition, wiley publications.
3. Material science and engineering, A first course, sixth edition, PHIlearning pvt. ltd.

REFERENCES:

1. R. M. Jones, Mechanics of Composite Materials, Mc Graw HillCompany, New York, 1st edition
2. L. R. Calcote, Analysis of Laminated Composite Structures, Van Nostrand Rainfold, 1st edition.
3. B. D. Agarwal and L. J. Broutman, Analysis and performance of fibre Composites, Wiley-Interscience, New York, 3rd edition.
4. Mechanics of Composite Materials, Second Edition (Mechanical Engineering), Autar K.Kaw, Publisher: CRC, 2nd edition.

Subject Code	Subject Name	L	T	P	C
R20CIT-OE4103	Computer Networks **(Open Elective –3)**	3	0	0	3

Course Objectives:

- Understand the network architecture and applications.
- Understand about the basic Networking Components and their functionality.
- Understand the functionalities of the Data Link Layer.
- Understand the protocols for data transfer.
- Analyze different protocols and architecture of IEEE802.11

Course Outcomes:

1. Understand and Compare the Reference Models. (L2)
2. Identify the Network Components and learn about their functionality. (L3)
3. Analyze the services provided by the Data Link Layer to the Network Layer.(L4)
4. Understand the use of Transport Layer protocol (L2).
5. Understand the architecture of Client Server (L2).

UNIT-1:Introduction:

Components of a Data Communication system, Dataflow, Network Topologies LAN, MAN, WAN. Reference models-The OSI Reference Model-the TCP/ IP Reference Model

Learning Outcomes: Student will be able to

- **Learn** the fundamentals of data communication and networks. (L2)
- **Learn** the need of layer architecture. (L2)
- **Analyze** the network reference models (L4)

UNIT2: Physical Layer and its overview:

Transmission Media: Guided, Unguided. Bandwidth, throughput, Latency. Multiplexing: frequency division multiplexing, wave length division multiplexing, synchronous time division multiplexing.

Learning Outcomes: Student will be able to

- **Understand** various transmission medium. (L2)
- **Analyze** analog and digital multiplexing techniques. (L4)

UNIT-3: Data Link Layer Design Issues:

Data link layer: Design issues, **Framing**: fixed size framing, variable size framing, flow control, error control, error detection and correction, CRC **Elementary Data Link Layer protocols**: simplex protocol, Simplex stop and wait, Simplex protocol for Noisy Channel. **Sliding window protocol**: One bit,
Go back N, Selective repeat-Stop and wait protocol.

Learning Outcomes: Student will be able to

- **Learn** various framing techniques. (L2)
- **Learn** about error and flow control mechanisms. (L2)

UNIT -4: Random Access:

ALOHA, MAC addresses, Carrier sense multiple access (CSMA), CSMA with Collision Detection, CSMA with Collision Avoidance

Network Layer: Routing algorithm shortest path routing, Flooding, Hierarchical routing, Broadcast, Multicast, distance vector routing.

The Transport Layer: addressing, establishing a connection, releasing a connection

Learning Outcomes: Student will be able to

- **Learn** how to access a channel. (L2)
- **Understand** various routing algorithms. (L2)
- **Understand** the connection establishment and release. (L2)

UNIT–V: Application layer (WWW and HTTP):

Architecture: Uniform Resource Locator, HTTP: HTTP Transaction, HTTP Operational Model and Client/Server Communication, HTTP Generic Message Format, HTTP Request Message Format, HTTP Response Message Format.

Learning Outcomes: Student will be able to

- **Analyze** HTTP message formats. (L4)
- **Understands** the basic architecture of client-server model. (L2)

Text Books:

1. Data Communications and Networking, Behrouz A Forouzan, FourthEdition.
2. Tanenbaumand David J Wetherall, Computer Networks,5th Edition, PearsonEdu.

Reference Books:

1. Computer Networks: A Top Down Approach, Behrouz A. Forouzan, Firouz Mosharraf, McGraw Hill Education
2. LarryL. Peterson and Bruce S.Davie, "Computer Networks-A Systems Approach" (5thed), Morgan Kaufmann/Elsevier.

Subject Code	Subject Name	L	T	P	C
R20EEE-OE4103	Basics of Utilization of Electrical Energy **(Open Elective –3)**	3	0	0	3

Course Objectives:

- To understand the laws of illumination and their applications for various lighting schemes.
- To understand the methods of electric heating and electric welding.
- To know the electric traction system and its equipment
- To identify the speed-time curves of different services and energy consumption levels at various modes of operation
- To analyze the economic aspects of utilization of electrical energy

Course Outcomes: After completion of the course, students are able to

1. Calculate the illumination levels produced by various lighting schemes (L3)
2. Identify most appropriate heating and welding techniques for different applications (L3)
3. Understand the basic concepts of electric traction (L2)
4. Calculate the energy consumption levels at various modes of operation (L3)
5. Analyze the economic aspects of utilization of electrical energy (L4)

UNIT–I

Illumination: Basic definitions of Illumination, Laws of Illumination, Polar Curves, Calculation of MHCP and MSCP, Lamps: Incandescent Lamp, Sodium Vapour Lamp, Fluorescent Lamp, CFL and LED. Requirement of Good Lighting Scheme, Types, Design and Calculation of Illumination, Street Lighting and Factory Lighting, Numerical Problems, Energy Conservation methods.

Learning outcomes: The students are able to

- Understand the concept of illumination and working principle of various lamps (L2)
- Calculation of Illumination for different lighting schemes (L3)

UNIT–II

Electric Heating &Electric Welding: Electrical Heating: Advantages, Methods of Electric Heating – Resistance, Arc, Induction and Dielectric Heating, Applications of electric heating. Electric Welding: Types – Resistance, Electric Arc, Gas Welding, Ultrasonic, Advantages & disadvantages of electric welding, Applications of electric welding .

Learning outcomes: The students are able to

- Understand the electrical heating methods (L2).
- Identify most appropriate welding techniques for various applications (L3)

UNIT–III

Electric Traction – I : Introduction, Systems of Electric Traction, Comparison Between A. C. and D. C Traction, Special Features of Traction Motors, The Locomotive, Wheel arrangement and Riding Qualities, Transmission of Drive, Characteristics and Control of Locomotives and Motor Coaches for Track Electrification, DC Equipment, AC Equipment, Electric Braking with DC Motors and AC Motors, Overhead Equipment, Numerical Problems.

Learning outcomes: The students are able to

- Understand the concepts of A. C. and D. C. Traction systems (L2).
- Understand the various equipment associated with electric traction system (L2)

UNIT–IV

Electric Traction – II: Speed-Time Curves of Different Services, Trapezoidal and Quadrilateral Speed-Time Curves, Numerical Problems, Mechanics of Train Movement, Calculations of Tractive Effort, Power, Specific Energy Consumption, Effect of Varying Acceleration and Braking Retardation, Adhesive Weight and Dead Weight, Adhesive Weight and Coefficient of Adhesion, Problems.

Learning outcomes: The students are able to

- Explain the speed time curves of different services (L2)
- Calculate Energy Consumption levels at various modes of operation (L3)

UNIT–V

Economic Aspects of Utilizing Electrical Energy: Power Factor Improvement, Load Factor improvement, Off Peak Loads, Use of Exhaust Steam, Waste Heat recovery, Pit Head Generation, Diesel Plant, General Comparison of Private Generating Plant and Public Supply- Initial Cost and Efficiency, Capitalization of Losses.

Learning outcomes: The students are able to

- Understand the concepts of Economic Aspects of Utilizing Electrical Energy(L2)
- Compare the various economic aspects of Utilization of Electrical Energy(L4)

Text Books:

1. Utilization of Electric Energy, E. Openshaw Taylor and V. V. L. Rao, Universities Press, 2009.
2. Art & Science of Utilization of electrical Energy, Partab,Dhanpat Rai & Co., 2004.

Reference Books:

1. Generation, distribution and utilization of electrical energy, C.L Wadhwa, Wiley Eastern Limited,1993
2. Electrical Power, S. L. Uppal, Khanna publishers,1988.
3. Utilization of Electrical Power including Electric drives and Electric traction – by N.V.Suryanarayana, New Age International (P) Limited, Publishers, 1996.

Subject Code	Subject Name	L	T	P	C
R20BSH-OE4103	Optimization techniques in Operations Management (**Open Elective –3)**	3	0	0	3

Course Objectives:

- Comprehend the knowledge of operations management andbest practices in the manufacturing units.
- Apply quantitative techniques for operations management decisions.
- Elucidate the recent trends in Operations management
- Learn tools, analytical frameworks and general principles for managingoperations.

Course Outcomes:

1. Develop the facility layouts for mass production and job order production systems for the space available, job and product manufacturing activities data (L3)
2. Apply the inventory management concepts for deterministic inventory models to optimize the total inventory control cost. (L3)
3. Develop mathematical models for aggregate capacity planningmethods to meet capacity requirements with variable demand of the products for optimizing the total cost of plan (L3)
4. Determine the optimal strategy for scheduling in make to order systemsfor the specified time elements required to fabricate the job orders. (L3)
5. Apply the operational economics principles to strategically optimize costs in business operations. (L3)

UNIT-I

Definition of operations management, Nature and Scope of Operations Management-– Characteristics of production systems, Make to order, Make to stock systems, facility layout – types, design of layouts-travel chart, assembly line balancing- exercise with heuristic method. Product mix decisions

Learning Outcomes:

At the end of this unit students will be able to:

- **outline** the scope of operations management(L2)
- **plan** the facility layout for optimization of time and cost.(L3)

Application:

- Planning work stations for assembly lines.
- Layout preparation for job shops.

UNIT-II

Materials Management – Objectives, functions, Inventory control : costs associated with inventory control, EOQ, finite rate of replenishment model. Selective Inventory control methods , reorder level in practical inventorysystem with variable demand and lead time

Learning Outcomes:

At the end of this unit students will be able to:

- **explain** the functions of materials management(L2)
- **apply** deterministic inventory control models to optimize cost of inventory control. [L3]

Application:

- Stores inventory management in manufacturing plants.
- Design the practical inventory control systems for cost optimization

UNIT-III

Operations planning and control as an integrated system - Aggregate planning strategies, optimal aggregate plan-Linear programming approach to Aggregate planning -exercises–

Concepts of just-in- time production, Pull and push system of work flow in JIT, kanban system.

Waiting lines in manufacturing units: Introduction – Basic queuing process, basic structure of queuing models terminology, Kendall's notation. Single work centre model with poisson arrivals of jobs, exponential processing times – exercises.

Learning Outcomes:

At the end of this unit students will be able to:

- **analyze** the Aggregate planning strategies for cost optimization (L4)
- **explain** the goals of designing waiting line model (L2)

Application: 1. Optimal aggregate plan in beverage plants.

2. JIT implementation in automobile plants.

UNIT-IV

Operations Scheduling in production systems: Forward scheduling, backward scheduling. Scheduling in batch production, determination of batch size, sequencing and scheduling for batch production

Job shop scheduling – Introduction – flow –shop sequencing – n jobs through two machines – n jobs through three machines – job shop sequencing – two jobs through 'm' machines. Scheduling on single work centre, flow time, lateness calculations, Gantt chart for scheduling.

Learning Outcomes:

At the end of this unit students will be able to:

- **solve** the problems of scheduling for batch production (L3)
- **compare** the priority decision rules for scheduling the jobs. (L2)

Application: 1. Scheduling in batch production units –beverage plants, soap making units.

2. Scheduling in job order plants- foundry units, machine shops

UNIT-V

Operational Economics : Introduction –Product life cycle- Elements of costs, Estimating manufacturing costs, Break even analysis-applications-Economical factors for make or buy decisions-exercises- reliability engineering –reliability concept-bath tub curve, MTBF, System reliability: series arrangement of components, parallel arrangement of components

Learning Outcomes:

At the end of this unit students will be able to:

- **analyze** the manufacturing costs for process selection and make or buydecisions (L4)
- **solve** the problems on System reliability (L3)

Application: 1**.** Automobile units applying concepts of make or buy decisions for ordering parts.

2. Reliability analysis of spare parts.

Text Books:

1. Prem kumar Gupta and Hira, Operations Research, 3rd Edition, S Chand CompanyLtd.,New Delhi.
2. Panner Selvem: "Production and Operation Management", Prentice Hall of India, New Delhi.

REFERENCE BOOKS:

1. Industrial Engineering & Production Management –Martand Telsang, S.Chand & Co
2. Production and operation Management–By P. Ramamurty –New Age International Publication, New Delhi

Subject Code	Subject Name	L	T	P	C
R20ECE-OE4105	**Fundamentals of Image Processing (Open Elective -3)**	3	0	0	3

Course Objectives: This course will help to

- Understand the fundamentals of image processing.
- Apply various processes on images for image understanding.
- Understand the design aspects and realization of image processing applications.

Course Outcomes (COs)

1. Understanding the fundamental concepts of a digital image processing system.
2. Analyze different image sampling domains.
3. Understand the concept of image transforms and implementation
4. Implement different image enhancement techniques for different applications
5. Estimate the different noises present in the image and restore the image quality.

UNIT 1

Introduction : Digital Image definitions ,Types of Operations ,Types of neighborhoods, Video parameters 2D convolution ,Properties of 2D convolution, 2D Fourier Transforms, Properties of 2D Fourier Transforms , Importance of phase and magnitude , Circularly Symmetric Signals,

Applications: Fundamentals of image processing is used to analyze the images.

Learning Outcomes:

- Understand the fundamental concepts of a digital image processing signals
- Analyze the different types of signals

UNI T 2

Image Sampling: Two dimensional Sampling theory, Extensions of sampling theory, Non rectangular Grid sampling, Hexagonal sampling, Optimal sampling. Image Quantization: The optimum Mean Square Lloyd-Max quantizer, Optimum mean square uniform quantizer for non uniform densities, Analytic Models for practical quantizes, Visual quantization, Vector Quantization. MATLAB Implementations.

Applications:

- Image sampling is mainly used to get the clear image .
- Video processing and image processing

Learning Outcomes:

- Analyze different image sampling theorems and simulation using MAT lab

UNIT 3

Image Transforms: Two dimensional orthogonal and unitary transforms, Separable unitary transforms, Basis images: Dimensionality of Image Transforms, Discrete linear orthogonal, DFT, WHT, KLT, DCT and SVD, Quantization of Transform coefficients, Transform Coding of Color images.

Applications:

- Signature Verification-Preprocessing of Signature Patterns Biometric Pattern Recognition-

Learning Outcomes:

- Understand the concept of image transforms and implementation

UNIT 4

Image Enhancement: Contrast and dynamic Range Modification, Histogram-based operations, Smoothing operations, Edge Detection-derivative based operation, Image Interpolation and Motion Estimation, Pseudo coloring.

Applications:

- XRay Image Analysis

- Spectral reflectance of various earth objects

Learning Outcomes:

- implement different image enhancement techniques for different applications

UNIT 5

Image Restoration: Degradation Estimation, Reduction of Additive Noise, Reduction of Image Blurring, Simultaneous reduction of noise and blurring, Reduction of Signal dependent noise, Temporal filtering for Image Restoration, Extrapolation of Band limited Signals.

Applications:

- Pixel-based model- Shadow Detection-Surveillance systemAgriculture Industry-Robotics

Learning Outcomes:

- Estimate the different noises present in the image and restore the image quality.

Text Books:

1. Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing", 3rd Edition, Hardcover August 31, (2007).
2. J. R. Parker, "Algorithms for Image Processing and Computer Vision", Paperback,December 21, (2010).
3. Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, "Digital Image ProcessingUsing MATLAB", Hardcover – December 26, (2003).

Subject Code	Subject Name	L	T	P	C
R20ECE-OE4106	Fundamentals of Neural Networks And Fuzzy Techniques **(Open Elective -4)**	3	0	0	3

Course Objectives:

Students are able to study

- Fundamental concepts of fuzzy logic and artificial neural networks.
- analyze the various intelligent control systems
- Design the various intelligent control systems

Course outcomes:

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

1. Comprehend the concepts of feed-forward neural networks. (L2)
2. Analyze the various feedback networks. (L4)
3. Understand the concept of fuzziness involved in various systems and fuzzy set theory. (L2)
4. Understand the principle of competitive neural networks and Adaptive resonance theory. (L2)
5. Learn the architecture and algorithm of Cognitron, Neo-cognitron along with the concepts of fuzzy associative memory and fuzzy systems. (L1)

Unit-I

Architecture Of Neural Networks: Architectures: motivation for the development of naturalnetworks-artificial neural networks-biological neural networks-area of applications.

Learning Outcome: students will be able to

- Understand what feed forward neural networks are and how they function. Applications:
- Artificial neural networks are used for solving real world problem

Unit II

Basic Neural Network Techniques: Back propagation neural net: standard back propagation-architecture algorithm- derivation of learning rules number of hidden layers--associative and other neural networks- hetro associative memory neural net, auto associative net- Bidirectional associative memory-applications-Hopfield nets-Boltzman machine

Learning outcome: students will be able to

- Examine the different feedback networks.

Applications:

- Neural Networks are used in the field of character and face recognition

Unit-III

Fundamentals Of Fuzzy Logic: Basic concepts: fuzzy set theory- basic concept of crisp sets and fuzzy sets- complements- union intersection combination of operation- general aggregation operations- fuzzy relations-compatibility relations-orderings- morphisms- fuzzy relational equations-fuzzy set and systems

Learning Outcome: Students will be able to

- Familiarize with the notion of fuzziness as it applies to different systems and fuzzy settheory.

Applications:

- Speech recognition, facial characteristics recognition are the important application of FuzzyLogic

UNIT IV

Competitive Neural Networks: Neural network based on competition: fixed weight competitive nets- Kohonenself organizing maps and applications-learning vector quantization- counter propagation nets and applications adaptive resonance theory: basic architecture and operation-architecture, algorithm, application and analysis of ART1 & ART

Learning Outcome: Students will be able to

- Understand the competitive neural network concept as well as adaptive resonancetheory.

Applications:

- Fuzzy Logic is used in the Aerospace industry to control the altitude of aircraft and satellites

UNIT V

Special Neural Networks: Cognitron and Neocognitron - Architecture, training algorithm and application-fuzzy associate memories fuzzy system architecture- comparison of fuzzy andneural systems.

Learning Outcome: Students will be able to

- Learn the design and algorithm of Cognitron and Neo cognitron, as well as fuzzyassociative memory and fuzzy systems ideas.

Applications:

- The target can be recognized easily using Fuzzy Logic, be it underwater or above the groundin the defence sector

Text books

1. T1. Kliryvan- Fuzzy System & Fuzzy logic Prentice Hall of India, First Edition.
2. Lawrence Fussett- fundamental of Neural network Prentice Hall , First Edition.

Reference Books:

1. Bart Kosko, ―Neural network and Fuzzy System‖ - Prentice Hall.
2. J.Klin and T.A.Folger, ―Fuzzy sets‖ University and information- Prentice Hall.
3. J.M.Zurada, ―Introduction to artificial neural systems‖-Jaico Publicationhouse,Delhi.
4. VallusuRao and HayagvnaRao , ―C++ Neural network and fuzzy logic‖- BPB andPublication, New Delhi.
5. Intelligent Systems and Control-http://nptel.ac.in/courses/108104049/16

Subject Code	Subject Name	L	T	P	C
R20CSE-OE4103	Operating System Concepts **(Open Elective –4)**	3	0	0	3

Course objectives:

- Provide knowledge about the services rendered by operating systems.
- Present detail discussion on processes, threads and scheduling algorithms.
- Expose the student with different techniques of handling deadlocks.
- Discuss various file-system implementation issues and memory management techniques..
- Learn the basics of Linux system and Android Software Platform**.**

Course Outcomes:

1. Understand the importance of operating systems and different types of system calls (L2).
2. Analyze process scheduling algorithms and various IPC mechanisms.(L4).
3. Understand the process synchronization, different ways for deadlocks handling. (L2).
4. Analyze different page replacement methods, various File management techniques. (L4).
5. Understand Mass Storage Management (L2).

UNIT-I:

Operating Systems Overview: Introduction: what is an operating system, Types of operating systems, operating systems concepts, operating systems services, Introduction to System call, System call types? Operating System Generation

Learning outcomes: Student should be able to

- Understand operating system structure and functions. (L2).
- Understand operating system services and system calls (L2).

UNIT–II:

Process Management: Process concept: Process Concept, Process Scheduling, Operations on Processes, Inter process Communication.

Multithreaded Programming: Overview, Multithreading models, Threading Issues.

Process scheduling: Basic Concepts, Scheduling Criteria, Scheduling Algorithms.

Learning outcomes: Student should be able to

- Identify various message sharing mechanisms used in IPC. (L2).
- Understand how to handling multiple threads. (L2).
- Differentiate between preemptive, non-preemptive and real time CPU scheduling (L2).

UNIT-III:

Synchronization: Process Synchronization,The Critical-Section Problem, Synchronization Hardware, Semaphores, Classic Problems of Synchronization, Monitors, Synchronization examples

Principles of deadlock – System Model, Deadlock Characterization, Deadlock Prevention, Detection and Avoidance, Recovery form Deadlock

Learning outcomes: Student should be able to

- Analyze various solutions for process synchronization. (L4).
- Analyze the reasons for deadlocks and proposed solutions to detect, avoid, recovery from deadlocks.(L4).

UNIT-IV:

Memory Management: Memory Managementstrategies: Swapping, Contiguous Memory Allocation, Segmentation, Paging, Structure of the Page Table.

Virtual Memory Management: Virtual Memory, Demand Paging, Page-Replacement Algorithms, Thrashing..

Learning outcomes: Student should be able to

- Demonstrate the ability to implement various memory management techniques (L2)
- Illustrate various demand paging techniques. (L2).

UNIT-V:

File system Interface- the concept of a file, Access Methods, Directory and Disk structure, File system mounting.

File System implementation: File system structure, allocation methods, free-space management

Mass-storage structure:overview of Mass-storage structure, Disk scheduling, Device drivers

Learning outcomes: Student should be able to

- Identify various file management and optimization techniques. (L2).
- Understand how data streams are exchanged between I\O subsystems.(L2).
- Analyze various storage structures to store the data in secondary memory. (L4).
- Analyze different disk scheduling algorithms. (L4).

Text Books:

1. Silberschatz A, Galvin P B, and Gagne G, Operating System Concepts, 9th edition, Wiley, 2013.
2. Tanenbaum A S, Modern Operating Systems, 3rd edition, Pearson Education, 2008. (forInterprocess Communication and File systems).

References:

1. Tanenbaum A S, Woodhull A S, Operating Systems Design and Implementation, 3rd edition, PHI, 2006.
2. Dhamdhere D M, Operating Systems A Concept Based Approach, 3rd edition, Tata McGraw-Hill, 2012.
3. Stallings W, Operating Systems -Internals and Design Principles, 6th edition, Pearson Education, 2009.
4. Nutt G, Operating Systems, 3rd edition, Pearson Education, 2004.

Subject Code	Subject Name	L	T	P	C
R20BSH-OE4104	Supply Chain Management **(Open Elective -4)**	3	0	0	3

Course objectives

The students will learn

- Identify the strategies and models of Supply Chain Management
- Describe the criteria for Supply Chain Management decisions
- Understand the Key issues in supply chain management
- Understand the uncertainties in supply chain management.

Course Outcomes

Students will be able to

1. Explain the strategies and models of Supply Chain Management(L2)
2. Identify the prospective supplier with Vendor rating (L3)
3. Apply the inventory management concepts for deterministic inventory models to optimize the total inventory control cost (L3)
4. Apply the inventory management concepts to uncertainty cases. (L3)
5. Determine the criteria for decision making in Supply Chain Management. (L3)

UNIT I

Introduction to Supply Chain Management (SCM): Concept of Logistics Management, Concept of SCM, Core competency, Value chain, Elements of supply chain efficiency, Flow in supply chains, Key issues in supply chain management.

Application: Automobile plants, Machinery units, Machine tools industry, Electronic goods industry

Learning Outcomes:

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

- **Compare** Logistics and Supply Chain Management(L2)
- **Explain** the key issues in supply chain management(L2)

UNIT II

Sourcing and Procurement: Outsourcing benefit, Importance of suppliers, Evaluating a potential supplier, Vendor rating, Competitive bidding and Negotiation, E-procurement Application: Online ordering system, Purchase of capital goods in large scale industries, Selection of supplies in manufacturing plants.

Learning Outcomes:

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

- **Outline** the sources to get suppliers information. (L2)
- **Identify** the prospective supplier with Vendor rating(L3)

UNIT III

Introduction to Inventory Management: Selective Control Techniques, ABC analysis – procedure, VED analysis, Inventory control costs. Deterministic Inventory Models with out shortages, Quantity Discounts -Make-or-buy decisions. -Exercises

Application: Stores management in manufacturing plants

Learning Outcomes:

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

- **Explain** the significance of Inventory Management. [L2]
- **Analyze** the inventory control costs related to deterministic models. [L4]

UNIT IV

Independent Demand Systems (Probabilistic Models): Q- system, P- system, Reorder level, buffer stock, and service level, -Exercises, Bullwhip effect, Information system for Supply Chain Management

Application: Inventory management with uncertainties in manufacturing plants

Learning Outcomes:

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

- **Develop** the parameters of practical inventory systems. [L3]
- **Explain** the bullwhip effect to meet demand in managing the Supply Chain[L2]

UNIT V

Decision making and application: Decision making in SC – Applications of SCM – warehouse management system – product data management – E –Commerce – Reverse logistics – Cases in Automobile industry – Machine tools industry, Electronic goods industry Application: Ware house management in manufacturing plants, Automobile industry –Machine tools industry, Electronic goods industry

Learning Outcomes:

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

- **Outline** the applications of SCM
- **Explain** the functions of the warehouse management system
- **Summarize** the issues related to Reverse logistics

Text Books

1. Doebler, D.W. and Burt, D.N., Purchasing and Supply Chain Management: Text and Cases, McGraw-Hill Publishing Company Limited, New Delhi.

Reference Books

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

Course code	Course Title	L	T	P	C
R20EEE-OE4102	Energy Conservation and Auditing **(Open Elective -4)**	3	0	0	3

Course objectives:

- To discuss essential aspects of the current and future energy scenario
- To acquire knowledge on energy auditing and uses of audit instruments for energy audit.
- To study about energy conservation systems and its importance
- To understand the methods of improving energy efficiency in different electrical systems.
- To calculate life cycle costing analysis and return on investment on energy efficient technologies.

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

1. Understand the current energy scenario and strategic plans for future energy development, focusing on renewable energy integration and efficient energy management (L2).
2. Apply the concepts of energy Index and cost index to represent energy consumption data (L3).
3. Develop strategies to conserve input energy requirements for different processes and energy systems (L3).
4. Analyze the performance of electrical utilities and its efficient improvement Approaches (L4).
5. Apply the principles of operational economics to optimize the total costs of energy systems through energy-efficient technologies (L3).

UNIT-I:

Energy Scenario: Commercial and Non-commercial energy, primary energy resources, commercial energy production, final energy consumption, energy needs of growing economy, energy intensity on purchasing power parity (PPP) basis, long term energy scenario, India energy scenario, energy pricing, energy security, energy strategy for the future.

Learning Outcomes:

- Understand the Energy resources and future energy scenario (L2).
- Understand the India energy scenario (L2).

UNIT-II:

Energy auditing: Energy audit- Definitions- concept- types of energy audit- energy index- cost index. Energy auditing- general & detailed energy audit, energy audit instruments. energy saving potential- Industrial energy use, Representation of energy consumption- pie charts- Sankey diagrams- Load profiles.

Learning Outcomes:

- Understand the basic definitions and types of energy audit (L2).
- Make use of audit instruments for energy audit (L3) .

UNIT-III:

Energy Conservation: Energy conservation systems- energy conservation and its importance, need of energy conservation, short, medium and long-term energy conversation systems, Energy Conservation Act-2001 and its features. Maximizing system efficiencies, optimizing the input energy requirements, fuel & energy substitution,

Learning Outcomes:

- Understand salient features of energy conservation act-2001(L2).
- Understand about energy conservation systems (L2).

UNIT-IV:

Energy Efficiency and Performance of Electrical Utilities: Electrical system: Electricity billing, maximum demand control, Transformer losses & Energy efficient transformers. Distribution losses in industrial systems. Assessment of transmission and distribution losses in power systems. Harmonics-causes-effects-overcoming.

Learning Outcomes:

- Understand the concept of different energy efficient electrical utilities (L2)
- Analyze the performance of electrical utilities and discuss the improvement methods (L4).

UNIT-V:

Economic Aspects and Analysis: Economics Analysis – Depreciation Methods – Time value of money – Rate of return – Present worth method – Replacement analysis – Life cycle costing analysis – Energy efficient motors (basic concepts). Economics of energy efficient motors and systems.

Learning Outcomes:

- Analyze different economic aspects in energy management (L4).
- Understand the basic concepts of energy efficient motors (L2).

Textbooks:

1. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-1, General Aspects (available online)
2. Guide books for National Certification Examination for Energy Manager / Energy Auditors Book-3, Electrical Utilities (available online)
3. Energy efficient electric motors by John .C. Andreas, Marcel Dekker Inc Ltd–2nd edition, 1995.
4. Amlan Chakrabarti, "Energy Engineering and management", PHI Publication.

Reference Books:

1. Energy management by W.R. Murphy & G. Mckay Butter worth, Elsevier publications. 2012
2. S.C.Tripathy,"UtilizationofElectricalEnergyandConservation",McGrawHill,1991.
3. Doty, Steven; Turner, Wayne C, Energy Management Handbook (8th Edition), Fairmont Press, Inc., 978-0-88173-707-3

Subject Code	Subject Name	L	T	P	C
R20BSH-HM4101	Universal human values-II: Understanding Harmony	3	0	0	3

COURSEOBJECTIVES:

- Development of a holistic perspective based on self-exploration about themselves (human being), family, society and nature/existence. (L3)
- Relate the harmony in the human being, family, society and nature/existence(L4)
- Outline and strengthening of self-reflection. (L2)
- Improvement of commitment and courage to act. (L5)
- Integrate the humanistic constitution and humanistic universal order. (L2)

COURSEOUTCOMES:

1. Enrich the knowledge on need of Value Education. (L2)
2. Considerate Human being as the Co-existence of the Self and the Body. (L2)
3. Identify the basic unit of human interaction(L3)
4. Comprehend the harmony in the nature (L2)
5. Analyze and exploring Ethical Human Conduct.(L4)

UNIT-I :

Introduction to Value Education

Understanding Value Education- Self-exploration as the Process for Value Education- Continuous Happiness and Prosperity – Basic Human Aspirations- Right Understanding, Relationship and Physical Facility - Happiness and Prosperity – Current Scenario.

Learning Outcomes:

- **Apply** Human values to balance their life and profession (L3)
- **Identify** and incorporate the levels of human values(L2)

Application:

- Natural acceptance in human being as the innate acceptance for living with responsibility (living in relationship, harmony and co-existence) rather than as arbitrariness in choice based on liking- disliking

UNIT-II:

Harmony in the Human Being

Understanding Human being as the Co-existence of the Self and the Body- Distinguishing between the Needs of the Self and the Body-The Body as an Instrument of the Self - Understanding Harmony in the Self – Harmony of the Self with the Body.

Learning Outcomes:

- **Distinguish** physical facilities the self and body (L4)
- **Related** to proper upkeep of the body and practice them in their daily routine. (L2)

Application: Differentiate between prosperity and accumulation.

Discuss program for ensuring health vs dealing with disease

UNIT-III:

Harmony in the Family and Society

Harmony in the Family –Basic Unit of Human Interaction – Values in Human-to-Human Relationship - 'Trust' – Foundational Value in Relationship-'Respect'–Right Evaluation - Understanding Harmony in the Society -Vision for the Universal Human Order.

Learning Outcomes:

- **Interpreting** Natural acceptance is always for living in harmony(L2)
- **Exemplifying** Right evaluation leads to fulfilment in relationship(L3)

Application:

Reflect on relationships in family, hostel and institute as extended family, real life examples, teacher-student relationship, goal of education etc., Gratitude as a universal value in relationships.

UNIT-IV:

Harmony in the Nature/Existence

Understanding Harmony in the Nature – Inter connectedness, self-regulation and Mutual Fulfilment among the Four Orders of Nature – Realizing Existence as Co-existence at All Levels – The Holistic Perception of Harmony in Existence.

Learning Outcomes:

- **Organizing** Confident that they can understand the whole existence made appropriateand holistic. (L2)
- **Differentiate** between the characteristics and activities of different orders able to see theinterconnectedness in the nature(L3)

Application:

Human being as cause of imbalance in nature (film "Home" can be used), pollution, depletion ofresources and roleof technology etc.

UNIT-V:

Implications of the Holistic Understanding – a Look at ProfessionalEthics

Natural Acceptance of Human Values – Definitiveness of (Ethical) Human Conduct - A Basis for Humanistic Education, Humanistic Constitution and Universal Human Order - Competence in Professional Ethics - Holistic Technologies, Production Systems and Management Models.

Learning Outcomes:

- **Present** sustainable solutions to the problems in society and nature. (L2)
- **analyze** the right utilization of their knowledge in their streams of Technologyto ensuremutual fulfilment. (L3)

Application:

Discuss Exercises and Case Studies will be taken up in Practice related to understanding

TEXT BOOK

A Foundation Course in Human Values and Professional Ethics, R R Gaur, RAsthana, G P Bagaria, 2nd Revised Edition, Excel Books, New Delhi, 2019.ISBN978-93-87034-47-1

REFERENCE BOOKS

1. Jeevan Vidya: Ek Parichaya, A Nagaraj, Jeevan VidyaPrakashan, Amarkantak,1999.
2. Human Values, A.N. Tripathi, New Age Intl. Publishers, NewDelhi,2004.
3. The Story of Stuff (Book).
4. The Story of My Experiments with Truth-by Mohandas Karamchand Gandhi
5. Small is Beautiful -E. F Schumacher.
6. Slow is Beautiful-Cecile Andrews
7. Economy of Permanence-J C Kumarappa
8. Bharat Mein Angreji Raj -Pandit Sunder lal
9. Rediscovering India- by Dharampal
10. Hind Swaraj or Indian Home Rule-by Mohandas K.Gandhi
11. India Wins Freedom-Maulana Abdul Kalam Azad
12. Vivekananda-Romain Rolland (English)
13. Gandhi-Romain Rolland (English)

E-Resources:

1. https://sist.sathyabama.ac.in/sist_coursematerial/uploads/SAIC4003.pdf
2. https://gyansanchay.csjmu.ac.in/wp-content/uploads/2022/09/UHVE-2.0-Class-Notes-Part-1- of-4- 1.pdf

Subject Code	Subject Name	L	T	P	C
R20MEC-SC4101	Computational Fluid Dynamics **(Skill Oriented Course-5)**	1	0	2	2

Course Objectives:

The objectives of the course are to

- understand the fundamentals and relevance of fluid mechanics in the broader context of engineering sciences in general.
- analyze fluid flows through different configurations along with the measurement of flow parameters.
- expertise of experimentation, simulation and the fundamental concepts those are required to translate a novel engineering idea to reality through dimensional analysis and similitude.
- expose a wide variety of research areas and concerns in and around fluid mechanics such as energy, health etc. across multidisciplinary domains.
- explain engineering skills such as solving engineering problems in a professional way, using commercial software packages such as ANSYS Fluent etc. for data analysis and presentation, numerical simulations etc.

Course Outcomes

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

1. Select the suitable computational method for specified Fluid flow conditions (L3)
2. Analyze the critical parameters of flow for the specified fluid flow conditions. (L4)
3. Apply appropriate solution strategy for the given incompressible fluid system (L3)
4. Develop CFD problem for the given boundary conditions of fluid flow. (L5)
5. Design computational solutions using software tools to analyze and solve specified fluid flow problems. (L5)

Introduction: Illustration of the CFD approach, CFD as an engineering analysis tool, Review of governing equations, Modeling in engineering, Partial differential equations- Parabolic, Hyperbolic and Elliptic equation, CFD application in Mechanical Engineering, CFD software packages and tools.

Principles of Solution of the Governing Equations: Finite difference and Finite volume Methods, Convergence, Consistency, Error and Stability, Accuracy, Boundary conditions, CFD model formulation.

Mesh generation: Overview of mesh generation, Structured and Unstructured mesh, Guideline on mesh quality and design, Mesh refinement and adaptation.

Solution Algorithms: Discretization schemes for pressure, momentum and energy equations - Explicit and implicit Schemes, First order upwind scheme, second order upwind scheme, QUICK scheme, SIMPLE, SIMPLER and MAC algorithm, pressure-velocity coupling algorithms, velocity-stream function approach, solution of Navier-Stokes equations.

CFD Solution Procedure: Problem setup – creation of geometry, mesh generation, selection of physics and fluid properties, initialization, solution control and convergence monitoring, results reports and visualization.

LIST OF EXPERIMENT:

Numerical simulation of the following flow problems using commercial software packages:

1. 2D and 3D structured grid generation – flat plates, aerofoil
2. 3D unstructured grid generation – pipe, external aerodynamics
3. Incompressible internal laminar flows
4. Incompressible external laminar flows
5. Incompressible internal turbulent flows

6. Incompressible external turbulent flows
7. Forced Convection flows
8. Fluid Structure Interaction (Flow past a cylinder, Flow over an airfoil.)
9. Heat transfer analysis in heat exchanger
10. Heat transfer analysis in solar flat plate collector
11. Multiphase flows
12. Compressible flows

Note: Any Ten ExperimentsText Books:

1. P.S. Ghosdastidar, Computer Simulation of Flow and Heat Transfer, Tata McGraw-Hill.
2. Muralidhar, K.,and Sundararajan,T. Computational Fluid Flow and Heat Transfer, NarosaPublishing. House .

Reference Books:

1. Niyogi, P. Chakrabarty, S.K. and Laha, M.K., Introduction to computational fluid dynamics,Pearson education
2. 2 S K Gupta. Numerical Methods for Engineers, New Age Publishers.
3. Anderson J.D. Computational Fluid Dynamics, Mc-Graw Hills.
4. Numerical Heat Transfer and Fluid Flow: Suhas V. Patankar
5. An introduction of computation fluid dynamics: Versteeg & Malalasekera