COURSE STRUCTURE (R23)
AND
DETAILED SYLLABUS
(III YEAR)

MECHANICAL ENGINEERING

For
B.Tech., Four Year Degree Course
(Applicable for the batches admitted from 2023-24)

LENDI INSTITUTE OF ENGINEERING AND TECHNOLOGY
An Autonomous Institution
Approved by AICTE & Permanently Affiliated to JNTUGV, Vizianagaram
Accredited by NAAC with "A" Grade and NBA (CSE,ECE, EEE & ME)
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COURSE STRUCTURE AND DETAILED SYLLABUS						
R23_B.TECH- MECHANICAL ENGINEERING						
III Year I Semester						
S. No	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**
1	R23MEC-PC3101	Design of Machine Members	3	0	0	3
2	R23MEC-PC3102	Applied Thermodynamics	3	0	0	3
3	R23MEC-PC3103	Dynamics of Machinery	3	0	0	3
4		**Professional Elective-I**	3	0	0	3
4	R23MEC-PE3101.1	1. Non-Destructive Testing	3	0	0	3
4	R23MEC-PE3101.2	2. Mechanical Behavior of Materials	3	0	0	3
4	R23MEC-PE3101.3	3. Operations Research	3	0	0	3
4	R23MEC-PE3101.4	4. Non-Conventional Energy Sources	3	0	0	3
4	R23MEC-PE3101.5	5. Automation in Manufacturing	3	0	0	3
5	R23MEC-OE3101	**Open Elective- I**	3	0	0	3
6	R23MEC-PC3104	Thermal Engineering Lab	0	0	3	1.5
7	R23MEC-PC3105	Theory of Machines Lab	0	0	3	1.5
8	R23MEC-SC3101	Artificial Intelligence and Machine Learning (Skill Oriented Course)	0	1	2	2
9	R23MEC-ES3101	Tinkering Lab	0	0	2	1
10	R23BSH-MC3101	English and Soft Skills for Job Seekers (Mandatory Course)	0	1	2	0
11	R23MEC-SI3101	Evaluation of Community Service Project Internship	0	0	0	2
Total			**15**	**2**	**12**	**23**

III Year II Semester						
S. No	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**
1	R23MEC-PC3201	Machine Tools & Metrology	3	0	0	3
2	R23MEC-PC3202	Design of Power Transmission Elements	3	0	0	3
3	R23MEC-PC3203	Heat Transfer	3	0	0	3
4		**Professional Elective-II**	3	0	0	3
4	R23MEC-PE3201.1	1. Mechanical Vibrations	3	0	0	3
4	R23MEC-PE3201.2	2. Advanced Materials	3	0	0	3
4	R23MEC-PE3201.3	3. Optimization Techniques for Operations Decisions	3	0	0	3
4	R23MEC-PE3201.4	**4.** Power Generation Systems	3	0	0	3
4	R23MEC-PE3201.5	**5.** Automotive Engineering	3	0	0	3
5		**Professional Elective-III**	3	0	0	3
5	R23MEC-PE3202.1	1. Advanced Machining Process	3	0	0	3
5	R23MEC-PE3202.2	**2.** Refrigeration and Air Conditioning	3	0	0	3
5	R23MEC-PE3202.3	3. Quality Assurance Systems	3	0	0	3
5	R23MEC-PE3202.4	**4.** Additive Manufacturing	3	0	0	3
5	R23MEC-PE3202.5	**5.** Industrial Robotics	3	0	0	3
6	R23MEC-OE3201	**Open Elective – II**	3	0	0	3
7	R23MEC-PC3204	Heat Transfer Lab	0	0	3	1.5
8	R23MEC-PC3205	Machine Tools & Metrology Lab	0	0	3	1.5
9	R23MEC-SC3201	Instrumentation and Control systems (Skill Oriented Course)	0	1	2	2
10	R23MEC-MC3201	Technical Paper Writing & IPR (Mandatory Course)	2	0	0	0
Total			**20**	**1**	**8**	**23**

DEPARTMENT OF MECHANICAL ENGINEERING

HONORS COURSE STRUCTURE AND SYLLABUS

(R23 REGULATION)

MEC (Honors)

Track- I (Manufacturing Technology)							
S.No	**Year & Semester**	**Course Code**	**Subject title**	**L**	**T**	**P**	**C**
1	II-II	R23MEC-HN2201	Material Characterization Techniques	3	0	0	3
2	III-I	R23MEC-HN3101	Product Design and Development	3	0	0	3
3	III-II	R23MEC-HN3201	Advanced Manufacturing Technology	3	0	0	3
4	IV-I	R23MEC-HN4101	Optimization and Reliability	3	0	0	3
5	II Year to IV Year	R23MEC-HM0001	Honors MOOCS-1	0	0	0	3
6	II Year to IV Year	R23MEC-HM0002	Honors MOOCS-2	0	0	0	3
Total							**18**
Track-II (Thermal Engineering)							
S.No	**Year & Semester**	**Course Code**	**Subject title**	**L**	**T**	**P**	**C**
1	II-II	R23MEC-HN2202	Advanced Fluid Dynamics	3	0	0	3
2	III-I	R23MEC-HN3102	Turbo Machinery	3	0	0	3
3	III-II	R23MEC-HN3202	Design of thermal Systems	3	0	0	3
4	IV-I	R23MEC-HN4102	Cryogenic Engineering	3	0	0	3
5	II Year to IV Year	R23MEC-HM0001	Honors MOOCS-1	0	0	0	3
6	II Year to IV Year	R23MEC-HM0002	Honors MOOCS-2	0	0	0	3
Total							**18**
Track III (Design Engineering)							
S.No	**Year & Semester**	**Course Code**	**Subject title**	**L**	**T**	**P**	**C**
1	II-II	R23MEC-HN2203	Advanced Mechanism Design	3	0	0	3
2	III-I	R23MEC-HN3103	Engineering Tribology	3	0	0	3
3	III-II	R23MEC-HN3203	Design for Fatigue and Facture	3	0	0	3
4	IV-I	R23MEC-HN4103	Design with advanced Material	3	0	0	3
5	II Year to IV Year	R23MEC-HM0001	Honors MOOCS-1	0	0	0	3
6	II Year to IV Year	R23MEC-HM0002	Honors MOOCS-2	0	0	0	3
Total							**18**
Track IV (Robotic Engineering)							
S.No	**Year & Semester**	**Course Code**	**Subject title**	**L**	**T**	**P**	**C**
1	II-II	R23MEC-HN2204	Mechanism and Robot Kinematics	3	0	0	3
2	III-I	R23MEC-HN3104	Flexible Manufacturing Systems	3	0	0	3
3	III-II	R23MEC-HN3204	AI and ML for Robotics	3	0	0	3
4	IV-I	R23MEC-HN4104	Autonomous Robot System	3	0	0	3
5	II Year to IV Year	R23MEC-HM0001	Honors MOOCS-1	0	0	0	3
6	II Year to IV Year	R23MEC-HM0002	Honors MOOCS-2	0	0	0	3
Total							**18**

 # NOTE: In addition to the four subjects mentioned in the table above, students are required to complete two MOOC programs (each with a duration of 12 weeks), as approved by the BOS Chairman

Honors Course Track Offered by Mechanical Department

DEPARTMENT OF MECHANICAL ENGINEERING

MINOR DEGREE TRACKS OFFERED BY MECHANICAL DEPARTMENT TO OTHER DEPARTMENTS

S.No.	Course Code	Year & Semester	Course Title	L	T	P	Credits
1	R23MEC-MN2201	II-II	Computer Aided Design	3	0	0	3
2	R23MEC-MN2202	II-II	Computer Aided Design Laboratory	0	0	3	1.5
3	R23MEC-MN3101	III-I	Additive Manufacturing	3	0	0	3
4	R23MEC-MN3102	III-I	3D Printing Technology Laboratory	0	0	3	1.5
5	R23MEC-MN3201	III-II	Industrial Engineering	3	0	0	3
6	R23MEC-MN4101	IV-I	Thermal Comfort Systems	3	0	0	3

NOTE: In addition to the Six Courses mentioned in the table above, students are required to complete **One MOOC programme** (each with a duration of 12 weeks), as approved by the BOS Chairman.

R23_Open Electives Courses for ME

Offering Department: Electronics and Communications Engineering						
S.No	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**
1	R23ECE-OE0001	Basics of Communication Systems	3	0	0	3
2	R23ECE-OE0002	Micro Processors and Interfacing	3	0	0	3
3	R23ECE-OE0003	Digital System Design using Verilog	3	0	0	3
4	R23ECE-OE0004	Fundamentals of Digital Image Processing	3	0	0	3
5	R23ECE-OE0005	Introduction to Internet of Things	3	0	0	3
6	R23ECE-OE0006	Wireless Sensor Networks	3	0	0	3
7	R23ECE-OE0007	Satellite Communication	3	0	0	3
8	R23ECE-OE0008	Fundamentals of Embedded Systems	3	0	0	3

Offering Department: Electrical and Electronics Engineering						
S.No	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**
1	R23EEE-OE0001	Renewable Energy Sources	3	0	0	3
2	R23EEE-OE0002	Energy Conservation and Management	3	0	0	3
3	R23EEE-OE0003	Electrical Safety & Standards	3	0	0	3
4	R23EEE-OE0004	Utilization of Electrical Energy	3	0	0	3

Offering Department: Computer Science and Engineering & Allied Branches						
S.No	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**
1	R23CSE-OE0001	Python Programming	3	0	0	3
2	R23CSE-OE0002	Data Structures Using C	3	0	0	3
3	R23CSE-OE0003	Operating System Concepts	3	0	0	3
4	R23CSE-OE0004	Introduction to Java Programming	3	0	0	3
5	R23CSE-OE0005	Database Management Systems Concepts	3	0	0	3
6	R23CSE-OE0006	Unix & Shell Programming	3	0	0	3
7	R23CSE-OE0007	Software Engineering	3	0	0	3
8	R23CSE-OE0008	Introduction to Data mining	3	0	0	3
9	R23CSE-OE0009	Fundamentals of Web Technologies	3	0	0	3
10	R23CSE-OE0010	Fundamentals of Computer Networks	3	0	0	3
11	R23CSE-OE0011	Basics of Cloud Computing	3	0	0	3
12	R23CSE-OE0012	Introduction to Machine Learning	3	0	0	3
13	R23CSE-OE0013	Essentials of Cyber Security	3	0	0	3
14	R23CSE-OE0014	Introduction to React JS	3	0	0	3
15	R23CSE-OE0015	Deep Learning	3	0	0	3
16	R23CSE-OE0016	DevOps	3	0	0	3
17	R23CSE-OE0017	Mobile Computing	3	0	0	3
18	R23CSE-OE0018	Java Full Stack Development	3	0	0	3
19	R23CSE-OE0019	Human Computer Interface	3	0	0	3
20	R23CSE-OE0020	Cryptography and Network Security	3	0	0	3
21	R23CSE-OE0021	Quantum Computing	3	0	0	3
22	R23CSE-OE0022	Big data Analytics	3	0	0	3
23	R23CSE-OE0023	Block Chain Technology	3	0	0	3
24	R23CSE-OE0024	Multimedia Application Development	3	0	0	3
25	R23CSE-OE0025	Mobile Adhoc Networks	3	0	0	3
26	R23CSS-OE0001	Operating Systems	3	0	0	3
27	R23CSS-OE0002	Redhat Linux	3	0	0	3
28	R23CSS-OE0003	Cloud Computing	3	0	0	3
29	R23CSS-OE0004	Distributed Operating System	3	0	0	3
30	R23CIT-OE0001	Basics of Computer Networks	3	0	0	3
31	R23CIT-OE0002	Cryptography and Network Security	3	0	0	3
32	R23CIT-OE0003	Mobile Computing	3	0	0	3
33	R23CIT-OE0004	Wireless sensor networks	3	0	0	3
34	R23CSM-OE0001	An Introduction to Artificial Intelligence	3	0	0	3
35	R23CSM-OE0002	Introduction to Machine Learning with Python	3	0	0	3
36	R23CSM-OE0003	Foundation of Deep Learning for Engineering Applications	3	0	0	3
37	R23CSM-OE0004	Natural Language Processing- Frontiers Approach	3	0	0	3

III B. Tech- I Semester Syllabus

Course Code	Course Name	L	T	P	C
R23MEC-PC3101	Design of Machine Members	3	0	0	3

Course Objectives: The objectives of the course are to

- Understand the material selection and manufacturing aspects influencing the design of machine elements.
- Apply the knowledge of fatigue, stress concentration, and endurance strength concepts in designing of machine elements.
- Apply knowledge of stresses, failure theories, and safety factors in designing of machine element for strength and rigidity.
- Understand the mechanical behaviour of bolted, riveted, and welded under various load conditions.
- Design mechanical springs by evaluating stresses, deflections, and energy storage under different loading scenarios.

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

1. Understand the role of materials, manufacturing considerations and tolerances in designing of machine components. (L2)
2. Apply failure theories to design the machine elements subjected to static and dynamic loads. (L3)
3. Design bolted joints considering eccentric, shear, and combined loading conditions. (L4)
4. Analyze the strength, and failure modes of welded and riveted joints under different load conditions. (L4)
5. Analyze the stress, deflection, and energy storage behaviour of helical springs under various loading conditions. (L4)

UNIT-I

Introduction to Machine Design: General considerations in the design of Engineering Materials and their properties and selection, Manufacturing consideration in design, tolerances, and fits.

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

Learning Outcomes: After completion of this unit, students will be able to

1. ***Identify*** the key engineering materials, their properties, and criteria for material selection in machine design**. (L2)**
2. ***Apply*** static loading concepts to asses combined stresses in Machine Elements. **(L3)**

Applications: Automotive Components, Aerospace Structures, Industrial Machinery, Bridges and Structural Frameworks, Pressure Vessels, and Boilers.

UNIT-II

Design against dynamic loading: Stress concentration, theoretical stress concentration factor, fatigue stress concentration factor, notch sensitivity, design for fluctuating stresses, endurance limit, estimation of endurance strength- Gerber parabola, Goodman's line, Soderberg's line, modified Goodman's line.

Learning Outcomes: After completion of this unit, students will be able to

1. ***Explain*** stress concentration, notch sensitivity, and their impact on dynamic loading. **(L2)**
2. ***Apply*** fatigue design methods like Gerber, Goodman, and Soderberg to assess fluctuating stresses. **(L3)**
3. ***Estimate*** endurance strength and predict failure under variable loading conditions. **(L3)**

Applications: Automotive Components, Aerospace Structures, Industrial Machinery, Bridges and Structural Frameworks, Pressure Vessels, and Boilers.

UNIT-III

Riveted joints: Methods of Riveting, Material of Rivets, Types of Riveted Joints, Important Terms Used in Riveted Joints, Caulking and Fullering, Failures of a Riveted Joint, Strength of a Riveted Joint, Efficiency of a Riveted Joint, Design of Boiler Joints, Eccentric Loaded Riveted Joint.

Welded joints: Types of Welded Joints, Strength of Transverse Fillet Welded Joints, Strength of Parallel Fillet Welded Joints, Special Cases of Fillet Welded Joints, Strength of Butt Joints, Stresses for Welded Joints, Eccentrically Loaded Welded Joints.

Learning Outcomes: After completion of this unit, students will be able to

1. ***Identify*** different types of riveted and welded joints used in mechanical structures. **(L2)**
2. ***Calculate*** the strength and efficiency of riveted and welded joints under various load conditions. **(L3)**
3. ***Analyze*** failure modes and design requirements for eccentrically loaded joints. **(L4)**

Applications: Steel Structures & Bridges, Boilers and Pressure Vessels, Automobile and Aerospace Assembly, Railway Coaches and Wagons, Shipbuilding and Marine Applications.

UNIT- IV

Bolted joints: Important Terms Used in Threaded Joints, Common Types of Screw Fastenings, Bolt of Uniform Strength, Locking Devices, Bolted Joint- Simple Analysis, Bolted Joints Under Eccentric Loading- Bolted Joints in Shear- Parallel to the axis of the Bolts, Perpendicular to the axis of the Bolts, Eccentric Load on Circular Base.

Learning Outcomes:

After completion of this unit, students will be able to

1. ***Describe*** key terms and types of bolted and threaded joints used in engineering. **(L2)**
2. ***Compute*** stresses and strength in bolted joints under axial and eccentric loads. **(L3)**
3. ***Analyse*** the performance and safety of bolted joints with locking devices and uniform strength. **(L4)**

Applications: Steel Structures & Bridges, Automobile and Aerospace Assembly, Railway Coaches and Wagons Assembly.

UNIT–V

Helical Springs: Types of Springs, Terminology used in Springs, Stresses in Helical Springs of Circular Wire, Deflection of Helical Springs of Circular Wire, Surge in Springs, Energy Stored in Helical Springs of Circular Wire, Springs in Series, Springs in Parallel.

Learning Outcomes:

After completion of this unit, students will be able to

1. ***Explain*** the types and functions of helical springs used in mechanical systems. **(L2)**
2. ***Calculate*** stresses, deflection, and energy storage in circular wire springs. **(L3)**
3. ***Compare*** spring behaviours in series and parallel configurations for design applications. **(L4)**

Applications: Vehicle suspension systems, Load cells and weighing machines and small mechanical devices

Text Books:

1. R.S. Khurmi & J.K. Gupta; A Textbook of Machine Design; S Chand Publications.
2. V B Bhandari; Design of Machine Elements; McGraw Hill Education India Private Limited.

Reference Books:

1. N.C. Pandya & C.S.Shah; Machine Design; Charotar Publishing House Pvt. Ltd.
2. S.Md.Jalaludeen; A TextBook of Machine Design; Anuradha Publications.
3. Shigley'S Mechanical Engineering Design by Richard G. Budynas, J. Keith Nisbett, Kiatfa Tangchaichit; McGraw Hill Education India Private Limited.
4. Robert L. Norton; Machine Design; Pearson Education.
5. M. F. Spotts, Terry E. Shoup, L. E. Hornberge; Design of Machine Elements; Pearson Education.

Web Resources:

1. https://archive.nptel.ac.in/courses/112/105/112105124/
2. https://archive.nptel.ac.in/courses/112/106/112106137/
3. https://www.youtube.com/playlist?list=PL3D4EECEFAA99D9BE

COURSE OUTCOMES VS POs MAPPING [1-slight (low), 2 - moderate (medium) and 3- substantial (high)]

CO/PO	PO1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	-	-	-	-	-	-	-	1	-	2	3	3
CO2	3	3	3	-	-	1	1	2	-	1	-	2	3	3
CO3	3	3	3	-	-	1	1	2	-	1	-	2	3	3
CO4	3	3	3	-	-	1	1	2	-	1	-	2	3	3
CO5	3	3	3	-	-	1	1	2	-	1	-	2	3	3
CO*	3	3	3	-	-	1	1	2	-	1	-	2	3	3

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-PC3102	**Applied Thermodynamics**	3	0	0	3

Course Objectives: The objectives of the course are:

- To analyze the working principles, components, and performance characteristics of internal combustion engines, including fuel systems, valve timing, testing methods, and evaluation of engine performance.
- To impart knowledge on the working of a Steam power plant.
- To explain the working of Steam Nozzles and Steam Turbines.
- To analyze the performance parameters of different compressors.
- To familiarize with the working operation of Gas turbines and Aircraft engines.

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

1. Analyze the operation, fuel systems, and performance of SI and CI engines using valve timing diagrams, performance parameters, and engine testing methods such as Morse test, motoring test, and heat balance calculations. (L4)
2. Apply the principle and operation of a vapor power cycle based on Rankine cycle in evaluating the efficiency of a thermal power plant (L3)
3. Apply thermodynamic principles to study the characteristics of steam nozzles and Steam turbines (L3)
4. Analyze the construction, working principles, and performance parameters of reciprocating, rotary, centrifugal, and axial flow compressors. (L4)
5. Apply the working principle of turbojet, turboprop, ramjet and pulsejet engines to interpret the performance characteristics including thrust power and propulsion efficiency. (L3)

Unit-I

I.C. Engines: Classification, Working of SI & CI, two and four stroke engines – Ideal and actual valve timing diagrams – Comparison of ideal and actual air standard cycles (p-v diagram) — Determination of fuel properties – Fuel injection system, ignition, cooling, lubrication and Governing system

Testing and Performance: Performance parameters, measurements of brake power, indicated power, friction power- William's line method, Morse test, motoring test, Calculation of various performance parameter, heat balance sheet.

Learning outcomes: After completion of this unit, students will be able to

1. ***understand*** the various types of IC engines **(L2)**
2. ***analyze*** various performance characteristics of an engine. **(L4)**

Application: Automobile vehicles

Unit-II

Vapour Power Cycles: Vapour power cycle, simple Rankine cycle, mean temp of heat addition thermodynamic variables effecting efficiency and output of Rankine cycle.

Boilers: Subcritical and supercritical boilers, fluidized bed boilers, fire-tube and water-tube boilers, mountings and accessories**,** Draught system.

Learning outcomes: After completion of this unit, students will be able to

1. ***Explain*** concepts of vapour power cycle used in steam power plant. **(L2)**
2. ***Evaluate*** the cycles used in gas turbines. **(L5)**

Applications: Power plants

Unit-III

Nozzles: Type of nozzles - air and steam nozzles, Compressible flow through nozzle condition for maximum discharge - nozzle efficiency.

Steam Turbines: Classification of steam turbines -impulse turbine and reaction turbine - compounding in turbines - velocity diagrams in impulse and reaction turbines, efficiency, degree of reaction - governing of turbines

Learning outcomes: After completion of this unit, students will be able to

1. ***Compare*** the performance of nozzles, used in turbines. **(L4)**
2. ***Classify*** steam turbines and applications**. (L2)**

Applications: spray coatings, power plants

Unit-IV

Compressors– Introduction, Classification

Reciprocating Compressors: Principle of operation, Work required Isothermal Efficiency, Volumetric efficiency and Effect of clearance volume, Multistage Compression.

Rotary Compressors: Roots blower and Vane‘s sealed compressor-principle of working and applications. Centrifugal and Axial flow compressors: Construction, Principle of operation and applications.

Learning outcomes: After completion of this unit, students will be able to

1. ***Classify*** different types of air compressors. **(L2)**
2. ***Compare*** the performance of different types of air compressors. **(L4)**

Applications: Refrigerators, Air conditioners

UNIT-V

Gas power Cycle: Simple gas turbine plant, Brayton cycle, closed cycle and open cycle for gas

Turbines, Methods to improve performance: regeneration, inter-cooling and reheating.

Jet Propulsion Systems: Principle of Operation –Classification of jet propulsive engines – Working Principles with schematic diagrams analysis and performance characteristics of turbojet, turboprop, ramjet and pulsejet; thrust power and propulsion efficiency

Learning outcomes: After completion of this unit, students will be able to

1. ***Explain*** the working Principle of Jet engines **(L2)**
2. ***Calculate*** the propulsive efficiency of the Jet engine **(L3)**

Application: Space Craft Engines

Text Books:

1. Ganesan V, Internal Combustion Engines, Tata McGraw Hill.
2. M.L. Mathur and F.S. Mehta, Thermal Engineering, Jain brothers.
3. R K Rajput, Thermal Engineering, Lakshmi publications
4. P.L. Ballaney, Thermal Engineering, Khanna.

Reference Books:

1. Cengal Y.A and Boles M.A, Thermodynamics: An Engineering Approach.
2. Yahya, S. M., Turbines, Compressors and Fans, Tata McGraw Hill.
3. Nag P.K, Engineering Thermodynamics, Tata McGraw-Hill.
4. Onkar Singh, Thermal Turbomachines, Wiley India.

Web Resources:

1. https://learnmech.com/valve-timing-diagram-for-ic-petro/
2. https://www.engineeringenotes.com/mechanical-engineering/ic-engine/ic-engine-working-classification-types-methods-construction-and-notes-thermal-engineering/51576
3. https://www.engineeringenotes.com/thermal-engineering/vapour-power-cycles/vapour-power-cycles-carnot-rankine-and-modified-rankine-cycle-thermodynamics/51016
4. https://www.mechstudies.com/rankine-cycle-actual-diagrams-equations-formula/
5. https://egyankosh.ac.in/bitstream/123456789/31859/1/Unit-10.pdf
6. https://www.sathyabama.ac.in/sites/default/files/course-material/2020-10/Unit%203_8.pdf
7. https://gcoeara.ac.in/learning_material/mech/UNIT-III_Steam_Turbine.pdf
8. https://gcekbpatna.ac.in/assets/documents/lecturenotes/FLOW_THROUGH_NOZZLES.pdf
9. https://testbook.com/mechanical-engineering/air-compressor-types-and-parts
10. https://boilersinfo.com/compressor-and-classification-of-compressor-operation-industrial-uses/
11. https://scienceinfo.com/brayton-cycle/
12. https://archive.nptel.ac.in/content/storage2/courses/112106133/Module_4/1_introduction.pdf

COURSE OUTCOMES VS POs MAPPING

[1-slight (low), 2 - moderate (medium) and 3- substantial (high)]

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O1	PS O2
CO1	3	3	3	3	-	3	-	2	1	2	-	2	3	3
CO2	3	3	3	3	-	3	-	2	-	2	-	2	3	3
CO3	3	3	3	3	-	3	-	2	-	1	-	2	3	3
CO4	3	3	3	2	-	3	-	2	1	1	-	2	3	3
CO5	3	3	3	2	-	3	-	2	1	1	-	2	3	3
CO*	3	3	3	3	-	3	-	2	1	1	-	2	3	3

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-PC3103	**Dynamics of Machinery**	3	0	0	3

Course Objectives: The objectives of the course are

- To comprehend the principles of gyroscopic motion and precession, and evaluate their effects on the stability of various moving vehicles such as automobiles, ships, and aircraft.
- To understand the fundamental laws of friction and their applications in mechanical systems, including braking mechanisms and dynamometers.
- To develop the ability to perform dynamic force analysis of slider-crank mechanisms and to understand the design principles of flywheels and various types of governors, including concepts like sensitiveness, isochronism, and hunting.
- To acquire knowledge of balancing techniques for rotating and reciprocating masses, and analyze the implications of unbalanced forces in mechanical systems such as engines and locomotives.
- To Understand the concept of natural frequency, and apply analytical methods to determine the vibration characteristics of different mechanical structures.

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

1. Explain the stabilization mechanisms of sea vehicles, aircraft, and automobiles under the influence of gyroscopic and processional effects (L2).
2. Apply the concepts of friction to find the effort required to drive screw, pivots and collars and other mechanical systems. (L3).
3. Apply the concepts of fluctuation of energy and fluctuation of speed to draw the turning moment diagrams for flywheels and to determine the behaviour of different types of governors under different load variations. (L3).
4. Analyze the balancing of rotating masses in single and multiple configurations across single and different planes with analytical and graphical methods. (L4).
5. Analyze the dynamic behaviour of mechanical systems subjected to free vibration, transverse loads, and various types of mechanical excitations (L4).

Unit-I

Precession: Gyroscopes, effect of precession motion on the stability of moving vehicles such as motor car, motorcycle, aero planes and ships.

Learning outcomes: After completion of this unit the students will be able to

1. ***Explain*** the stability of vehicles on road, sea and air **(L2)**
2. ***Understand*** the gyroscopic effects on aero planes, ships and automobiles **(L2)**

Applications:

1. Aero planes
2. Ships

Unit-II

Friction: Inclined plane, friction of screw and nuts, pivot and collar, uniform pressure, uniform wear, friction circle and friction axis: lubricated surfaces, boundary friction, film lubrication.

Clutches: Friction clutches- single disc or plate clutch, multiple disc clutch, cone clutch,

centrifugal clutch.

Learning outcomes: After completion of this unit the students will be able to

1. ***Explain*** the working principle of transmission systems and the role of friction in mechanical components. **(L2)**
2. ***Apply*** frictional principles to evaluate the performance of pivot and collar bearings in mechanical systems. **(L3)**

Applications:

1. Screw jack
2. Automobiles

Unit-III

Turning Moment Diagrams: Dynamic force analysis of slider crank mechanism, inertia torque, angular velocity and acceleration of connecting rod, crank effort and turning moment diagrams – fluctuation of energy – flywheels and their design.

Governors: Watt, porter and proell governors, spring loaded governors – Hartnell and Hartung with auxiliary springs. sensitiveness, isochronisms and hunting.

Learning Outcomes: After completion of this unit the students will be able to

1. ***Describe*** the fluctuation of energy and speed in internal combustion (IC) engines. **(L2)**
2. ***Apply*** the principles of the slider-crank mechanism to calculate the turning moment on a crankshaft. **(L3)**
3. ***Explain*** the working of various governors and their response to changing load conditions. **(L2)**

Applications:

1. Flywheels in IC Engines
2. Speed control in Power plants

Unit-IV

Balancing: Balancing of rotating masses single and multiple –single and different planes, use analytical and graphical methods. Primary, secondary, and higher balancing of reciprocating masses. analytical and graphical methods, unbalanced forces and couples – examination of "V" multi cylinder in line and radial engines for primary and secondary balancing, locomotive balancing, hammer blow, swaying couple, variation of tractive effort.

Learning Outcomes: After completion of this unit the students will be able to

1. ***Explain*** static and dynamic balancing using force and couple diagrams **(L2)**
2. ***Determine*** unbalanced forces and couples in rotary and reciprocating engines **(L3)**

Applications:

1. Transmission in coupled beam of locomotive
2. Balancing of automobile engine systems

Unit-V

Vibrations: Free Vibration of spring mass system, transverse loads, vibrations of beams with concentrated and distributed loads. Dunkerly's methods, Rayleigh's method, whirling of shafts, critical speeds, vibration isolation and transmissibility.

Learning Outcomes: After completion of this unit the students will be able to

1. ***Explain*** the natural frequencies of vibrating systems and their significance in mechanical analysis **(L2)**
2. ***Explain*** undamped and damped free vibrations for beams and bars **(L2)**

Applications:

1. Whirling speed in transmission shafts
2. Vibration in vehicle systems

Textbooks

1. S.S Rattan. Theory of Machines. McGraw-Hill Publication.
2. Kurmi. Theory of Machines. S.Chand Publication.

References

1. Ashok G. Ambedkar. Mechanism and machine theory. PHI Publications.
2. Shigley.Theory of Machines. MGH – Rajput.

Web Resources:

1. https://www.youtube.com/watch?reload=9&app=desktop&v=TPlqvCg5xJ4
2. https://archive.nptel.ac.in/courses/112/104/112104114/
3. https://www.youtube.com/watch?v=JmphiHyAuJI

COURSE OUTCOMES VS POs MAPPING

[1-slight (low), 2 - moderate (medium) and 3- substantial (high)]

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	3	3	3	2	-	2	2	-	-	1	-	2	3	3
CO2	3	3	3	2	-	2	2	-	-	1	-	2	3	2
CO3	3	3	3	2	1	1	2	-	-	1	-	1	3	3
CO4	2	2	2	-	-	1	2	-	-	1	-	1	3	2
CO5	3	3	3	3	-	2	2	-	-	1	-	2	3	2
CO*	3	3	3	3	1	2	2	-	-	1	-	2	3	3

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-PE3101.1	**Non-Destructive Testing (Professional Elective-I)**	3	0	0	3

Course Objectives: The objectives of the course are to

- To develop the fundamental concepts of various NDE techniques including radiography, ultrasonics, liquid penetrant, magnetic particle, eddy current, infrared, and thermal testing.
- To Understand the Basic Principles of NDE Methods And develop The Ability to Select Appropriate Testing Techniques for Specific Applications.
- Analyze key non-destructive testing methods, their principles, procedures, equipment, and applications for effective and reliable material inspection.
- Apply non-destructive testing methods for defect detection and quality assurance without compromising material integrity
- Evaluate infrared and thermal testing methods for material evaluation, focusing on heat transfer, inspection techniques, and industrial applications."

Course Outcomes: At the end of this course, students will be able to:

1. Select suitable NDT methods for specific material and structural evaluations. (L2)
2. Describe ultrasonic testing procedures to inspect materials and assess compliance with Quality criteria. (L2)
3. Illustrate Liquid Penetrate System and Eddy Current Test System. (L2)
4. Apply the fundamentals of Magnetic Particle Testing to assess its effectiveness for Different types of materials and defects. (L3)
5. Apply infrared and thermal testing techniques for Analysing sandwich structures. (L3)

UNIT-I

Introduction to Non-Destructive Testing and NDT Methods and Their Engineering Importance.

Radiographic Test: Sources of X and Gamma Rays and their interaction with Matter, Radiographic equipment, Radiographic Techniques, Safety Aspects of Industrial Radiography

Learning outcomes:

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

1. ***summarize*** the basic concepts of Radiographic test. **(L2)**
2. ***outline*** the concepts of sources of X and Gamma Rays. **(L2)**

Applications:

Inspection of products:

1.Inspection of welds on pressurized piping,

2.pressure vessels, high-capacity storage containers,

3.pipelines and some structural welds.

Unit-II

Ultrasonic test: Principle of Wave Propagation, Reflection, Refraction, Diffraction, Mode Conversion and Attenuation, Sound Field, Piezo-electric Effect, Ultrasonic Transducers and them 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

1. Explain the principle of ultrasonic test. (l2)
2. Discuss the characteristics of ultrasonic transducers. (l2)
3. Outline the limitations of ultrasonic testing. (l2)

Applications:

1. Forging Test
2. Tube Testing

Unit-III

Liquid Penetrant Test: Liquid Penetrant Test, Basic Concepts, Liquid Penetrant System, Test Procedure,

Effectiveness and Limitations of Liquid Penetrant Testing

Eddy Current Test: Principle of Eddy Current, Eddy Current Test System, Applications of Eddy Current Testing

Effectiveness of Eddy Current Testing.

Learning outcomes:

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

1. ***elucidate*** the procedure of Liquid Penetrant, eddy current tests. **(L2)**
2. ***outline*** the limitations of Penetrant, eddy current tests. **(L2)**
3. ***explain*** the effectiveness of Penetrant, eddy current tests. **(L2)**

Applications:

1 Liquid penetrant inspection is applied to nonporous and smooth materials such as metals, glass, plastics, and fired ceramics.

2 Eddy current testing is mainly used for surface inspection and tubing inspections

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

1. Demonstrate proper use of Magnetic Particle Test equipment and standardized procedures. (L2)
2. Explain the role of standardization and calibration in ensuring test accuracy. (L2)
3. Interpret results and assess the effectiveness of Magnetic Particle Testing in inspections. (L3)

Applications:

1. Surface defects
2. Welded joints
3. boilers, pressure vessels, locomotives

Unit-V

INFRARED AND THERMAL TESTING Introduction and fundamentals to infrared and thermal testing–Heat transfer –Active and passive techniques –Lock in and pulse thermography _Contact and non-contact thermal inspection methods–Heat sensitive paints –Heat sensitive papers –-thermally quenched phosphors liquid crystals –techniques for applying liquid crystals – other temperature sensitive coatings–Inspection methods–Infrared radiation and infrared detectors–thermo mechanical behavior of materials–IR imaging in aerospace applications, electronic components, Honey comb and sandwich structures–Case studies.

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

1. Understand the fundamentals of thermal testing. (l2)
2. Explain the techniques of liquid crystals, active and passive. (l2)
3. Illustrate thermal inspection methods. (l2)
4. Outline the limitations of thermal testing. (l2)

Applications:

1. Electrical and Mechanical System Inspection.
2. Electronic Component Inspection.
3. Corrosion Damage.
4. Flaw Detection.

Text Books:

1. J Prasad, GCK Nair, Non-destructive test and evaluation of Materials, Tata mcgraw-Hill Education Publishers.
2. Josef Krautkrämer, Herbert Krautkrämer, Ultrasonic testing of materials, Springer- Verlag.
3. X.P.V.Maldague, Non-destructive evaluation of materials by infrared thermography, Springer-Verlag.

References:

1. Gary L.Workman, Patrick O.Moore, Doron Kishoni, Non-destructive, Hand Book, Ultrasonic Testing, Amer Society for Non-destructive.
2. ASTM Standards, Vol3.01, Metals and alloys

Web resources:

1. Nondestructive%20testing%20(NDT)%20allows%20evaluation%20of%20components%20without,safety%20during%20production%20and%20use.
2. https://www.youtube.com/watch?v=U3aR5R8q07Y
3. https://www.youtube.com/watch?v=6MbxUMes_y0
4. https://www.youtube.com/watch?v=lD95ri6F2YY

COURSE OUTCOMES VS POs MAPPING

[1-slight (low), 2 - moderate (medium) and 3- substantial (high)]

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO 1	3	3	2	3	-	-	-	-	-	-	-	2	3	2
CO 2	3	3	3	3	-	1	-	-	-	1	-	2	3	3
CO 3	3	3	3	3	-	-	-	-	-	-	1	2	3	3
CO 4	3	2	3	3	-	-	-	1	-	1	1	2	3	3
CO 5	3	2	3	3	-	1	-	1	1	1	2	3	3	2
CO	3	3	3	3	-	1	-	1	1	1	1	2	3	3

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-PE3101.2	**Mechanical Behaviour of Materials (Professional Elective-I)**	3	0	0	3

Course objectives: The objectives of the course are to

- To explain how the structure of a material influences its mechanical properties.
- To understand the internal structural defects in materials and their effects on mechanical properties.
- To impart knowledge on the various strengthening mechanisms in materials.
- To analyze mechanisms of failures of materials (fracture, fatigue and creep) and their relationship with the different types of stress.
- To understand the metallurgical factors influencing creep behavior in materials.

Course Outcomes: At the end of this course, students will be able to:

1. Illustrate the elastic and plastic Behaviour of metals through Hooke's law and dislocation theory (L2)
2. Explain strengthening mechanisms in metals and their effect on mechanical properties (L2)
3. Apply the principles of fracture mechanism to find the types and causes of metal fracture (L3)
4. Demonstrate fatigue behavior in metals with stress cycles, S-N curves. (L2)
5. Explain the factors affected creep behavior in order to assess material performance at high temperatures (L2)

UNIT– I

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

Learning outcomes:

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

1. ***Explain*** the elastic behavior of engineering materials (L2)
2. ***Explain*** the dislocation theory (L2)

3. ***Understand*** the forces in between dislocations(L2)

Application:

1. Construction purposes, analysis of various structures like bridges, columns, pillars, beams etc.,

UNIT–II

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

Learning outcomes:

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

1. ***Describe*** various strengthening mechanisms(L2)
2. ***Discuss*** grain size and solid solution strengthening (L2)
3. ***Compare*** strain aging and dynamic strain aging (L2)

Application:

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

UNIT–III

Fracture and fracture mechanics: Types of Fracture, Basic Mechanism of Ductile and Brittle Fracture, Griffith's Theory of Brittle Fracture, Ductile to Brittle Transition

Temperature (DBTT). Fracture Mechanics-Introduction, Modes of Fracture, Stress Intensity Factor,Strain Energy Release Rate, Fracture Toughness.

Learning outcomes:

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

1. ***Explain*** the basic mechanism of ductile and brittle fracture (L2)
2. ***Understand*** the Application of griffith's theory (L2)
3. ***Predict*** factors effecting on DBTT(L2)
4. ***Classify*** various modes of fracture(L2)

Application:

1. Prediction of failure in applied loads, residual loads and Size, shape, location orientation of crack

UNIT-IV

Fatigue behavior and testing: Stress Cycles, S-N Curves, Effect of Mean Stress, Factors Affecting Fatigue, Structural Changes Accompanying Fatigue, and CumulativeDamage.

Learning outcomes:

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

1. ***Explain*** the S-N curves for different materials(L2)
2. ***Understand*** the fatigue behavior of fiber's in fiber composites (L2)

Application:

1. Analysis of Fatigue behavior of fibers in fiber composites as the load bearers are fiber's, Analysis of plastic behavior in metals etc.

UNIT-V

Creep Behaviour and testing: Creep Curve, Stages in Creep Curve and Explanation, Structural Changes During Creep, Creep Mechanisms, Metallurgical Factors Affecting Creep, High Temperature Alloys, Stress Rupture Testing, Creep Testing Machines.

Learning outcomes:

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

1. ***Explain*** the stages in creep curve (L2)
2. ***Understand*** the metallurgical factors affecting creep(L2)
3. ***Illustrate*** the working of creep testing machines(L2)

Applications:

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

Textbooks:

1. George E. Dieter., Mechanical Metallurgy, McGraw Hill Education.
2. Thomas Courtney, Mechanical Behaviour of Materials, McGraw-Hill International eds.

References:

1. Marc Andre Meyers, Krishan Kumar Chawla, Mechanical Behavior of Materials, Cambridge University Press.
2. A V K Suryanarayana, Testing of Metallic Materials, BSP Books Private Limited.

3. O P Khanna, A Textbook of Material Science and Metallurgy, Dhanpat Rai.

Web Sources References:

1. https://www.youtube.com/watch?v=lWr8fmUGXeE&list=PLfIFNJ1DPG4nwAQAY8aEi2-1JPwCRj9Gq&index=3
2. https://www.youtube.com/watch?v=yvxDcmvyZes&list=PLfIFNJ1DPG4nwAQAY8aEi2-1JPwCRj9Gq&index=6
3. https://www.youtube.com/watch?v=zH05sDLKMoU&list=PLfIFNJ1DPG4nwAQAY8aEi2-1JPwCRj9Gq&index=26
4. https://www.youtube.com/watch?v=ySYX444zI8I&list=PLfIFNJ1DPG4nwAQAY8aEi2-1JPwCRj9Gq&index=28

COURSE OUTCOMES VS POs MAPPING

[1-slight (low), 2 - moderate (medium) and 3- substantial (high)]

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	-	-	-	-	-	2	2	2
CO2	3	2	-	-	-	-	-	-	-	-	-	2	2	2
CO3	3	3	2	2	1	-	-	-	-	-	-	2	3	2
CO4	3	2	2	2	1	-	-	-	-	-	-	2	3	2
CO5	3	2	3	-	-	-	1	-	-	-	-	2	3	2
CO*	3	2	2	2	1	-	1	-	-	-	-	2	3	2

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-PE3101.3	**Operations Research (Professional Elective-I)**	3	0	0	3

Course Objectives:

The objectives of the course are

- Explore advanced methodologies in Operations Research to model and optimize decision-making processes in complex systems.
- Comprehend the theoretical foundations and practical applications of Linear Programming to address challenges in industrial and operational domains.
- Develop effective solutions for Transportation and Assignment Problems by applying optimization techniques to enhance productivity in manufacturing and efficiency in logistics.
- Impart knowledge of strategic tools in Game Theory and Network Analysis to evaluate and improve competitive scenarios and project management systems.
- Evaluate Queuing models and Simulation models to address uncertainty and improve the system performance.

Course Outcomes

After completing the course, the student will be able to

1. ***construct*** mathematical models for allocation problems to find the optimal solutions. **(L3)**
2. ***determine*** optimal solutions for transportation and assignment problems and ***test*** for optimality to obtain the optimal solutions. **(L4)**
3. ***design*** simulation models for discrete systems under uncertainties to obtain the solutions for decision making. **(L4)**
4. ***apply*** the concepts of PERT and CPM for scheduling the projects. **(L3)**
5. ***determine*** strategic solutions for competitive scenarios in two-person zero-sum games **(L4)**

UNIT I

Introduction to Operations Research (OR): OR definition - Classification of Models,

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

Learning Outcomes:

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

1. ***explain*** the classification of models in Operations Research **(L2)**
2. ***explain*** the application areas of operations research in manufacturing and service firms. **(L2)**
3. ***solve*** linear programming problems**(L3)**

Applications: Determination of Production quantities of different products in manufacturing industries

UNIT II

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

Learning Outcomes:

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

1. ***construct*** mathematical model for transportation and assignment Problems**(L3)**
2. ***solve*** transportation Problem to get feasible solution **(L3)**
3. ***apply*** hungarian algorithm to assignment and traveling salesman problems. **(L3)**

Applications: Optimizing transportation costs in distribution of goods

UNIT III

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

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

Learning Outcomes:

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

1. ***explain*** the basic structure of queuing models and characteristics **(L2)**
2. ***Calculate*** the parameters of the single channel waiting line **(L3)**
3. ***Illustrate*** the steps in Monte Carlo simulation model for waiting line **(L2)**

Applications: Decision making in uncertainty situations

UNIT IV

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

Learning Outcomes:

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

1. ***construct*** the network diagram for the given precedence relationship between the activities**(L3)**
2. ***calculate the*** starting time, finishing times of the activities with forward Pass and backward Pass methods**(L2)**

3. ***find*** the probability of completing the project with PERT **(L3)**

Applications: Project planning control in manufacturing and maintenance

UNIT V

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

Learning Outcomes:

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

1. ***identify*** the optimal strategies in competitive situations (L3)
2. ***solve*** pay off matrix games using dominance rules and algebraic method. (L3)

Applications: Determination of optimal strategies in competition between industries

Text books:

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

Reference books:

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

Web Source References:

1. https://onlinecourses.nptel.ac.in/noc22_mg15
2. https://onlinecourses.nptel.ac.in/noc22_ma48
3. https://onlinecourses.nptel.ac.in/noc24_mg30
4. https://www.britannica.com/topic/operations-research
5. https://www.theorsociety.com/about-or

COURSE OUTCOMES VS POs MAPPING

[1-*slight* (low), 2 - *moderate* (*medium*) and 3- substantial (high)]

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	3	3	3	1	-	-	1	-	-	2	3	3	3
CO2	3	3	3	3	1	-	-	1	-	-	2	3	3	3
CO3	3	3	3	3	2	-	-	1	-	-	2	3	3	3
CO4	3	3	3	3	1	-	-	1	-	-	3	3	3	3
CO5	3	3	3	3	1	-	-	1	-	-	1	3	-	3
CO*	3	3	3	3	1	-	-	1	-	-	2	3	3	3

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-PE3101.4	**Non-Conventional Energy Sources (Professional Elective-I)**	3	0	0	3

Course Objectives:

The objectives of the course are

- To explore the national and global energy scenarios to develop the energy sources
- To apply the thermal and photovoltaic technologies to design the solar energy systems
- To explore the role technologies in power generation
- To expose towards developments in power generation towards tidal energy, geothermal energy and fuel cell technologies
- To evaluate ethical and social responsibility in power generation includes environmental sustainability and community impact

Course Outcomes:

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

1. ***Explain*** the global and Indian energy scenario along with various renewable energy sources **(L2)**
2. ***Illustrate*** the working and applications of solar thermal systems. **(L2)**
3. ***Apply*** the principles of solar photovoltaic technology for optimizing the performance of Photovoltaic system **(L3)**
4. ***Design*** Wind energy and Geothermal systems to the specific power requirements. **(L4)**
5. ***Find*** the optimal operational parameters for tidal power systems, biomass energy, and fuel cells to improve their performance. **(L3)**

UNIT I:

Energy Systems and Solar energy: Energy conservation principle, Energy scenario (world and India), various forms of renewable energy, Solar radiation: measurement of solar radiation, Solar Constant, Solar radiation at earth's surface, solar radiation Geometry, Analysis of solar radiation data -Numerical problems

Learning Outcomes: After the completion of this unit students will able to

1. ***Explain*** *the* Fundamentals of Energy Systems and Solar energy**(L2)**
2. ***Explain*** the principles of solar radiation outside Earth's atmosphere and at the Earth's surface and *solar radiation Geometry***(L2)**

Application:

1. Solar resource assessment for power plant site selection
2. Energy audits in industries to improve efficiency

UNIT–II: Solar Thermal Systems

Liquid flat plate collectors, effect of various parameters on performance and material selection for various parts of Flat plate collector, Numerical problems, solar air heaters, working, Advantages, Applications, Concentrating collectors, Focusing type and Non-

Focusing type, solar pond, Applications and solar still, solar heating/cooling technique, solar distillation, solar cookers–solar electric power plant, construction, working

Learning Outcomes: After the completion of this unit students will able to

1. ***Explain*** the working principles of solar thermal devices **(L2)**
2. ***Explain*** the working principle solar electric power plant, construction, working. **(L2)**

Application:

1. Domestic solar water heaters for residential hot water supply
2. Solar cookers used in rural and remote areas for clean cooking

UNIT–III: Solar Photovoltaic and Geothermal Systems

Solar Photovoltaic Systems: Solar photovoltaic cell, module, And array, construction, classification of solar cell, Efficiency of solar cells, Cell I,V characteristics Equivalent circuit of solar cell, Maximum power point techniques: Perturb and observe (P&O) technique, Hill climbing technique.

Geothermal System: Types of Geo-Thermal Resources, Hydro thermal, Geo-Pressurized, Hot Dry Rock (HDR), Magma–Geothermal based electric power generation, Design of Geothermal system for specific power requirement

Learning Outcomes: After the completion of this unit students will able to

1. ***Describe*** the construction and working of solar photovoltaic cells, modules, and arrays and I–V characteristics and equivalent circuit parameters of a solar cell. **(L2)**
2. ***Classify*** geothermal resources with their application in electric power generation systems**(L2)**

Application:

1. Roof top solar panel systems for residential electricity generation
2. Geothermal heating systems for buildings in volcanic or tectonic areas

UNIT–IV: Wind Energy

Sources of wind energy–Types of wind turbines–Horizontal Axis Wind Turbine (HAWT)and vertical Axis Wind Turbine (VAWT),Construction, Principles and components of wind energy conversion system, Wind data and energy storage, Site selection considerations, Wind Turbine Aerodynamics, Analysis of Aerodynamic forces acting on the blade-Power extraction from wind-Power Coefficient, Axial Thrust, Torque, Maximum power extraction, Tip Speed ratio, Blade setting angle, Design of wind energy system for specific power requirement.

Learning Outcomes: After the completion of this unit students will able to

1. ***Explain*** different types of wind turbines and wind energy patterns relevant to power generation**(L2)**
2. ***Apply*** aerodynamic principles to optimize performance on wind turbine blades**(L3)**

Application:

1. Wind farms for large-scale electricity generation
2. Power supply for telecom towers, weather stations, and surveillance systems located in remote or hard-to-access areas.

UNIT–V: Tidal power systems, Biomass and Fuel cells

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

Learning Outcomes: After the completion of this unit students will able to

1. ***Apply*** *the principles of tidal and wave power systems using kinetic energy equations***(L3)**
2. ***Demonstrate*** *types of fuel cells and bio-mass energy conversion technologies including pyrolysis and digester sizing***(L2)**

Application:

1. Tidal power plants used for electric power generation
2. Biogas digesters in villages for cooking gas from organic waste

Text Books

1. B.H.Khan "Non-conventional energy source" -TMH.
2. G.D.Rai "Non-Conventional Energy Sources", Khanna Publishers

Reference Books

1. S.P. Sukhatme,"Solar Energy: principles of Thermal Collection and Storage" McGraw-Hill Education Private Limited
2. God frey-Boyle "Renewable Energy"-Oxford University. Press
3. R. Ramesh and K. Uday Kumar, "Renewable Energy Technologies", Narosa Publishing House

Web source referece:

1. https://nptel.ac.in/courses/103103206
2. https://onlinecourses.nptel.ac.in/noc25_ge24/preview
3. https://www.coursera.org/courses?query=renewable%20energy
4. https://www.classcentral.com/institution/nptel
5. https://market.tutorialspoint.com/course/non-conventional-sources-of-energy/index.asp

COURSE OUTCOMES VS POs MAPPING

[1-*slight* (low), 2 - *moderate* (*medium*) and 3- substantial (high)]

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	3	2	-	-	1	1	1	1	1	2	2	3	3
CO2	3	3	3	-	2	1	1	1	1	1	2	2	3	3
CO3	3	3	3	-	2	1	1	1	1	1	2	2	3	3
CO4	3	3	3	-	2	1	1	1	1	1	2	2	3	3
CO5	3	3	3	-	-	1	1	1	1	1	2	2	3	3
CO*	**3**	**3**	**3**	**-**	**2**	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**3**	**3**

**For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-PE3101.5	**Automation In Manufacturing (Professional Elective-I)**	3	0	0	3

Course Objectives: The objectives of the course are

- 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. Apply the methods to balance the assembly line. (L3)
4. Compare conventional and automated material transport, storage system. (L2)
5. Explain the 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 changing and machine tool control. Economical and technological factors for automation. Barriers of 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)

Applications:

1. Automated Material Handling System in Manufacturing
2. Automation in Machine Tools for Precision Manufacturing

Unit-II

AUTOMATED FLOW LINES: Methods of part transport, transfer mechanism, buffer storage, 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, implementation 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).**

Applications:

1. Automated Conveyor Systems in Assembly Lines
2. Buffer Storage in Automotive Manufacturing

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)**

Applications:

1. Optimized Assembly Line Balancing in Electronics Manufacturing
2. Flexible Manufacturing Systems (FMS) in Automotive Production

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)**

Applications:

1. Automated Storage and Retrieval System (ASRS) in Warehousing
2. Radio Frequency Identification (RFID) in Supply Chain Management

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)**

Applications:

1. Industrial Control Systems in Chemical Processing Plants
2. Machine Vision-Based Automated Inspection in Automotive Manufacturing

Text Books:

1. M.P. Groover, Automation, Production systems and Computer Integrated Manufacturing, PHI Learning.
2. Geoffrey Boothroyd, Assembly Automation and Product design, Taylor and Francis Publishers.

Reference Books:

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

COURSE OUTCOMES VS POs MAPPING

[1-*slight* (low), 2 - *moderate* (*medium*) and 3- substantial (high)]

CO/PO	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO11	PO12	PSO 1	PSO2
CO1	3	1		1	-	2	2	-	-	-	-	1	2	2
CO2	3	2	2	1	-	1	-	-	-	-	-	2	1	-
CO3	3	3	2	1	-	2	2	-	-	-	-	-	2	2
CO4	3	3	3	1	-	1	-	-	-	-	-	2	2	2
CO5	3	3	3	1	-	2	-	-	-	-	-	-	2	-
CO*	3	3	3	1	-	2	2	-	-	-	-	2	2	2

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-PC3104	**Thermal Engineering laboratory**	0	0	3	1.5

Course Objectives:

The objectives of the course are

- Familiarize students with the working principles of internal combustion (I.C.) engines and compressors by analysing valve and port timing diagrams.
- Enable students to conduct performance tests on different engine types and evaluate parameters such as frictional power, heat balance, and efficiency.
- Develop students ability to analyse experimental data from engine tests and apply the findings for optimizing engine performance and fuel economy.
- Evaluate various engine testing methods and instrumentation used for measuring engine performance parameters.
- Integrate thermodynamic principles with experimental findings from real-world engine and compressor systems.

Course Outcomes:

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

- ***Draw*** the valve and port timing diagrams of 4-stroke CI engine and 2-stroke SI engines
- ***Analyse*** the performance parameters of engines and compressors using load tests
- ***Determine*** friction power of engines through retardation, motoring and Morse tests.
- ***Evaluate*** performance, fuel economy and heat balance sheet for engines
- ***Demonstrate*** experimental techniques in the thermal engineering lab

List of Experiments

1. I.C. engines valve timing diagram.
2. I.C. engines port timing diagram
3. Load test on twin cylinder compression ignition engine
4. Determination of frictional power by retardation test
5. I.C engine heat balance sheet.
6. Motoring test on 4-stroke, single cylinder SI engine test rig
7. Load test on variable compression ratio on 4-stroke, single cylinder petrol engine test rig.
8. Performance test on two stage reciprocating air compressor.
9. Economical speed test on multi cylinder SI engine.
10. Morse test on multi cylinder SI engine.
11. Heat rejection analysis on automobile radiator.
12. Combustion analysis of hydrocarbon fuels

COURSE OUTCOMES VS POs MAPPING

[1-*slight* (low), 2 - *moderate* (*medium*) and 3- substantial (high)]

CO No.	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2
CO1	3	3	2	1	-	1	1	1	1	1	1	2	1	1
CO2	3	3	2	-	-	1	1	1	1	1	1	1	1	2
CO3	3	3	2	1	-	1	1	1	1	1	1	2	2	2
CO4	3	3	2	-	1	1	1	1	1	1	1	1	1	1
CO5	3	3	2	-	-	1	1	1	1	1	1	1	1	1
CO*	**3**	**3**	**2**	1	1	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**2**

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-PC3105	Theory of Machines laboratory	0	0	3	1.5

Course Objectives:

The objectives of the course are

- To determine the theoretical whirling speed of a shaft using mathematical models and equations
- To analyze the effect of controlling forces, such as centrifugal and spring forces, on sleeve displacement.
- To conduct experiments to observe and measure gyroscopic motion in practical applications
- To compare the behavior of different damping conditions and their influence on system stability.
- To apply balancing techniques to improve the efficiency and lifespan of rotating machinery.

Course Outcomes:

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

1. ***Analyze*** the behavior of rotating systems, including critical speeds, gyroscopic motion, and the influence of unbalanced forces, using theoretical and experimental approaches. **(L4).**
2. ***Analyze*** the dynamic behavior of governors and gyroscopes, plotting performance characteristics for stability and control in mechanical systems. (**L4)**
3. ***Determine*** the natural frequencies of free and forced vibrations in a spring-mass systems under damped and undamped conditions. **(L5).**
4. ***Apply*** concepts of static and dynamic balancing techniques for rotating masses to achieve proper balancing **(L3).**
5. ***Evaluate*** the kinematic and dynamic parameters of mechanical systems such as cam-follower, slider-crank mechanisms, and frictional parameters of power transmission systems using graphical, analytical, and experimental methods. **(L5).**

LIST OF THE EXPERIMENTS

1. To determine the whirling speed of the shaft theoretically and experimentally.
2. To determine the position of sleeve against controlling force and speed of a Hartnell governor and to plot the characteristic curve of radius of rotation.
3. To analyze the motion of a motorized gyroscope when the couple is applied along its spin axis
4. To determine the frequency of undamped free vibration of an equivalent spring mass system.
5. To determine the frequency of damped force vibration of a spring mass system
6. To study the static and dynamic balancing using rigid blocks.
7. To find the moment of inertia of a flywheel
8. To plot follower displacement vs cam rotation for various Cam Follower systems.
9. To plot slider displacement, velocity and acceleration against crank rotation for single slider crank

mechanism/Four bar mechanism

10. To find coefficient of friction between belt and pulley.

COURSE OUTCOMES VS POs MAPPING

[1-*slight* (low), 2 - *moderate* (*medium*) and 3- substantial (high)]

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	3	3	2	3	-	2	1	1	2	2	1	2	3	2
CO2	3	3	3	3	-	2	1	2	2	2	2	2	3	3
CO3	3	3	2	3	-	2	2	1	3	3	2	3	2	3
CO4	2	3	3	2	-	2	1	2	2	2	2	2	3	3
CO5	3	3	3	3	-	2	2	2	3	3	2	3	3	3
CO*	**3**	**3**	**3**	**3**	**-**	**2**	**2**	**2**	**3**	**3**	**2**	**2**	**3**	**3**

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-SC3101	**Artificial Intelligence and Machine Learning (Skill Enhancement Course)**	0	1	2	2

Course Objectives:

The objectives of the course are to

- Understand fundamental concepts of graph theory and apply graph search algorithms like DFS and BFS for problem solving.
- Model and solve classical Artificial Intelligence problems using state-space representation and recursion-based techniques.
- Introduce the principles of Machine Learning, including types of learning, key terminologies, and evaluation metrics.
- Develop skills in data preprocessing and applying supervised learning techniques such as regression and classification.
- Explore unsupervised learning methods and model evaluation techniques to analyze and interpret real-world datasets.

Course Outcomes:

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

1. ***Apply*** stack and queue-based graph traversal algorithms such as DFS and BFS.**(L3)**
2. ***Solve*** classical AI problems using state space representation and recursive problem-solving techniques. **(L3)**
3. ***Apply*** fundamental machine learning algorithms and model performance using standard metrics. **(L3)**
4. ***Prepare*** datasets through preprocessing techniques and implement regression and classification algorithms for predictive analytics. (**L3)**
5. ***Apply*** unsupervised learning methods to cluster data and use statistical evaluation metrics to assess model effectiveness. **(L3)**

UNIT I

Introduction to Artificial Intelligence: Philosophy of artificial intelligence, Definitions - Evolution of AI - Applications of AI, Classification of AI, Graph Theory Basics: Nodes, Edges, Adjacency List/Matrix**,** Uninformed Search: DFS, BFS**,** Stack and Queue-based traversal**,** Graph traversal efficiency

Programs:

1. Write a program to implement DFS
2. Write a program to implement BFS

Learning Outcomes:

- Understand and apply stack and queue-based search techniques **(L2).**
- Apply graph traversal algorithms to explore connected nodes and determine the traversal order in a given graph **(L3).**

Applications:

1. Web crawling and link traversal
2. Path finding in route navigation systems

UNIT II

Classical AI Problem Solving: State Space Search**,** Problem formulation: Initial state, Goal state, Operators**,** Backtracking and recursion

Programs:

1. Write a program to implement Water Jug problem using Python

2. Write a program to implement Towers of Hanoi
3. Solve 8-Queens Problem with suitable assumptions

Learning Outcomes:

- Apply state space representation to model real-world problem scenarios **(L3).**
- Solve recursive and constraint-based problems **(L3).**

Applications:

1. Robotics task planning
2. Constraint satisfaction in scheduling

UNIT III

Introduction to Machine Learning: Types of Machine Learning, Supervised, Unsupervised, Reinforcement Learning, Key Terminologies, Features, Labels, Training, Testing, Validation, Evaluation Metrics, Accuracy, Precision, Recall, F1 Score.

Programs:

1. Write a program on supervised learning using Linear Regression.
2. Write a program to calculate accuracy, precision, recall, and F1 score.
3. Write a program to split a dataset into training and testing sets, train a simple classifier, and evaluate its accuracy.

Learning Outcomes:

- Explain the types of machine learning techniques including supervised, unsupervised, and reinforcement learning. **(L2).**
- Apply basic machine learning algorithms to real datasets and evaluate model performance using metrics such as accuracy, precision, recall, and F1 score.**(L3).**

Applications:

1. Spam Email Detection
2. Customer Segmentation

UNIT IV

Data Preprocessing and Supervised Learning: Handling Missing Data, Categorical Encoding**,** Feature Scaling: Normalization and Standardization**,** Linear Regression, Logistic Regression**,** Classification Algorithms: KNN, Decision Trees

Programs:

1. Data preprocessing: Handle missing data, encoding, scaling
2. Implement Linear Regression and analyze performance
3. Implement KNN Classification
4. Implement Decision Tree Classification
5. Logistic Regression for binary classification

Learning Outcomes:

- Prepare and clean datasets for ML model input **(L3).**
- Apply regression and classification techniques for prediction tasks **(L3).**

Applications:

1. Predictive analytics (e.g., house prices)
2. Spam filtering and binary classification

UNIT V

Unsupervised Learning and Model Evaluation: Unsupervised Learning Basics**,** K-Means and Hierarchical Clustering**,** Model Evaluation: Accuracy, Precision, Recall, Cross-Validation

Programs:

1. Implement K-Means Clustering (e.g., customer segmentation)
2. Implement Hierarchical Clustering with dendrogram
3. Evaluate models using Accuracy, Precision, Recall

Learning Outcomes:

- Apply clustering techniques to group unlabeled data and visualize inherent patterns **(L3).**
- Apply statistical metrics to assess the performance of machine learning models **(L3).**

Applications:

1. Market segmentation and pattern discovery
2. Anomaly detection in networks

Text Books:

1. Russell and Norvig, *Artificial Intelligence: A Modern Approach*, Pearson Education.
2. AurélienGéron, *Hands-On Machine Learning with Scikit-Learn, Keras, and TensorFlow*, O'Reilly.

Reference Books:

1. Tom Mitchell, *Machine Learning*, McGraw Hill.
2. Ian Goodfellow, YoshuaBengio, Aaron Courville, *Deep Learning*, MIT Press.
3. Elaine Rich and Kevin Knight – Artificial Intelligence, Tata McGraw-Hill

Web Resources:

1. **Artificial Intelligence** by *Prof. Mausam*, IIT Delhi https://nptel.ac.in/courses/106/102/106102220
2. **Machine Learning** by *Prof. PabitraMitra*, IIT Kharagpur https://nptel.ac.in/courses/106/105/106105152

COURSE OUTCOMES VS POs MAPPING

[1-*slight* (low), 2 - *moderate* (*medium*) and 3- substantial (high)]

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	3	2	3	-	-	-	-	2	1	2	2	1
CO2	3	2	3	3	3	-	-	-	-	1	1	2	2	1
CO3	3	3	3	2	3	-	-	-	-	2	1	3	2	1
CO4	3	3	2	2	3	-	-	-	-	2	1	2	2	1
CO5	3	2	2	3	3	-	-	-	-	2	-	3	2	1
CO*	3	3	3	3	3	-	-	-	-	2	1	3	2	1

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-ES3101	**Tinkering Laboratory**	3	0	0	3

Course Objectives: The objectives of the course are to

1. Introduce students to microcontroller programming and basic circuit prototyping using Arduino and electronic components.
2. Enable students to interface a variety of sensors and actuators with microcontrollers for interactive system development.
3. Train students in digital fabrication techniques such as 3D printing, laser cutting, and PCB milling to support functional prototyping.
4. Develop the ability to integrate mechanical, electrical, and computing elements into complete working systems.
5. Foster creativity, problem-solving, and teamwork through the design and execution of interdisciplinary mini projects.

Course Objectives: After completion of the course, the students will be able to:

1. ***Construct*** basic electronic circuits and write simple programs using Arduino to control input and output devices. ***(L3)***
2. ***Interface*** sensors and actuators with microcontrollers and fabricate basic custom PCBs using PCB milling tools. ***(L3)***
3. ***Design*** mechanical components using CAD software and fabricate them using 3D printing and laser cutting tools. ***(L3)***
4. ***Integrate*** mechanical structures with electronics and apply IoT platforms for real-time data monitoring and control. ***(L4)***
5. ***Design*****,** build, and demonstrate a functional electromechanical mini project with proper documentation and teamwork. ***(L6)***

Unit I – Fundamentals of Tinkering and Microcontroller Programming

Introduction to the Tinkering Lab: safety, tools, and interdisciplinary scope, Basics of Arduino: pinout, IDE, digital I/O, analog input, Serial communication and interfacing with PC, Basic circuit building using breadboard, switches, buzzers, LEDs, Introduction to sensors: LDR, IR, temperature (LM35, DHT11)

Practical Activities:

- LED blinking, button control
- Analog sensor input and serial monitor visualization
- Temperature sensing and display

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

1. ***Identify*** components of the Arduino development board and install the Arduino IDE. *(L1)*
2. ***Write*** basic Arduino programs to control LEDs, buzzers, and read button inputs. *(L3)*
3. ***Construct*** and test simple circuits using breadboards and electronic components. *(L3)*
4. ***Use*** the serial monitor for debugging and sensor data visualization. *(L4)*

Unit II – Sensor Interfacing, Actuators, and PCB Prototyping

Interfacing sensors: ultrasonic, IR, humidity, temperature, Actuators: DC motors, servos, steppers using L298N, ULN2003, IR remote and Bluetooth communication using HC-05, Introduction to PCB Design (EasyEDA/KiCad/anyother), PCB Milling using PCB Milling Machine

Practical Activities:

- Obstacle detection system using ultrasonic sensor
- Mobile-controlled light/motor using Bluetooth
- Design and mill a basic PCB (sensor or LED circuit)

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

1. ***Interface*** common sensors (IR, ultrasonic, temperature, humidity) with microcontrollers. *(L3)*
2. ***Control*** DC, servo, and stepper motors using motor drivers and PWM signals. *(L3)*
3. ***Design*** a simple electronic circuit layout using PCB design software. *(L3)*
4. ***Fabricate*** and ***assemble*** a custom PCB using a PCB milling machine. *(L4)*

Unit III – Digital Fabrication: Laser Cutting and 3D Printing

- Basics of CAD design using TinkerCAD/Fusion 360
- STL file generation and slicing software (Cura/PrusaSlicer/anyother)
- 3D printing: machine setup, calibration, post-processing
- Laser cutting basics: vector design (Inkscape/CorelDraw/anyother), material safety, engraving/cutting
- Creating casings, panels, and gear systems

Practical Activities:

- Design and 3D print a bracket/gear
- Laser cut a project enclosure or custom keychain
- 3D-print and assemble simple mechanical joints

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

1. ***Model*** basic mechanical parts using CAD software. *(L3)*
2. ***Generate*** and slice STL files for 3D printing using slicing software. *(L3)*
3. ***Operate*** a 3D printer and perform calibration and post-processing. *(L4)*
4. ***Create*** and fabricate 2D designs using laser cutting equipment. *(L4)*

Unit IV– System Integration and IoT Applications

Integration of sensors, actuators, and mechanical parts into systems, PWM for speed control and automation, Real-time data logging and visualization using Python/Excel, Introduction to IoT platforms (ThinkSpeak/Blynk/any other), Enclosure design and testing for integration

Practical Activities:

- IoT-based temperature logger with graph
- Fan speed controller using temperature input
- Assembly and testing of a complete mechanical-electronic system

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

1. ***Integrate*** sensors, actuators, and fabricated parts into a functioning prototype. *(L5)*
2. ***Implement*** PWM-based control for automation (e.g., fan, motor speed control). *(L3)*
3. ***Collect*** and analyze sensor data using Python or spreadsheets. *(L4)*
4. ***Use*** IoT platforms like ThinkSpeak/Blynk for remote monitoring. *(L5)*

Unit V – Project-Based Learning and Demonstration

Design thinking and idea finalization for mini projects, Creating 3D-printed or laser-cut mechanical frameworks, Custom PCB, sensor-actuator integration, and testing, Debugging,

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

1. ***Develop*** and document a functional mini project addressing a real-world problem. *(L6)*
2. ***Select*** and integrate suitable sensors, components, and mechanical systems. *(L5)*
3. ***Demonstrate*** and troubleshoot the final prototype in a team-based setting. *(L6)*
4. ***Present*** the project effectively with clear explanation and demonstration. *(L6)*

Textbooks:

1. **Simon Monk**, *Programming Arduino: Getting Started with Sketches*, McGraw-Hill Education,
   (Excellent beginner-friendly guide to Arduino programming.)
2. **Dhananjay V. Gadre**, *Arduino-Based Embedded Systems*, Universities Press.
   (By an Indian author; practical insights into interfacing and embedded development.)
3. **C.K. Chua, K.F. Leong, C.S. Lim**, *Rapid Prototyping: Principles and Applications*, 3rd Edition, World Scientific.
   (Covers 3D printing fundamentals, prototyping processes, and applications.)
4. **Sanjay Mohapatra**, *Product Design and Manufacturing*, PHI Learning.
   (Useful for understanding product development processes relevant to tinkering projects.)

Reference Books:

1. **Ben Redwood**, *The 3D Printing Handbook: Technologies, Design and Applications*, 3D Hubs.
2. **David A. Mellis et al.**, *Getting Started with Arduino*, Make Media, 3rd Edition.
3. **John Baichtal**, *Make: Electronics – Learning Through Discovery*, Maker Media.
4. **Rafiq Elmansy**, *Practical Laser Cutting Projects*, Maker Media.

Online Resources:

1. **Arduino Official Website** – https://www.arduino.cc/
   Official tutorials, documentation, and beginner-to-advanced projects.
2. **Tinkercad Circuits** – https://www.tinkercad.com/learn/circuits
   Free browser-based tool for simulating and testing Arduino-based circuits.
3. **MIT OpenCourseWare – How to Make (Almost) Anything**
   Hands-on digital fabrication course with resources on laser cutting, 3D printing, electronics, and more.
4. **Instructables** – https://www.instructables.com/
   Thousands of DIY electronics, Arduino, CAD, and mechanical projects with step-by-step guides.
5. **All About Circuits** – https://www.allaboutcircuits.com/
   Electronics theory, simulation, and component reference portal.

COURSE OUTCOMES VS POs MAPPING

[1-*slight* (low), 2 - *moderate* (*medium*) and 3- substantial (high)]

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**3**	1	–	1	**2**	–	–	–	1	1	–	1
CO2	**3**	**2**	1	1	**3**	1	–	–	1	–	–	1
CO3	**3**	1	**2**	1	**3**	–	1	–	1	–	1	1
CO4	**3**	**2**	**2**	**2**	**3**	1	–	–	**2**	1	–	1
CO5	**2**	**2**	**3**	**2**	**2**	**2**	1	1	**3**	**2**	**2**	1
CO*	**3**	**2**	**2**	**2**	**3**	**1**	1	1	**2**	**2**	**2**	1

***** *For Entire Course, PO & PSO Mapping*

Course code	Course Title	L	T	P	Credits
R23BSH-MC3101	**English and Soft Skills for Job Seekers (Mandatory Course)**	0	1	2	0

Course Objectives:

Upon completion of this course, students will be able to:

- To develop proficiency in spoken and written English by effectively using a wide range of grammatical structures and vocabulary, and by mastering skills such as paraphrasing, report and résumé writing, and formal correspondence.
- Communicate fluently and confidently in English through active participation in informal group discussions and formal presentations, leveraging audio-visual aids.
- Understand and apply best practices for successful performance in job interviews, including visume (video resume) preparation.
- Develop essential self-learning, communication, and soft skills that enhance employability through group discussions, teamwork, and case-based tasks.
- To prepare students for international education by building competence in the admission process, application writing, interview skills, and awareness of visa, cultural, and financial aspects.

Course Outcomes:

1. ***Understand*** the grammatical forms of English and the use of these forms in specific communicative and professional writing. **(L2)**
2. ***Improve*** their speaking ability in English, both in terms of fluency and comprehensibility by participating in Group discussions and oral assignments.
3. ***Master*** interview skills for effective preparation and confident performance in diverse job scenarios.
4. ***Demonstrate*** confidence and professionalism in job interviews and workplace interactions by effectively applying practiced soft skills.
5. ***Demonstrate*** readiness for Higher education by effectively navigating its admission process.

Unit I:

Grammar for Professional Writing: Initial Assessment Readiness Articles—Usage, context, and error correction, Prepositions—Functions and contextual use Tenses—Forms, purposes, and corrections, Subject-Verb Agreement (Concord)—Identification and Correction Voice—active and passive usage, conversions, Paraphrasing and Summarizing Techniques of paraphrasing, summarizing key ideas, Report Writing—Elements of formal reports, format and organization, Clarity and coherence in expression, Resume and Visume Creation,

Types of resumes: Chronological, Functional, hybrid Customizing resumes for job applications, Planning and scripting visumes, Recording and reviewing visumes, LOR (Letter of Recommendation)- Purpose, structure, tone, and content, SOP (Statement of Purpose) - Academic/professional goal alignment, personal background, clarity, coherence,

Proofreading and Editing: Common writing errors, strategies for self-editing, peer editing, and collaborative revision.

Learning Outcomes

At the end of the module, the learners will be able to

- Apply appropriate grammar structures—including articles, prepositions, tenses, voice, and subject-verb agreement—in a variety of professional and academic writing contexts.
- Paraphrase and summarise complex texts using accurate language and coherent structures.
- Prepare tailored resumes and visumes suited to specific job roles and presentation styles.
- Draft effective LORs and SOPs, and apply proofreading techniques and editing strategies to identify and correct common writing errors through self-assessment and peer feedback.

Unit II:

Preparing for Oral Assessment:

Group Discussions: Techniques, etiquette, turn-taking, active listening,

Expressing Opinions: Polite agreement/disagreement, clarity in communication,

Oral Presentations: Structure (introduction, body, conclusion), use of transitions, logical flow,

Vocabulary Use: Selecting formal/semi-formal expressions for interviews, academic and professional discussions,
Clarity & Confidence: Voice modulation, articulation, managing speaking pace, reducing fillers,

Public Speaking: Planning and delivering one-minute speeches, engaging openings and impactful conclusions.

Learning Outcomes

By the end of this unit, learners will be able to:

- Demonstrate effective group discussion skills, including appropriate techniques, turn-taking, active listening, and polite expression of opinions.
- Express agreement and disagreement politely in formal and semi-formal settings while maintaining clarity and professionalism in communication.
- Organise and deliver structured oral presentations using clear introductions, well-developed content, logical transitions, and strong conclusions.
- Select and use appropriate vocabulary suitable for academic discussions, professional interviews, and workplace communication.
- Plan and deliver short public speeches (e.g., one-minute talks) with engaging openings and impactful closing statements tailored to the audience.

Unit III:

Mastering Interview Skills

Purpose of Interviews: Understand recruiter expectations, align personal goals, skills, and achievements.

Interview Preparation: Pre-interview research, behaviour, and presentation. FAQs: Framing answers about self, family, strengths, and weaknesses.
Interview Dynamics: Understanding assessment areas and developing effective responses.

Types of Interviews: Awareness of formats: one-on-one, panel, telephonic, video/virtual, group discussions, and walk-in interviews; differences between HR and technical interviews.
Mock Interviews and Role Plays: Practising real-time interview scenarios, peer feedback, video recording for self-review, identifying areas of improvement in verbal and non-verbal communication.

Learning Outcomes

At the end of the module, the learners will be able to:

- Understand recruiter expectations and the interview process.
- Prepare and behave appropriately during interviews.
- Respond confidently to common personal and career-related questions.
- Improve interview skills through mock interviews and feedback.

Unit IV:

Employability through Soft Skills

Teamwork and Collaboration: Importance of teamwork in the workplace, Role-based team challenges and problem-solving tasks, Reflective journaling on team dynamics, Workplace Etiquette and Professionalism, Basics of workplace behavior and grooming, Punctuality, discipline, and digital etiquette,
Decision-Making and Conflict Resolution: Decision-making models and techniques, Conflict styles and resolution strategies,

Emotional Intelligence and Motivation: Self-awareness and empathy in the workplace, Identifying emotional triggers and responses, Time Management and Goal Setting: Prioritizing tasks using the Eisenhower Matrix, SMART goals (Specific, Measurable, Achievable, Relevant, Time-bound),

Adaptability and Flexibility: Managing change in the workplace Developing resilience and growth mindset, networking, and building professional relationships.

Learning Outcomes

At the end of the module, the learners will be able to:

- Demonstrate effective teamwork and collaboration in professional settings.
- Exhibit professional behaviour, workplace etiquette, and digital discipline.
- Apply decision-making techniques and resolve conflicts constructively.
- Build emotional intelligence, self-awareness, and motivation to perform in diverse work environments.
- Manage time effectively, set achievable goals, and adapt to change with resilience.

Unit V:

English for Abroad Education

Introduction to Studying Abroad: Overview of global education systems and Admission Process, Research and University Selection:H ow to research courses and universities, Creating an application calendar, Understanding course credits, intakes, and rankings,
Application Documents: SOP (Statement of Purpose): Structure, language, and sample writing ,LOR (Letters of Recommendation): Types, tone, and formatting, Admission and Visa Interview SkillsTypes of admission interviews (in-person, video), FAQs and model responses, Justifying candidature and demonstrating motivation,
Visa Process: Documentation, interview preparation,

English Proficiency and Entrance Tests: Overview of TOEFL, IELTS, GRE, GMAT, SAT, ACT, Preparation strategies and practice samples.

Learning Outcomes

By the end of the module, learners will be able to:

- Understand and plan the international university admission process.
- Research and shortlist suitable universities by evaluating courses, intakes, credits, and global rankings
- Prepare essential application documents such as SOPs, LORs, and admission essays using appropriate academic language
- Demonstrate effective communication in admission and visa interviews by confidently responding to FAQs and justifying candidature
- Gain awareness of visa procedures, cultural expectations, financial planning, and student safety for successful transition to higher education.

III B. Tech-II Semester Syllabus

Course Code	Course Name	L	T	P	C
R23MEC-PC3201	**Machine Tools and Metrology**	3	0	0	3

Course Objectives: The objectives of the course are to

- Familiarize with the specifications and capabilities of various machine tools to select appropriate machines for specific tasks.
- Explore advanced machine tools such as turret and capstan lathes, and their specific applications in manufacturing
- Develop problem-solving skills related to optimizing cutting conditions and improving machining efficiency
- Familiarize with international standards and practices in metrology to ensure consistency and reliability in measurements.
- Develop problem-solving skills to address complex measurement challenges in industrial settings.

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

1. Calculate cutting forces using the Merchant Circle diagram for the given speed and feed. (L3)
2. Describe the operations required on Drilling, Shaping, Slotting, and Planning machines as per the given configuration of the job. (L2)
3. Identify the sequence of milling and finishing operations to be performed for the given configuration of the job. (L2)
4. Find the tolerance systems applicable in specifying dimensional limits for the mechanical components. (L3)
5. Explain methods for measuring gear tooth thickness, including the chordal thickness method and the constant chord method. (L2)

UNIT I

Metal Cutting: Introduction, geometry of single point cutting tool, types of chips produced in metal cutting, orthogonal cutting and oblique cutting, cutting forces- Merchant's circle, tool life.

Lathe: Principle of Lathe, types of lathes, lathe components, specifications, tool and work holding devices, Lathe operations, machining time calculations. Turret and capstan lathes.

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

- ***Differentiate*** orthogonal and oblique cutting **(L2)**
- ***Classify*** types of chips, cutting tool materials, and cutting fluids. **(L2)**
- ***Calculate*** various cutting forces in metal cutting **(L3)**
- ***Discuss*** the factors influencing chip formation, such as cutting speed, feed rate, and tool geometry. **(L2)**

Applications:

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

UNIT II

Drilling, Shaping, Slotting, and Planning: Principles of working, types, and operations performed, specifications, and machining time calculations.

Milling: Principle of working, classification of milling machines, specification, principal features of horizontal milling machines, milling operations, types of milling cutters.

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

- Explain the working Principle of the drilling machine. (L2)
- Compare shaping, slotting, and planning operations. (L2)
- Identify the twist drill required as per the specifications of the job. (L2)
- Explain the working of various milling and grinding machines. (L2)

Applications:

- Used to machine flat surfaces, produce irregular surfaces
- Accurate holes in the work pieces in the Metalworking and woodworking industries.
- Gears, straight/flat surfaces, cutting keys, and accurate flat surfaces.

UNIT III

Finishing Operations: classification of grinding machines, cylindrical and surface grinding machines, designation of a grinding wheel. Lapping and honing processes.

Limits and fits: Limits, fits, and tolerances- Types of fits- unilateral and bilateral tolerance system, hole and shaft basis system, interchangeability, and selective assembly.

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

1. ***Explain*** fits & tolerances and employ plug and ring gauges for dimensional inspections **(L2)**
2. ***Compare*** the lapping and honing process. **(L2)**

Applications:

- Finishing operations on flat and cylindrical objects.
- Selection of types of fits (clearance, interference, transition and application of selective assembly to manage dimensional variations.

UNIT- IV

Linear and Angular Measurement: Length standards, end standards, slip gauges- calibration of the slip gauges, dial indicators, micrometers, Different methods – bevel protractor, angle slip gauges, angle dekkor, spirit levels, sine bar, sine table, rollers.

Limit Gauges: Taylor's principle, Design of GO and No-Go gauges, plug, ring, and snap gauges.

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

1. ***Explain*** the different methods of angular measurement, including the use of bevel protractors, angle slip gauges, and angle dekkors.
2. ***Compare*** interchangeability and selective assembly with applications. **(L2)**

Applications:

- Quickly confirming if holes and shafts are within acceptable limits of size and form using GO and No-Go gauges.
- Calibration of displacement detection, angle measurement, level checking, and

precise angle setting in machining using sine tools.

UNIT- V

Surface Roughness Measurement: surface roughness, surface waviness, and finding the surface finish- C.L.A, R.M.S values, Ra, Rq, and Rz values. Method of measurement of surface finish – Profilograph, Talysurf.

Screw thread measurement: Elements of measurement – errors in screw threads- concept of virtual effective diameter, measurement of effective diameter, angle of thread and thread pitch, and profile thread gauges.

Coordinate Measuring Machines: Types and applications of CMM.

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

1. Calculate surface finish values for different surface textures using the Talysurf surface meter (L2)
2. Classify CMM and its applications. (L2)
3. Explain Gear Nomenclature (L2)

Applications:

- Measurement of thread angle and pitch, and verification using profile thread gauges.
- CMMs are applicable in the inspection of precision components, the automotive industry, the aerospace industry, medical devices, mold and die making, and tool and fixture setup.

Text Books:

1. P. N. Rao, Manufacturing Technology Volume 2: Metal Cutting and Machine Tools, McGraw-Hill.

2. I C Gupta, Engineering Metrology, Dhanpath Rai & Co.

Reference Books:

1. Kalpakjian and S R Schmid, Manufacturing Engineering and Technology, Pearson.
2. R.K. Jain and S.C. Gupta, Production Technology, Khanna Publishers.
3. M.Mahajan, *Engineering Metrology*, Danapath Rai publications.

Web Resources:

1. https://drive.google.com/file/d/1K10OU-GZbqc5ogT4AOUOkZxN2sTs_iuh/view
2. https://www.youtube.com/watch?v=9IpRlVe6neI
3. https://testbook.com/mechanical-engineering/limits-fits-and-tolerances
4. https://www.google.co.in/books/edition/Workshop_Processes_Practices_and_Materia/HoSmAiD9qhgC?hl=en&gbpv=1&dq=Milling:+Principle+of+working,+classification+of+milling+machines,+specification,+principal+features+of+horizontal+milling+machines,+milling+operations,+types+milling+cutters,+Finishing+Operations:+classification+of+grinding+machine,+cylindrical+and+surface+grinding+machine,+designation+of+a+grinding+wheel.+Lapping+and+honing+processes.+google+book&printsec=frontcover

5. https://www.youtube.com/watch?v=sKEw48dkB90

6. https://www.mitutoyo.com/webfoo/wp-content/uploads/1984_Surf_Roughness_PG.pdf

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1**):**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	P O6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	3	1	1	-	1	1	1	1	1	-	2	2	3
CO2	3	3	1	2	-	2	1	1	1	1	-	2	2	2
CO3	3	3	1	1	-	2	1	1	1	1	-	2	2	2
CO4	3	3	1	1	-	2	1	1	1	1	-	2	2	2
CO5	3	3	1	1	-	2	1	1	1	1	-	2	2	2
CO*	3	3	1	1	-	2	1	1	1	1	-	2	2	2

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-PC3202	**Design of Power Transmission Elements**	3	0	0	3

Course Objectives: The objectives of the course are to

- Introduce fundamental concepts and principles of designing shafts and couplings for strength, rigidity, and reliability in power transmission.
- Analyze various bearing types, their design, and applications under static and dynamic loads in mechanical systems.
- Explore the design and functions of different clutches and brakes used in power transmission.
- Apply design principles to spur and helical gears, ensuring strength, durability, and efficient operation.
- Develop design skills for power screws, focusing on applications, efficiency, and understanding failure mechanisms.

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

1. Design the shafts and couplings to solve real-world mechanical design problems under various loads. (l3)
2. Select suitable bearings based on application requirements to predict their expected service life. (l3)
3. Analyze the torque capacity and performance of clutches and brakes to ensure reliable power transmission and controlled stopping in mechanical systems. (l4)
4. Design spur and helical gears, calculating essential parameters and ensuring they meet strength and durability requirements. (l3)
5. Evaluate the efficiency and torque carrying capacity of power screws. (l4)

UNIT–I

Keys: Types of Keys-Sunk Keys, Saddle keys, Strength of a Sunk Key, Stresses in the Keys, Effect of Keyways

Shafts: Design of solid and hollow shafts for strength and rigidity, design of shafts for combined bending and axial loads.

Shaft coupling: Introduction- Requirements of a Good Shaft Coupling-Types of Shafts Couplings- Advantages and limitations. Rigid couplings–Muff Coupling, Compression Coupling and Flange Couplings. Flexible Coupling- Bushed Pin Flexible Coupling.

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

- ***Understand*** the design principles of solid and hollow shafts under various loads. **(L2)**
- ***Apply*** design methods to create shafts that handle bending and axial forces safely. **(L3)**
- ***Analyse*** different types of shaft couplings and select suitable ones for mechanical systems. **(L4)**

Applications: Power Transmission Systems, Automotive and Transport Equipment, Industrial Machines, Electrical Generators and Motors, Wind Turbines and Hydropower Plants

UNIT-II

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

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

- ***Understand*** the different types of bearings and their applications in mechanical systems. **(L2)**
- ***Apply*** bearing design principles, including lubrication, material selection, and load considerations. **(L3)**
- ***Analyse*** static and dynamic loading conditions for ball and roller bearings to estimate their lifespan and performance. **(L4)**

Applications: Automotive Industry, Electric Motors and Generators, Industrial Machinery, Wind Turbines

UNIT-III

Clutches: Working principle, Types of clutches, single plate clutch and multiple plate clutch, conical clutch, centrifugal clutches.

Brakes: Working principle, Types of brakes, self-energizing brakes, self-locking brake, Shoe or block brakes, Pivoted Block or Shoe Brake, band brakes.

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

- ***Apply*** the working principles of different clutches in power transmission systems. **(L3)**
- ***Compare*** various types of brakes and their uses in mechanical systems. **(L4)**
- ***Analyze*** the design and functionality of clutches and brakes for effective performance. **(L4)**

Applications: Automotive Industry, Motorcycles, Industrial Machinery, Agricultural Equipment.

UNIT-IV

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

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

- ***Design*** spur and helical gears considering load and material strength. **(L4)**
- ***Calculate*** gear parameters like center distance, module, and face width. **(L3)**
- ***Analyze*** dynamic effects and wear considerations in gear design. **(L4)**

Applications: Automotive Transmissions, Industrial Machinery, Manufacturing Equipment, Wind Turbines, Robotics.

UNIT-V

Design of Power Screws: Types of Screw Threads used for Power Screws, Torque Required to Raise/Lower the Load by Square Threaded Screws, Efficiency of Square Threaded Screws, Design of screw, square ACME, Buttress screws, Design of nut, Compound screw, differential screw, ball screw, Design of Screw Jack, possible failures of screws and nuts.

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

- ***Understand*** the different types of screw threads used in power screws and their applications. **(L2)**
- ***Calculate*** the torque required to raise or lower the load using square threaded screws, and evaluate their efficiency. **(L3)**
- ***Design*** various types of power screws, including square, ACME, and ball screws, and identify potential failure modes in screws and nuts. **(L4)**

Applications: Lifting Mechanisms, Clamping Devices, Automated Systems, Industrial Machinery.

Text Books:

1. R.S. Khurmi & J.K. Gupta; A Textbook of Machine Design; S Chand Publications.
2. V B Bhandari; Design of Machine Elements; McGraw Hill Education India Private Limited.

Reference Books:

1. N.C. Pandya & C.S.Shah; Machine Design; Charotar Publishing House Pvt. Ltd.
2. S.Md.Jalaludeen; A TextBook of Machine Design; Anuradha Publications.
3. Shigley'S Mechanical Engineering Design by Richard G. Budynas, J. Keith Nisbett, Kiatfa Tangchaichit; McGraw Hill Education India Private Limited.
4. Robert L. Norton; Machine Design; Pearson Education.
5. M. F. Spotts, Terry E. Shoup, L. E. Hornberge; Design of Machine Elements; Pearson Education.

Design Data Books:

1. S.Md. Jalaludeen; Design Data Hand Book; Anuradha Publications.
2. V B Bhandari; Machine Design Data Book; McGraw Hill Education India Private Limited.

Web Resources:

1. https://archive.nptel.ac.in/courses/112/105/112105124/
2. https://archive.nptel.ac.in/courses/112/106/112106137/
3. https://www.youtube.com/playlist?list=PL3D4EECEFAA99D9BE

COURSE OUTCOMES VS POs MAPPING

[1-*slight* (low), 2 - *moderate* (*medium*) and 3- substantial (high)]

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	-	-	1	1	-	-	1	-	2	3	3
CO2	3	3	3	-	-	1	1	2	-	1	-	2	3	3
CO3	3	3	3	-	-	1	1	2	-	1	-	2	3	3
CO4	3	3	3	-	-	1	1	2	-	1	-	2	3	3
CO5	3	3	3	-	-	1	1	2	-	1	-	2	3	3
CO*	3	3	3	-	-	1	1	2	-	1	-	2	3	3

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-PC3203	**Heat Transfer**	3	0	0	3

Course Objectives: The course is intended to

- Analyse heat transfer mechanisms and their practical engineering applications.
- Analyze heat transfer through fins and transient conduction to optimize thermal performance in engineering systems.
- Interpret convective heat transfer phenomena in diverse fluid flow scenarios pertinent to modern thermal systems.
- Evaluate heat transfer performance on heat exchangers, evaporators, and condensers, with an emphasis on energy efficiency and system performance.
- Apply the fundamental principles of radiative heat transfer in advanced thermal applications such as aerospace, electronics cooling, and renewable energy systems.

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

1. Explain the basic heat transfer principles and their practical relevance in Planes, Cylinders and Spherical components. (L2)
2. Design fins for optimal heat dissipation based on the specific requirements of the system (L3)
3. Apply the governing laws of convection to solve both forced and free convection heat transfer problems. (L3)
4. Identify different boiling regimes in boiling curve to calculate the critical heat flux and Leidenfrost point for various applications. (L3)
5. Apply the radiation to calculate the radiative heat transfer in different engineering systems (L3)

UNIT-I

Introduction:
Modes and mechanisms of heat transfer – Basic laws of heat transfer – General discussion on applications of heat transfer.

Conduction Heat Transfer:
Fourier's law of heat conduction – General heat conduction equation in Cartesian, cylindrical, and spherical coordinates. Steady, unsteady, and periodic heat transfer – Initial and boundary conditions.

One-Dimensional Steady-State Conduction:
Heat conduction through homogeneous slabs, hollow cylinders, and spheres – Overall heat transfer coefficient – Electrical analogy – Critical radius of insulation.

Applications:
Heat transfer in cooking utensils, electric iron, and water geysers.

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

- ***Explain*** the mathematical expression of Fourier's law and its significance in heat conduction **(L2)**
- ***Describ***e the general heat conduction equation in Cartesian, cylindrical, and spherical coordinate systems **(L2)**

UNIT-II

Extended Surfaces (Fins):
Heat transfer through fins – Analysis of long fins, fins with insulated tips, and short fins – Applications in temperature measurement and enhancement of heat dissipation.
One-Dimensional Transient Conduction:
Concept of systems with negligible internal resistance – Significance of Biot and Fourier numbers – Use of **Heisler charts** for transient conduction analysis.
Applications:
Heat transfer in radiators of automobiles, air-cooled I.C. engines, air conditioner condensers, electric transformers, reciprocating air compressors, electric motors, heating/cooling of engines, buildings, and food products.
Learning Outcomes:
At the end of this unit, students will be able to:

- ***Apply*** the principles of heat transfer through fins to design appropriate fin geometries for specific thermal applications. ***(L3)***
- ***Determine*** the transient temperature response of a body using analytical or chart-based methods for specified conditions. ***(L3)***

UNIT–III

Forced Convection:
External & Internal flows: Boundary layer concepts – hydrodynamic and thermal – empirical correlations for flat plates and cylinders
Free (Natural) Convection:
Boundary layer development on vertical surfaces, Empirical relations for plates and cylinders in vertical and horizontal orientations, Physical interpretation of Grashoff and Rayleigh numbers
Applications:

- Forced convection: Cooling of engines, air/water flow in pipes, heat exchangers
- Free convection: Natural cooling in transformers, ventilation systems, and buildings

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

- ***Apply*** empirical correlations to determine heat transfer coefficients in convective systems. ***(L3)***
- ***Compare*** forced and free convection using dimensionless numbers and flow behavior. ***(L2)***

UNIT–IV

Boiling Heat Transfer and Heat exchangers: Boiling regimes, Pool boiling vs. flow boiling
Parallel flow, counter flow, cross flow, Shell and tube, plate, and compact heat exchangers, Overall heat transfer coefficient (U) and fouling, LMTD method and ε-NTU method
Radiation Heat Transfer: Fundamentals of thermal radiation, Laws of radiation: Stefan–Boltzmann law, Planck's law, Wien's displacement law, Kirchhoff's law: Black, gray, and real bodies – emissivity and absorptivity, Radiation shape factors and their computation,
Applications: Boilers, kettles, power plant evaporators, chemical reactors, Refrigerators, condensers, distillation equipment
Learning Outcomes:
At the end of this unit, students will be able to:

- ***Apply*** the LMTD and NTU methods for analysing heat exchanger performance. ***(L3)***
- ***Solve*** basic design problems involving in boiling, and condensation. ***(L3)***

UNIT–V

Diffusion and Mass Transfer: Basic concepts of molecular diffusion, Steady-state diffusion in stationary media, Convective mass transfer – mass transfer coefficients. applications in simultaneous heat and mass transfer systems (e.g., humidification, drying)

Applications:

- Thermal radiation in furnaces, solar energy systems, and spacecraft
- Mass transfer in air-conditioning systems, chemical reactors, drying, and absorption
- Radiation/diffusion coupling in re-entry vehicles, electronics, and advanced material processing

Learning Outcomes:

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

- ***Describe*** the basic laws of thermal radiation and characteristics of idealized surfaces. ***(L2)***
- ***Determine*** radiation heat exchange using shape factors and surface properties. ***(L3)***

Text Books:

1. R.K. Rajput, *Heat and Mass Transfer*, S. Chand & Company Ltd.
2. D.S. Kumar, *Heat and Mass Transfer*, S.K. Kataria & Sons Publishers.
3. R.C. Sachdeva, *Fundamentals of Engineering Heat and Mass Transfer*, New Age International Publishers.
4. P.K. Nag, *Heat Transfer*, Tata McGraw-Hill.
5. C.P. Kothandaraman and S. Subramanyan, *Heat and Mass Transfer Databook*, New Age International Publishers.

Reference Books:

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

Web sources:

1. https://nptel.ac.in/courses/112105182
2. https://ocw.mit.edu/heat and mass transfer
3. https://www.coursera.org/heat and mass transfer
4. https://www.edx.org/heat and mass transfer
5. https://www.engineeringtoolbox.com

COURSE OUTCOMES VS POs MAPPING

[1-*slight* (low), 2 - *moderate* (*medium*) and 3- substantial (high)]

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	-	-	1	2	-	-	-	-	2	2
CO2	3	3	2	2	-	-	-	-	-	-	-	3	-	2
CO3	3	3	3	2	-	-	-	-	-	-	-	3	-	2
CO4	2	2	3	3	2	-	1	-	1	-	2	3	2	2
CO5	2	2	3	3	2	2	2	1	-	1	-	2	3	3
CO*	3	3	3	3	2	2	2	2	1	1	2	3	3	2

**For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-PE3201.1	**Mechanical Vibrations (Professional Elective-II)**	3	0	0	3

Course Objectives: The objectives of the course are

- To understand the formulation of equations of motion for discrete spring-mass systems using classical and energy methods.
- To study the behavior of systems under forced vibrations, vibration transmissibility, isolation techniques, and seismic instruments.
- To familiarize with the characteristics and dynamics of two-degree-of-freedom systems and various types of vibration absorbers.
- To study the principles and analysis of two-degree and multi-degree-of-freedom vibration systems.
- To comprehend the working and applications of vibration measuring devices in engineering practice.

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

1 Explain the dynamic response of single degree of freedom systems subjected to various damping mechanisms. (l2)

2 Analyze the system response to non-periodic excitations using laplace transform and convolution integral methods. (l4)

3 Apply modal analysis and matrix methods to determine natural frequencies and mode shapes of multi-degree freedom systems. (l3)

4 Analyze vibratory systems using numerical methods such as rayleigh's, stodola's, and holzer's techniques. (l4)

5 Evaluate the vibratory characteristics of mechanical components under critical speed and torsional vibration scenarios. (l3)

Unit-I

Single degree of Freedom systems: Fundamental Aspects of Vibrations: Vibration, main causes, classification of vibrations, advantages and disadvantages; engineering applications of vibration and noise; Undamped and damped free vibrations: forced vibrations; coulomb damping; Response to harmonic excitation; rotating unbalance and support excitation, Vibration isolation and transmissibility.

Learning Outcomes: After completion of this unit student will able to

1. ***explain*** the behavior of single degree freedom systems with damping. **(L2)**

Applications: Engine mounts in automobiles reduce chassis vibration using damping and isolation.

Unit-II

Response to Non-Periodic Excitations: unit Impulse, unit step and unit Ramp functions; response to arbitrary excitations, The Convolution Integral; shock spectrum; System response by the Laplace Transformation method.

Learning Outcomes: After completion of this unit the students will be able to

1. ***explain*** unit Impulse, unit step and unit Ramp functions. **(L2)**
2. ***apply*** Laplace Transformation method for System response. **(L3)**
3. ***analyze*** system response to arbitrary inputs using the convolution integral and interpret the resulting shock spectrum for engineering applications. **(L4)**

Applications: Automobile gearbox design uses impulse response to simulate impact absorption.

Unit-III

Multi degree freedom systems: Principal modes–undamped and damped free and forced vibrations; undamped vibration absorbers, Matrix formulation, stiffness and flexibility influence coefficients; Eigen value problem; normal modes and their properties; Free and forced vibration by Modal analysis; Method of matrix inversion; Torsional vibrations of multi – rotor systems and geared systems;

Learning Outcomes: After completion of this unit the students will be able to

1. ***explain*** the undamped and damped free and forced vibrations **(L2)**
2. ***apply*** the Method of matrix inversion for Torsional vibrations of multi – rotor systems and geared systems. **(L3)**

Applications:

1. Automotive drivetrains use multi-DOF models to analyze gear and shaft vibrations for designing dampers and absorbers.
2. Jet engines undergo forced vibration analysis of multi-rotor systems to ensure dynamic stability and avoid shaft failure.
3. Wind turbine gearboxes are analyzed using stiffness and flexibility matrices to reduce dynamic loads and enhance reliability.

Unit-IV

Numerical Methods: Rayliegh's, stodola's, Matrix iteration, Rayleigh-Ritz Method and Holzer's methods, Mode superposition technique for vibration analysis.

Learning Outcomes: After completion of this unit the students will be able to

1. ***explain*** the steps in Numerical Methods **(L2)**
2. ***apply*** the numerical methods for vibration problems. **(L3)**
3. ***analyze*** complex vibration problems using mode superposition techniques. **(L4)**

Applications: Mahindra tractor crankshafts use Holzer's method to determine torsional critical speeds.

Unit-V

Application of concepts: Free vibration of strings – longitudinal oscillations of bars- transverse vibrations of beams- Torsional vibrations of shafts. Critical speeds without and with damping, secondary critical speed. Vibrations in machine tools and their impact on surface finish. Virtual simulation/demonstration of vibration modes in beams and shafts

Learning Outcomes: After completion of this unit the students will be able to

1. ***explain*** the working principle of vibration pickups. **(L2)**

2. ***understand*** the torsional vibrations of shafts **(L2)**

Applications: CNC machines analyze beam vibrations to improve surface finish and reduce chatter, Vande Bharat Express monitors shaft vibrations to avoid failures at critical speeds.

Textbooks:

1. Meirovitch, L. *Elements of Vibration Analysis*. McGraw-Hill College.
2. Grover, G.K. *Mechanical Vibrations*. Nem Chand & Bros.
3. Thomson, W.T., & Dahleh, M.D. *Theory of Vibration with Applications*. Pearson India.
4. Kelly, S. Graham. *Schaum's Outline of Mechanical Vibrations*. McGraw-Hill.

References:

1. Timoshenko, S.P., Young, D.H., & Weaver, W. Jr. *Vibration Problems in Engineering*. Wiley-Interscience.
2. Ramamurti, V. *Mechanical Vibration Practice and Noise Control*. Alpha Science International Ltd.

Web Resources:

1. https://ocw.mit.edu/courses/2-003sc-engineering-dynamics-fall-2011/pages/mechanical-vibration/
2. https://archive.nptel.ac.in/courses/112/103/112103111/
3. /https://www.iitiansgateclasses.com/Document/4.%20mechanical%20vibrations_gate%20pyqs_ae_qns%20and%20answer_keys.pdf
4. https://archive.nptel.ac.in/courses/112/107/112107212/
5. /https://www.madeeasy.in/uploads/examsolution/205ufrep_ME_GATE-2020_Session-1-revised.pdf

COURSE OUTCOMES VS POs MAPPING

[1-*slight* (low), 2 - *moderate* (*medium*) and 3- substantial (high)]

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	3	2	2	1	-	1	1	-	-	1	-	1	3	2
CO2	3	3	2	2	-	1	-	-	-	-	-	1	3	2
CO3	3	3	2	2	-	-	-	-	-	1	-	2	3	3
CO4	3	3	2	2	-	-	-	-	-	-	-	2	3	2
CO5	3	2	2	1	1	2	1	1	-	-	-	2	3	2
CO*	3	3	2	2	1	1	1	1	-	1	-	2	3	2

*For Entire Course, PO & PSO Mapping

Subject Code	Subject Name	L	T	P	C
R23MEC-PE3201.2	**Advanced Materials (Professional Elective-II)**	3	0	0	3

Course objectives: The objectives of the course are

- To understand the classification, reinforcements, and applications of composite materials.
- To study the types, manufacturing methods, and applications of polymer, metal, and ceramic matrix composites
- To analyze the macro mechanical behavior of a lamina using Hooke's law and compliance/stiffness matrices.
- To understand the properties and applications of functionally graded materials and shape memory alloys
- To suitability of smart and nano materials for engineering applications.
- To identify the appropriate material types for solving real-world engineering problems.

Course Outcomes: On successful completion of this course student will be able to

1. Describe the types of material processing techniques for advanced materials (L2)
2. Explain the suitable material for specific applications (L2)
3. Apply Hooke's law to analyze lamina behavior and use laminate code for composite analysis. (L3)
4. Explain the concept of functionally graded materials and shape memory alloys/ Composites (L2)
5. Analyze the top-down and bottom-up methods for nanomaterials synthesis (L4)

UNIT– I

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

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

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

Learning outcomes:

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

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

Application:

1. Aircraft fuselage, wings, and interior components.
2. Used in sports cars and aircraft brakes

UNIT–II

MANUFACTURING METHODS OF COMPOSITE MATERIALS:

Polymer composite: Autoclave, tape production, molding methods, filament winding, manual layup, pultrusion, Resin Transfer Molding (RTM), Additive Manufacturing, Vacuum Infusion,

Metal composites: Solid State Methods, Semi-Solid State Methods, Liquid State Methods

Learning outcomes:

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

1. ***Select*** appropriate manufacturing techniques for a given composite structure/ application **(L2)**
2. ***Understand*** the various methods for manufacturing of composite materials **(L2)**

Application:

1. Car body panels
2. Bumpers in sports and luxury cars

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:

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

1. ***Understand*** the laws of composite materials **(L2)**
2. ***Explain*** the elastic constants of laminates **(L2)**

Application:

1. Aircraft wings

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:

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

1. ***Summarise*** the functionally graded materials for a given application **(L2)**
2. ***Explain*** the concept of shape memory alloys/composites **(L2)**

Application:

1. Thermal barrier coatings
2. Biomedical implants, and aerospace components

UNIT-V

NANO MATERIALS SYNTHESIS AND CHARACTERIZATION:

Introduction to Nanoscience and Nanotechnology: Advantages, disadvantages, and applications. Synthesis of nanomaterials using Top-Down and Bottom-Up approaches

Characterization of Nanomaterials: Scanning Electron Microscopy (SEM), Transmission Electron Microscopy (TEM), Atomic Force Microscopy (AFM), Scanning Tunneling Microscope (STM), Field Ion Microscope (FEM)

Learning outcomes:

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

1. ***Illustrate*** the concept of nanomaterials and associated changes in their properties from bulk **(L2)**
2. ***Analyze*** the various top-down and bottom-up methods for the synthesis of nanomaterials. **(L4)**
3. ***Explain*** the properties and applications of some recently developed nanostructures **(L2)**

Application:

1. Antibacterial coatings
2. Bicycle frames, helmets
3. Transparent conductors

Textbooks:

1. A.K. Bandyopadhyay, Nano material, New Age International Pvt Ltd Publishers.
2. R Balasubramaniam, Callister's Materials Science and Engineering, Wiley Publications.
3. Isaac M. Daniel (Author), Ori Ishai, Engineering Mechanics of Composite Materials, OUP USA.

References:

1. Robert M. Jones, Mechanics of Composite Materials, McGraw-Hill Company, New York.
2. L. R. Calcote, Analysis of Laminated Composite Structures, Van Nostrand Reinhold.
3. B. D. Agarwal and L. J. Broutman, Analysis and performance of fibre Composites, Wiley-Interscience, New York.
4. Autar K.Kaw, Mechanics of Composite Materials, Taylor & Francis-India.

Web Sources References:

1. https://www.youtube.com/watch?v=szkERUMtVIw&list=PLbRMhDVUMngdzwQyMgoUgdaGBqi_p4nVM&index=17
2. https://www.youtube.com/watch?v=2bDf7JSRvf8&list=PLbRMhDVUMngdzwQyMgoUgdaGBqi_p4nVM&index=37
3. https://www.youtube.com/watch?v=2bDf7JSRvf8&list=PLbRMhDVUMngdzwQyMgoUgdaGBqi_p4nVM&index=37
4. https://www.youtube.com/watch?v=x95WVjARWLs

COURSE OUTCOMES VS POs MAPPING

[1-slight (low), 2 - moderate (medium) and 3- substantial (high)]

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO12	PSO1	PSO2
CO1	3	2	1	-	-	-	-	-	-	-	-	2	3	2
CO2	3	2	1	-	-	2	1	-	-	-	-	2	3	2
CO3	3	2	2	1	1	1		-	-	-	-	2	3	3
CO4	3	2	1	-	-	2	1	-	-	-	-	2	3	2
CO5	3	2	2	1	1	1	1	-	-	-	-	2	3	3
CO*	3	2	1	1	1	2	1	-	-	-	-	2	3	2

**For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-PE3201.3	**Optimization techniques for Operations decisions (Professional Elective-II)**	3	0	0	3

Course Objectives: The objectives of the course are

- Comprehend the knowledge of decisions and best practices in the manufacturing industries
- Formulate real-world operations management problems into mathematical models suitable for optimization.
- Develop problem-solving and decision-making skills relevant to operations management challenges
- Explore the role of technology and innovation in optimizing operations decisions.
- Evaluate the ethical and social responsibility considerations in operations management practices, including environmental sustainability and community impacts.

Course Outcomes: On successful completion of this course, students will be able to

1. Develop the facility layouts for mass production and job order production systems for the given job order details and product manufacturing activities (L3)
2. Design the inventory management systems for deterministic and probabilistic inventory models to optimize the total inventory control cost(L4)
3. Analyze aggregate capacity planning methods to meet capacity requirements with variable demand of the products for optimizing the total cost of plan (L4)
4. Compare the strategies for scheduling in make to order systems for the specified time elements required to fabricate the job orders to determine optimal scheduling decisions (L4)
5. Apply the operational economics principles to strategically optimize costs in business operations. (L3)

UNIT-I

Operations decisions for facility layout design-–Characteristics of production systems, make to order, Make to stock systems, facility layout – principles, types, design of layouts -travel chart, assembly line balancing- exercise with heuristic and other methods. Sustainability in facility design. Computer based methods for facility layout design, case studies.

Learning Outcomes:

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

1. ***Explain*** the scope of operations decisions in manufacturing industries(L2)
2. ***Plan*** the facility layout for the given specifications of available space(L3)
3. ***Determine the*** work stations in assembly line to produce the required output(L3)

Applications:

1. Planning work stations for assembly lines.
2. Layout decisions for jobs hops.

UNIT-II

Operations decisions for Materials Management–Objectives, functions, ethics in purchasing materials, Inventory control: costs associated with inventory control, infinite rate of replenishment model, finite rate of replenishment model. Selective Inventory control methods, reorder level in practical inventory system with variable demand and lead time, JIT system, simulation and software tools to design inventory systems, case studies.

Learning Outcomes:

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

1. ***Explain*** the functions of materials management(L2)
2. ***Determine*** optimal inventory quantities ***to*** optimize cost of inventory control. (L3)

Applications:

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

UNIT-III

Operations decisions for aggregate production planning: Framework for Aggregate Planning, Aggregate planning strategies, Techniques of Aggregate Planning optimal aggregate plan-Linear programming approach to Aggregate planning, Preparation of Master Production Schedule -exercises– Tools and Software for Aggregate Planning, Case Studies and Practical Applications

Learning Outcomes:

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

1. ***explain*** the Aggregate planning strategies for cost optimization(L2)
2. ***construct*** mathematical model for Schedule (L2)

Applications:

1.Optimal aggregate plan in beverage plants.
2.Prepare aggregate plan for batch production systems

UNIT-IV

Operations decisions for 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**. software tools** for **scheduling operations** in production systems, Case Studies and Practical Applications

Learning Outcomes:

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

1. ***Solve*** the problems of scheduling for batch production(L3)
2. ***Compare*** the priority decision rules for scheduling the jobs. (L2)

Applications:

1. Scheduling in batch production units–beverage plants, soap making units.
2. Scheduling in job order plants-foundry units, machine shops

UNIT-V

Operations decisions for operational economics: Introduction –Product life cycle- Elements of costs, estimating manufacturing costs, Break even analysis-applications-Economical factors for make or buy decisions-exercises- Quality costs, Economics of quality, Industrial maintenance method, costs of maintenance, replacement costs

Learning Outcomes:

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

1. ***compare*** the manufacturing costs for process selection and make or buy decisions(L2)
2. ***explain the*** economic factors for operations decisions (L2)

Applications:

1. Automobile units applying concepts of make or buy decisions for ordering parts.
2. Optimization of quality control costs in manufacturing industries
3. Decisions related to maintenance of equipment to optimize maintenance cost.

Text Books

1.Prem Kumar Gupta and Hira, Operations Research, S Chand Company Ltd.,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 operations Management–By P.Ramamurty, New Age International Publication, New Delhi

Web Source References:

1.https://onlinecourses.nptel.ac.in/noc22_mg15
2.https://nptel.ac.in/courses/112107238
3.https://onlinecourses.nptel.ac.in/noc21_mg79
4.https://onlinecourses.nptel.ac.in/noc20_me30
5.https://nptel.ac.in/noc19_ge18

COURSE OUTCOMES VS POs MAPPING

[1-*slight* (low), 2 - *moderate* (*medium*) and 3- substantial (high)]

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	3	2	1	1	-	1	-	-	2	2	3	3
CO2	3	3	3	2	1	1	-	2	-	-	2	2	3	3
CO3	3	3	3	2	1	1	-	1	-	-	2	2	3	3
CO4	3	3	3	2	1	1	-	1	-	-	2	2	3	3
CO5	3	3	3	2	-	1	-	1	-	-	2	2	3	3
CO*	3	3	3	2	1	1	-	1	-	-	2	2	3	3

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-PE3201.4	**Power Generation Systems (Professional Elective-II)**	3	0	0	3

Course Objective: The objectives of the course are:

- To Familiarize with the concepts of nuclear power generation, including nuclear fission and chain reaction
- To Emphasize the importance of nuclear waste management in ensuring the safety and sustainability of nuclear power plants.
- To Impart knowledge on optimized performance of power plants with different combinations of hydro, steam, gas turbine, and nuclear power.
- To Explore the various types of futuristic energy technologies, including fuel cells, MHD steam power plants, thermoelectric steam plants, thermionic steam plants and Waste heat recovery system
- To Identify the criteria for selecting the type of generation (thermal, hydro, nuclear, etc.) based on economic factors such as cost, efficiency and environmental considerations.

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

1. ***Comprehend*** the working Principles of Nuclear Power stations and different Nuclear reactors **(L2).**
2. ***Identify*** the different types of nuclear materials, nuclear waste and the associated radiation hazards **(L3)**
3. **Apply** the energy system coordination techniques to optimize the integration with diverse power plants to enhance energy efficiency **(L3)**
4. ***Classify*** waste heat based on quality (high, medium, and low temperature) and identify suitable advanced power generation methods as per the Applications **(L2)**
5. ***Select*** appropriate types of power generation based on load patterns, costs, and system requirements **(L3)**

UNIT-I

Nuclear Power Station: Introduction, Nuclear power station in India, India's 3-Stage Programme for Nuclear power development**,** Nuclear Fuel, Nuclear Fission, Chain Reaction, Breeding and Fertile Materials-Nuclear Reactor, Components-Operation.

Types of Reactors: Different types of Reactors, Pressurized Water Reactor, Heavy water- cooled and Moderated CANDU (Canadian-Deuterium Uranium) Boiling Water Reactor, Gas Cooled Reactor.

Learning Outcomes

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

1. **Classify** types of power plants based on their applications (L2).
2. **Identify** different types of reactors used in a power plant (L2).

Applications: Nuclear power plant

UNIT-II

Nuclear Materials: Introduction, Fuels, Cladding and Structural Materials coolants, Moderating and Reflecting Materials, Control Rod Materials, Shielding Materials

Nuclear Waste & its Disposal: Introduction, Radiation Hazards, Types of Nuclear waste, Effect of Nuclear Radiation, Radioactive waste disposal system, Gas disposal system

Learning Outcomes

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

1. **Summarize** the importance of materials used in nuclear power plant (L2).
2. **Apply** safety principles to assess radiation hazards and suggest protective measures for nuclear facilities (L3).

Applications: Nuclear waste Management, Nuclear power plant

UNIT-III

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

Learning Outcomes

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

1. **Illustrate** the different combinations of various power plants (L2)
2. **Apply** knowledge of coordinated plant operations to real-world power systems for sustainable and efficient electricity generation(L3)

Applications: combined cycle power plants

UNIT-IV

Waste Heat Recovery: Potential benefits of waste heat recovery, Quantifying waste heat, Classification of waste heat by its quality, Storage of waste heat and equipment for waste heat recovery.

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

Learning Outcomes

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

1. **Illustrate** the futuristic technologies in power generation (L2).
2. **Describe** the various energy conversion systems (L2).

Applications: Conventional and un-conventional energy sources

UNIT-V

Economics of Power Generation: Load curves–effects of variable load on power plant design and operation–peak load plant– requirements of peak load plants–cost of electrical energy– selection of type of generation– selection of generating equipments–performance and operating characteristics of power plants

Learning outcomes

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

1. **Explain** various types of load curves (daily, monthly, annual) and their significance in power system planning (L2)
2. **Calculate** the components of energy cost (fixed, variable, fuel, maintenance) and perform cost analysis for different generation methods (L3)

Applications: Power plant planning and Design, Cost optimization in Energy Production, Peak Load Management

Text Books

1. P.K.Nag, Power Plant Engineering, 3rd edition, TMH.
2. Arora sand S.Domkundwar, A course in Power Plant Engineering, 8th edition, Dhanpat Rai &Co(P)Ltd.

Reference Books

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

Web Sources:

1. NPTEL-Power plant Engineering (IIT Roorkee)
   https://nptel.ac.in/courses/112/107/112107291/
2. NPTEL- Introduction to Nuclear Engineering (IIT Bombay)
   https://nptel.ac.in/courses/112/101/112101007/
3. NPTEL-Fundamentals of Nuclear Power Generation (IIT Guwahati)
   https://nptel.ac.in/courses/112/103/112103243/

COURSE OUTCOMES VS POs MAPPING

[1-*slight* (low), 2 - *moderate* (*medium*) and 3- substantial (high)]

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	-	2	2	2	-	-	-	3	3	3
CO2	3	3	2	2	-	2	2	2	-	-	-	3	3	3
CO3	3	3	2	2	-	2	2	-	-	-	-	3	3	3
CO4	3	3	2	2	-	2	2	-	-	-	-	3	3	3
CO5	3	3	2	2	-	2	2	2	-	-	2	3	3	3

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-PE3201.5	**Automotive Engineering (Professional Elective-II)**	3	0	0	3

Course Objectives: By the end of this course, students will:

- Impart knowledge on the construction, layout, and components of various types of automobiles with emphasis on engine, chassis, and body design
- Develop understanding of ignition, fuel supply, and emission control systems, including modern fuel injection technologies and environmental impact considerations
- Explain the structure and function of various transmission systems including manual, automatic, and continuously variable transmissions used in automotive and allied vehicles.
- Provide a comprehensive understanding of the construction, working principles, and functional importance of steering, suspension, and braking systems in vehicles.
- Equip with comprehensive knowledge of automobile electrical systems, instrumentation, and emerging automotive technologies

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

1. ***Comprehend*** the different types of engine construction, location, components and working of auxiliary systems **(L2)**
2. ***Identify*** the appropriate Ignition, Injection and emission control systems for automobiles **(L3)**
3. ***Apply*** the knowledge of gear mechanisms and differential action to identify appropriate gear boxes and interpret vehicle behaviour for specific driving conditions **(L3)**
4. ***Select*** appropriate steering, suspension, braking, shock absorber and spring systems for specific vehicle requirements **(L3)**
5. ***Apply*** the principles of electrical circuits to diagnose and service automotive battery and wiring systems **(L3)**

UNIT- I

Introduction to vehicle structure and engine components: Vehicle construction - Chassis and body - Specifications - Engine - Types - Construction - Location of engine - Cylinder arrangement - Construction details - Cylinder block - Cylinder head - Cylinder liners - Piston
– Piston rings - Piston pin - Connecting rod-Crankshaft - Valves. Lubrication system - Types - Oil pumps - Filters - Cooling system - Types - Water pumps - Radiators - Thermostats - Anti-freezing compounds.

Learning Outcomes:

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

- **Explain** the construction and function of various engine components (L2).
- **Discuss** the purpose and operation of the lubrication system, including types of lubrication, oil pumps and filters (L2)

Applications: Automobile vehicles

UNIT- II

Ignition, fuel supply and emission control system: Ignition system - Coil and Magneto - Spark plug - Distributor – Electronic ignition system - Fuel system - Carburettor - Fuel pumps
Fuel injection systems -Single point and Multi point – Unit injector – Nozzle types - Electronic Fuel Injection system (EFI) – GDI, MPFI, DTSI-Automobile Emissions - Source of formation – Effects on human health and environment - Control techniques - Exhaust Gas Recirculation (EGR) - Catalytic converter - Emission tests and standards (Indian and Europe)

Learning Outcomes:

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

- Explain the working principles of ignition and fuel Injection systems.(L2)
- **Select** suitable emission control methods based on vehicle type and emission standards(L3)

Application: Automobile vehicles, Marine Engines, Aerospace vehicles

UNIT -III

Transmission system: Clutches - Function - Types - Single plate, Multiple plate and Diaphragm Clutch – Fluid coupling - Gearbox - Manual - Sliding - Constant - Synchromesh - Overdrive – Automatic transmission - Torque converter - Epicylic and Hydromatic transmission – Continuously variable transmission - Universal joint - Propeller shaft - Hotchkiss drive – Final drive - Rear axle assembly - Types -Differential - Need - Construction – Non-slip differential – Differential locks - Four wheel drive.

Learning Outcomes:

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

- **Differentiate** between manual transmission types: sliding mesh, constant mesh, and synchromesh gearboxes. (L2)
- **Apply** gear ratio concepts to determine speed and torque output in manual and automatic transmissions (L3)

Applications: Automobile vehicles, Marine Engines

UNIT-IV

Steering, suspension and braking system: Principle of steering - Steering Geometry and wheel alignment - Steering linkages – Steering gearboxes - Power steering - front axle - Suspension system - Independent and Solid axle – coil, leaf spring and air suspensions - torsion bar - shock absorbers – Wheels and Tires - Construction - Type and specification - Tire wear and causes - Brakes - Needs – Classification –Drum and Disc Mechanical - Hydraulic and pneumatic - Vacuum assist – Retarders – Anti-lock Braking System(ABS)

Learning Outcomes:

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

- Describe the steering and the suspension systems. (L2)
- Classify the brakes in automobile. (L3)

Applications: Automobile vehicles

UNIT- V

Automobile electrical systems, instrumentation and advances in automobile engineering: Battery-General electrical circuits-Dash board instrumentation - Passenger comfort – Safety and security - HVAC - Seat belts - Air bags - Automotive Electronics - Electronic Control Unit (ECU) - Variable Valve Timing (VVT) - Active Suspension System (ASS) - Electronic Brake Distribution (EBD) – Electronic Stability Program(ESP) Traction Control System (TCS) - Global Positioning System (GPS) - X-by-wire - Electric - Hybrid vehicle.

Learning Outcomes:

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

- Explain the working principles of various automobile electrical systems. (L2)
- Identify the various electrical components in automobile (L3)

Applications: Automobile vehicles

Text Books:

1. William.H.Crouse, Automotive Mechanics, McGraw-Hill.
2. David A. Corolla, Automotive Engineering: Powertrain, Chassis System and Vehicle Body, Butterworth-Heinemann Publishing Ltd.
3. Richard Stone, Jeffrey K. Ball, Automotive Engineering Fundamentals, SAE International.
4. Kirpal Singh, Automobile Engineering, Vol.1&2, Standard Publications year

Reference Books:

1. Bosch, Automotive Hand Book, SAE Publications year.
2. K. Newton and W. Steeds, The motor vehicle, Butterworth-Heinemann Publishing Ltd.

COURSE OUTCOMES VS POs MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	-	-	2	2	2	-	-	-	3	3	3
CO2	3	3	2	-	1	2	2	2	-	-	-	3	3	3
CO3	3	3	2	-	-	2	2	2	-	-	-	3	3	3
CO4	3	3	2	-	1	2	2	2	-	-	-	3	3	3
CO5	3	3	2	-	1	2	2	2	-	-	-	3	3	3

[1-*slight* (low), 2 - *moderate* (*medium*) and 3- substantial (high)]

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-PE3202.1	**Advanced Machining Processes (Professional Elective–III)**	3	0	0	3

Course Objectives: The objectives of the course are to

- Introduce students to the need for advanced machining techniques in modern manufacturing, where conventional processes are inadequate.
- Provide an in-depth understanding of various non-traditional machining processes such as Electric Discharge Machining (EDM), Ultrasonic Machining (USM), Laser Beam Machining (LBM), Electron Beam Machining (EBM), Abrasive Jet Machining (AJM), and Chemical Machining.
- Explain each advanced machining process's working principles, process parameters, equipment, and applications.
- Analyse the effects of input parameters on machining performance measures such as material removal rate, surface finish, and tool wear.
- Develop the ability to apply analytical and empirical models to optimise process parameters for improved efficiency and quality.

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

1. ***Select*** the need for advanced machining processes and the limitations of conventional machining methods. **(L1)**
2. ***Define*** non-traditional machining techniques' principles, mechanisms, and process parameters. **(L1)**
3. ***Determine*** the appropriate advanced machining techniques for specific industrial or research applications based on workpiece material and desired features. **(L3)**
4. **Describe** the influence of process parameters on machining performance in terms of material removal rate, surface integrity, and dimensional accuracy. **(L2)**
5. ***Demonstrate*** suitable advanced machining methods for complex shapes, hard-to-machine materials, and modern machining techniques in industrial scenarios. **(L2)**

UNIT- I

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

Learning outcomes:

After completion of this unit, students will be able to

- ***List*** the non-traditional Machining Processes **(L1)**
- ***Choose*** the source of energy for various nontraditional machining processes **(L1)**
- ***Recognise*** the process Parameters in different nontraditional machining processes **(L1)**

Application: pharmaceutical industries and fabrication of CNT

UNIT-II

Mechanical Processes:

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

Learning outcomes:

After completion of this unit, students will be able to

1. ***Define*** the working principle of Ultrasonic Machining. **(L1)**
2. ***Explain*** the working principle of Abrasive Water Jet Machining. **(L1)**

Application:

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

UNIT- III

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

Application: Die making and mould making

Learning outcomes:

After completion of this unit, students will be able to

- ***Understand*** the process of Electrical Discharge Machining. **(L2)**
- ***Apply*** the knowledge in solving MRR at different process parameters. **(L3)**
- **Illustrate the** EDM application for various difficulties in machine materials. **(L3)**

UNIT-IV

Chemical and Electrochemical Machining: Chemical Machining: fundamentals, Principle– classification and selection of Etchant - chemical milling, Engraving, Blanking – Advantages and limitations–Applications. Electro Chemical Machining: Electro-chemistry of the process- Electrolytes–Electrolyte and their Properties– Material Removal Rate– Tool Material– Tool Feed System–Design for Electrolyte Flow– Process Variables–Advantages and Limitations – Applications – Electro Chemical turning, deburring and cutting off. Electro Chemical- Grinding, Honing.

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

Learning outcomes:

After completion of this unit, students will be able to

- ***Understand*** the parameters of the chemical machining process. **(L2)**
- ***Distinguish*** chemical and electrochemical processes to machine various materials. (**L2)**
- ***Classify*** different electrolytes and their properties in electrochemical machining. **(L2)**

UNIT-V

High Energy Machining Process:

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

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

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

Application:

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

Learning outcomes:

After completion of this unit, students will be able to

- ***Identify*** the key components and construction features of LBM systems and plasma torches. **(L1)**
- ***Explain*** the roles of gas mixtures, laser materials, and electron sources in the performance of each machining process. **(L2)**
- ***Determine*** the critical process parameters affecting machining efficiency, accuracy, and material removal rate in EBM, PAM, and LBM. **(L3)**

Text books

1. P.K. Mishra, Nonconventional Machining, Narosa Publishing.
2. P.C. Pandey And H.S. Shan," Modern Machining Process",Tata McGraw–Hill Publishing Company Limited, New Delhi.

References

1. P.K. Mishra, "Modern Machining Processes", Narosa Publishing House, Recent Addition
2. Gary F. Benedict, "Nontraditional Manufacturing Processes", CRC Press.
3. Dr. S. Senthil, Non-conventional Machining Process, ARS Publication.

Web Resources

1. https://www.iitg.ac.in/rkmittal/assets/me688/ME688_Introduction_2.pdf
2. https://nptel.ac.in/courses/112103202
3. https://www.slideshare.net/slideshow/advanced-maching-processes/22646850#3

COURSE OUTCOMES VS POs MAPPING

[1-*slight* (low), 2 - *moderate* (*medium*) and 3- substantial (high)]

CO/ PO	PO1	PO2	PO 3	PO 4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	**3**	**3**	**1**	**1**	**3**	**1**	**-**	**2**	-	-	-	**3**	**3**	**3**
CO2	**3**	**3**	**3**	**3**	**3**	**2**	**-**	**2**	-	-	-	**3**	**3**	**3**
CO3	**3**	**3**	**3**	**2**	**2**	**1**	**-**	**2**	-	-	-	**3**	**3**	**3**
CO4	**3**	**3**	**1**	**1**	**3**	**1**	**-**	**1**	-	-	-	**3**	**3**	**3**
CO5	**3**	**3**	**1**	**1**	**2**	**3**	**3**	**1**	-	-	-	**3**	**3**	**3**
CO*	**3**	**3**	**2**	**2**	**3**	**2**	**3**	**2**	-	-	-	**3**	**3**	**3**

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-PE3202.2	**Refrigeration and Air Conditioning (Professional Elective-III)**	3	0	0	3

Course Objective: The objectives of the course are to

- Familiarize the operating cycles and different systems of refrigeration.
- Evaluate the cooling capacity and coefficient of performance (COP) of various refrigeration systems for energy-efficient and sustainable operation.
- Empower students with the skills to design, optimize, and maintain sustainable refrigeration systems using modern refrigerants and components for industrial and commercial applications.
- Equip students with psychrometric analysis and air-conditioning system design skills for developing energy-efficient HVAC solutions compliant with ASHRAE standards.
- Familiarize students with refrigeration and air-conditioning system components enabling them to design, operate and maintain efficient thermal management systems.

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

1. ***Apply*** the thermodynamic principles and performance metrics (COP, efficiency) of refrigeration cycles, including Carnot, Bell-Coleman, Aircraft and Vapour Compression (VCRS). **(L3)**
2. ***Explain*** the selection criteria for refrigerants and refrigeration system components based on thermodynamic properties, environmental impact, and functional requirements. **(L2)**
3. ***Analyze*** vapor absorption, steam-jet, and thermoelectric refrigeration systems through performance calculations, and component selection. **(L4)**
4. ***Apply*** psychrometric principles to interpret air-conditioning processes and analyze system requirements using standard charts and parameters. **(L2)**
5. ***Analyze*** different air-conditioning systems (central, unitary, packaged) by evaluating their configurations, components, and load calculation methodologies. **(L4)**

Unit 1: Air Refrigeration and Vapour Compression Refrigeration Systems

Air Refrigeration: Air Refrigeration Cycles - reversed Carnot cycle, Bell-Coleman cycle analysis, Air Refrigeration systems - merits and demerits, analysis. Vapour Compression Refrigeration System (VCRS): Vapour Compression Refrigeration system - Carnot Vapour compression refrigeration cycle, Working and analysis, Limitations, Standard Vapour

Compression Refrigeration system, Working and analysis, Effects of sub cooling and super heating, Multi-Pressure or Compound Vapour Compression Refrigeration Systems - Methods like Flash Gas removal, Flash inter cooling and water inter cooling, Numerical Problems.

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

1. Explain the working principles of Carnot, Bell-Coleman, and VCRS cycles. (L2)
2. Calculate COP and efficiency for different refrigeration cycles. (L3)
3. Illustrate the effects of subcooling/superheating in VCRS. (L2)

Application Areas:

1. Transport Refrigeration: Reefer containers for perishable goods (using VCRS with subcooling)
2. Aircraft Cooling: Air-cycle refrigeration (Bell-Coleman cycle) in cabin air conditioning
3. Industrial Cold Storage: Multi-stage VCRS with flash intercooling for large-scale food preservation

Unit 2: Refrigerants and Refrigeration System Equipment

Refrigerants: Classification, Selection of Refrigerants and Nomenclature of refrigerants, Desirable Properties of an ideal refrigerant, A discussion on Ozone layer Depletion and Global Warming. Refrigeration systems Equipment: Refrigeration System Equipment - Compressors, Condensers, Expansion Devices and Evaporators, A brief look at other components of the system.

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

1. Explain refrigerants impact environmental impact. (L2)
2. Describe the functions of compressors, condensers, expansion devices, and evaporators. (L2)
3. Explain the selection criteria for refrigerants and components. (L2)

Application Areas:

1. HVAC Systems: Eco-friendly refrigerant selection (e.g., R-32/R-290) for residential Acs.
2. Commercial Refrigeration: Scroll compressors and microchannel condensers in supermarket freezers.
3. Ozone Protection: Retrofitting R-22 systems with low-GWP alternatives (e.g., R-454B).

Unit 3: Vapour Absorption and Other Refrigeration Systems

Vapour Absorption systems: Other types of Refrigeration systems - Vapour Absorption Refrigeration Systems, Absorbent - Refrigerant combinations, Water-Ammonia Systems, Water-Lithium Bromide System, Contrast between the two systems, Modified Version of Aqua-Ammonia System with Rectifier and Analyser Assembly, Numerical Problems. Other systems: Steam-Jet refrigeration system and Thermoelectric refrigeration system.

Learning Outcomes:

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

1. Differentiate water-ammonia and LiBr-water absorption systems. (L2)
2. Compare operational advantages of VARS, steam-jet, and thermoelectric systems. (L2)
3. Identify key components in modified aqua-ammonia systems. (L2)

Application Areas:

1. Industrial Waste Heat Recovery: LiBr-H_2O absorption chillers in chemical plants
2. Solar Cooling: Ammonia-water systems for off-grid refrigeration
3. Electronics Cooling: Thermoelectric refrigeration in PCR devices and laser diodes

Unit 4: Psychrometry and Air-Conditioning

Psychrometry: Introduction to Air-Conditioning, Basic Definition, Classification, ASHRAE Nomenclature pertaining to Air-Conditioning, Applications of Air-Conditioning, Psychrometry - Air-water vapour mixtures, Psychrometric Properties, Psychrometric or Air-Conditioning processes, Psychrometric Chart, Numerical Problems.

Learning Outcomes:

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

1. Utilize psychrometric charts to examine air-conditioning processes. (L3)
2. Implement ASHRAE-compliant temperature/humidity ranges for thermal comfort systems. (L2)

Application Areas:

1. Data Center Cooling: Psychrometric analysis for humidity control in server rooms
2. Hospital HVAC: Precision air-conditioning for operating theaters (dew point control)
3. Textile Industry: Humidification processes using adiabatic cooling

Unit 5: Air-Conditioning Systems and Components

Air-Conditioning: Mathematical Analysis of Air-Conditioning Loads, Related Aspects, Numerical Problems, Different Air-Conditioning Systems-Central - Station Air-Conditioning System, Unitary Air-Conditioning System, Window Air-Conditioner and Packaged Air-Conditioner, Components related to Air-Conditioning System.

Learning Outcomes:

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

1. Estimate cooling loads for central, unitary, and packaged air-conditioning systems to determine required system capacity. (L3)
2. Distinguish between central, unitary, and packaged systems. (L2)
3. Explain methodologies for system configuration selection. (L2)

Application Areas:

1. Building HVAC Design: Load calculations for central AC systems in skyscrapers
2. EV Thermal Management: Packaged AC units in electric vehicle cabins
3. Cleanrooms: Unitary systems for pharmaceutical manufacturing

Text books:

1. Roy J. Dossat, Principles of Refrigeration, Wiley Limited
2. Arora, C. P., Refrigeration and Air-Conditioning, Tata McGraw - Hill, New Delhi.
3. Stoecker, W. F., and Jones, J. W., Refrigeration and Air-Conditioning, McGraw - Hill, New Delhi.
4. Prasad, M., Refrigeration and air conditioning. New Age International.

Reference books:

1. Khurmi, R.S and Gupta, R. K., Textbook of refrigeration and air conditioning. S. Chand Publishing.
2. Rajput, R. K., Refrigeration and Air-Conditioning. S.K. Kataria & Sons.
3. Ananthanarayan, P. N. , Refrigeration and Air conditioning: TMH.
4. Jordan & Preister: Refrigeration and Air conditioning, McGraw Hill
5. Prasad, M., Refrigeration and air conditioning. New Age International

Web Resources:

1. https://archive.nptel.ac.in/courses/112/105/112105129/
2. https://www.youtube.com/playlist?list=PLiSPNzs4fD9utSvnF9GxzWA7vCehPTtT0
3. https://www.geeksforgeeks.org/refrigeration-and-air-conditioning/
4. https://www.youtube.com/watch?v=FEWF9N1LE6g&list=PLEaHqdgEVu6rgimtDDFGVeCfMPLp1q-TQ

COURSE OUTCOMES VS POs MAPPING

[1-*slight* (low), 2 - *moderate* (*medium*) and 3- substantial (high)]

CO/ PO	PO1	PO2	PO 3	PO 4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	3	2	1	1	1	2	-	-	-	-	2	2	3
CO2	3	1	1	1	1	3	3	-	-	-	-	2	3	3
CO3	3	2	2	2	1	2	2	-	-	-	-	2	3	3
CO4	3	3	2	1	1	1	2	2	-	-	-	2	1	3
CO5	3	3	2	2	1	2	2	-	-	-	-	2	3	3
CO*	3	3	2	2	1	2	2	2	-	-	-	2	3	3

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-PE3202.3	**Quality Assurance Systems (Professional Elective-III)**	3	0	0	3

Course Objectives: The Objectives of this course are to

- Explore the techniques for identifying customer needs, gathering customer feedback, and using that information to drive quality improvements.
- develop skills in analyzing quality control data and making data-driven decisions to maintain or improve product quality
- Design and apply TQM tools and techniques such as control charts, process capability analysis, and Kaizen for continuous process improvement.
- Comprehend Six Sigma methodologies and acceptance sampling plans for quality excellence and reduce operational costs.
- foster a culture of quality and support quality management initiatives to ensure compliance, sustainability, and competitive advantage.

Course outcomes: Upon completion of this course students will be able to

1. Apply the concept of Quality function deployment to meet the customer quality requirements in product development (L3)
2. Apply tools and techniques of Quality Management to identify the assignable causes for process variations to control the manufacturing process (L3)
3. Construct control charts for variables and attributes for controlling manufacturing process (L3)
4. Develop acceptance sampling plan to minimize producer risk and consumer risk. (L4)
5. Comprehend Six Sigma methodologies and ISO quality systems to achieve quality excellence (L2)

UNIT –I

INTRODUCTION

Introduction to quality – Definition of Quality, Dimensions of Quality, Quality Planning, Total quality management – history – stages of evolution– objectives –Inspection and quality control, Quality Management versus TQM, Reliability engineering –reliability as a parameter of quality for sustainability -bathtub curve, MTBF, System reliability calculations, Quality Loss Function, Quality function deployment (QFD). applications, real life examples

Learning Outcomes:

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

- ***explain*** the concept of Total Quality Management. **(L2)**
- ***comprehend*** the importance of quality & role quality control. **(L2)**
- ***calculate*** reliability of the systems with arrangement of components**(L3)**

Application:

Quality control concepts used to meet customer requirements in manufacturing industries

UNIT II

TOOLS AND TECHNIQUES OF TQM: Process capability, Natural Tolerance limits, Process capability index. Check Sheets, Histograms, Scatter Diagrams, Cause and Effect Diagrams, Pareto Chart, control charts, TPM, Kaizen, JIT, Quality Circles, Seven wastes elimination in manufacturing industries for sustainable development, Five S principle

Learning Outcomes:

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

- ***Illustrate*** Quality control tools **(L2)**
- ***Construct*** the Cause-and-Effect Diagrams for casting, machining, forging processes **(L3)**
- ***Calculate*** Process capability Index for the given data**(L3)**

Application: Perform Process capability studies in machine tool industries

UNIT III

STATISTICAL PROCESS CONTROL

Control charts: Statistical basis of the Control Charts-principles, Control limits for X and R-Charts, analysis of pattern on control charts, Type I and Type II errors, p chart, c chart construction. Simple Numerical Problems, revised control limits

Learning Outcomes:

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

- ***understand*** statistical concepts related to control charts. **(L2)**
- ***analyze*** the assignable causes for process deviations. **(L4)**
- ***Construct*** control charts for variables and attributes**(L3)**

Application:
Identify the assignable causes Quality control in manufacturing to control the processes

UNIT- IV

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

Learning Outcomes:

After completion of this unit student will be able to

- ***Describe*** the concepts of acceptance sampling**(L2)**
- ***Draw*** OC curve for the given acceptance sampling plan **(L3)**

Application: Selection of sampling plan to minimize risk in purchasing parts, components from the suppliers

UNIT- V

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: Cost of Poor Quality, Benefits and Costs of Six Sigma.

Need for ISO 9000 and Other Quality Systems, ISO 9000: 2000 Quality System – Elements, Implementation of Quality System, Documentation, Quality Auditing, QS 9000, ISO 14000 – Concept, Requirements and Benefits.
Case Studies of TQM projects and Six Sigma projects.

Learning Outcomes:

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

- ***Understand*** the Six Sigma Problem Solving Approach **(L2)**
- ***Explain*** the significance of ISO9000 and Other Quality systems. **(L2)**

Application: Systems followed in manufacturing units for quality excellence

Text books:

1. Subburaj Ramaswamy, Total Quality Management, Tata Mcgraw Hill Publishing Company Ltd.
2. *Statistical Quality Control,* M.*Mahajan, Dhanpat Rai* Publishing Co Pvt Ltd

Reference Books:

1. Introduction to statistical quality control: By D.C. Montgomery, John Wiley &Sons.I nc.
2. Forrest W. Breyfogle, Implementing Six Sigma, John Wiley & Sons, Inc.
3. Statistical Quality Control – R.C. Gupta– Khanna Publishers, Delhi
4. Grant,E,L.and LavenWorth,R.S.: Statistical Quality Control, McGraw Hill.
5. Evans, J R and W M Lindsay, An Introduction to Six Sigma and Process Improvement, Cengage Learning.

Web Source References:

1. https://nptel.ac.in/courses/112/107/112107259/- Inspection and Quality control manufacturing.
2. https://nptel.ac.in/courses/110105039
3. https://www.youtube.com/watch?v=qb3mvJ1gb9g
4. https://nptel.ac.in/courses/110104085
5. https://onlinecourses.nptel.ac.in/noc20_mg19

COURSE OUTCOMES VS POs MAPPING

[1-*slight* (low), 2 - *moderate* (*medium*) and 3- substantial (high)]

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	-	2	2	1	-	-	2	2	3	3
CO2	3	3	2	2	1	2	2	1	-	-	2	2	3	3
CO3	3	3	2	2	1	2	2	1	-	-	2	2	3	3
CO4	3	3	2	-	1	2	2	1	-	-	2	2	3	3
CO5	3	2	-	-	-	2	2	1	-	-	2	2	3	3
CO*	3	3	2	2	1	2	2	1	-	-	2	2	3	3

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-PE3202.4	**Additive Manufacturing (Professional Elective-III)**	3	0	0	3

Course Objectives: The main objectives of this course are to

- Understand the fundamentals, evolution, and need for Additive Manufacturing in modern product development.
- Learn the principles and process chains of various liquid-based, solid-based, and powder-based AM technologies.
- Compare AM techniques with traditional manufacturing methods in terms of process, flexibility, and efficiency.
- Explore industry-specific applications of AM in aerospace, automotive, medical, and consumer products.
- Foster innovation through customization, prototyping, and production using advanced AM systems.

Course Objectives: After the end of the course, the student will be able to:

1. Explain the fundamentals, of am, and compare it with conventional manufacturing methods. (l2)
2. Describe the working principles, materials, and applications of liquid-based am systems. (l2)
3. Illustrate and compare the processes, advantages, and limitations of solid-based am systems. (l3)
4. Analyze powder-based am processes with respect to their working mechanisms and industrial use cases. (l4)
5. Evaluate the applications of am in various industries such as aerospace, automotive, medical, and others. (l5)

UNIT I - ADDITIVE MANUFACTURING FUNDAMENTALS

Need for time compression in product development, Need for Additive Manufacturing (AM), Historical development, Fundamentals of Additive Manufacturing, AM Process Chain, Advantages and Limitations of AM, Classification of AM process, Comparison of AM with CNC and other technologies.

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

- Distinguish between 3D printing and CNC machining. (L1)
- Classify the various 3D printing processes and systems. (L2)
- Summarize the benefits and limitations of Additive Manufacturing. (L2)
- Identify key milestones in the development of 3D printing technologies. (L1)

UNIT II- LIQUID-BASED AM SYSTEMS

Stereo lithography Apparatus (SLA): Models and specifications, Process, working principle, photopolymers, photo polymerization, Layering technology, Laser scanning, Applications, Advantages and Limitations, Case studies. Solid Ground Curing (SGC): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case

studies. Polyjet: Process, working principle, Applications, Advantages and Limitations, Case studies. Introduction to microfabrication.

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

- ***understand*** the basic principles of liquid-based 3D printing systems. ***(L2)***
- ***explain*** the working of Stereo Lithography Apparatus (SLA). ***(L2)***
- ***illustrate*** the laser scanning and layering technologies in SLA. ***(L2)***
- ***list*** the advantages and limitations of SLA, SGC, and PolyJet techniques. ***(L1)***

UNIT III SOLID-BASED AM SYSTEMS
Laminated Object Manufacturing (LOM): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case studies. Fused Deposition Modelling (FDM): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case studies. Multi-Jet Modelling (MJM): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case studies. Introduction to Direct Metal Deposition (DMD), Electron Beam Based Metal Deposition and Directed Energy Deposition Processes

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

- Elucidate the basic principle of solid-based AM systems such as LOM and FDM. (L2)
- Explain the process and components of Fused Deposition Modelling (FDM). (L2)
- Identify suitable applications for solid-based systems. (L1)

UNIT IV - POWDER-BASED AM SYSTEMS
Selective laser sintering (SLS): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case studies. Three-dimensional Printing (3DP): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case studies. Laser Engineered Net Shaping (LENS): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case studies. Electron Beam Melting (EBM): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case studies.
Learning Outcomes: At the end of the unit, the student will be able to:

- Illustrate the working principles of selective laser sintering (sls). (l2)
- Explain the process of three-dimensional printing (3dp) and its applications. (l2)
- Describe the lens and electron beam melting (ebm) processes. (l2)
- Compare powder-based systems based on material, resolution, and cost. (l4)

UNIT V - AM APPLICATIONS
Applications of AM- Prototyping- Tooling- Production- Customization and Personalization- Spare Parts, Maintenance and Repair- Art, Design, and Architecture- Evaluating the Adoption of AM- Applications in Aerospace Industry, Automotive Industry, Jewellery Industry application. AM in Medical and |Bioengineering Applications: Planning and simulation of complex surgery, Customised Implants & Prosthesis, Design and Production of Medical Devices.

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

- Apply knowledge of 3D printing to real-life medical and healthcare applications. (L3)
- Select appropriate AM materials and techniques for specific biomedical use cases. (L2)
- Discuss the limitations and future trends of 3D printing in medicine. (L2)
- Analyze the role of AM in creating implants, prosthetics, and surgical models. (L4)
- Evaluate business opportunities and customization potential of AM. (L5)

Text Books :

1. Olaf Diegel, "A Practical Guide to Design for Additive Manufacturing", Springer.
2. Martin Leary, "Design for Additive Manufacturing", Elsevier.

Reference Books:

1. Ben Redwood, "The 3D Printing Handbook: Technologies, Design and Applications",3D Hubs.
2. Rapid prototyping: Principles and Applications - Chua C.K., Leong K.F. and LIM C.S, World Scientific publications, Third Edition.
3. Rapid Manufacturing – D.T. Pham and S.S. Dimov, Springer.
4. Wholers Report – Terry Wohlers, Wohlers Associates.
5. Rapid Prototyping & Engineering Applications – Frank W.Liou, CRC Press, Taylor & Francis Group.
6. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: 3D Printing,Rapid Prototyping, and Direct Digital Manufacturing", Springer.

Web Source Resources :

1. **Coursera – Additive Manufacturing by University of Illinois:** Comprehensive course on AM principles, processes, and applications.
   https://www.coursera.org
2. **edX – Additive Manufacturing by MIT:** High-level understanding of AM technologies and materials.
   https://www.edx.org
3. **MIT OpenCourseWare – How to Make (Almost) Anything:** MIT's legendary course on 3D printing and digital fabrication.
   https://fab.cba.mit.edu/classes/863.21/
4. **Hubs Knowledge Base (formerly 3D Hubs):** Industry-grade guides on design, materials, and AM processes.
   https://www.hubs.com/knowledge-base/
5. **Autodesk Design Academy – Fusion 360 for 3D Printing:** Learn CAD and DfAM with hands-on tutorials using Fusion 360.
   https://academy.autodesk.com
6. **ASTM AM Center of Excellence (AM CoE):** Research, webinars, and global standards in additive manufacturing.
   https://amcoe.org

7. **YouTube – Maker's Muse / Thomas Sanladerer / Additive Manufacturing Media:** Practical insights and technology reviews in AM.
   https://www.youtube.com

COURSE OUTCOMES VS POs MAPPING

[1-*slight* (low), 2 - *moderate* (*medium*) and 3- substantial (high)]

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	**3**	**1**	1	1	**2**	–	**1**	–	–	–	–	**1**
CO2	**3**	**2**	1	1	**2**	–	1	–	–	–	–	**1**
CO3	**3**	**2**	**2**	1	**2**	–	–	–	**1**	–	–	**1**
CO4	**3**	**3**	**2**	**2**	**3**	**1**	1	–	–	–	**1**	**1**
CO5	**2**	**2**	**3**	**2**	**2**	**3**	**2**	**1**	**1**	**1**	**2**	**1**
CO*	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**2**	**1**

***** *For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-PE3202.5	**Industrial Robotics (Professional Elective-III)**	3	0	0	3

Course Objectives: The objectives of the course are

- To understand the Geometrical Configuration and Components of Industrial Robots (Anatomy)
- To analyze the factors influencing gripper selection and design.
- To grasp the concept of rotation matrices and their significance in robotics.
- To understand forward and inverse kinematics of robot manipulator
- To familiarize the students with the fundamentals of sensors and various drive systems.
- To develop Program Robot for applications in various fields.

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

1. ***Understand*** the anatomy of robots including the components and structure. **(L2)**
2. ***Design*** the grippers considering grasping force, Engelberger-g-factors, and actuation mechanisms **(L2)**
3. ***Apply*** basic transformation and rotation matrices in robot kinematics **(L3)**
4. ***Explain*** the function of feedback components such as position sensors (potentiometers, resolvers, encoders) and velocity sensors. **(L2)**
5. ***Understand*** the use of robots in manufacturing, inspection and quality control applications. **(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: speed of motion, load carrying capacity & speed of response, Sensors, Internal sensors: Position sensors, & Velocity sensors, External sensors: Proximity sensors, Tactile Sensors, & Force and Torque sensors.

Learning outcomes: After completion of this unit the students will be able to

1. ***Classify*** robots with respect to geometric configuration. **(L2)**
2. ***Illustrate*** the components of robots. **(L2)**

Applications:

1. Pick and place applications by robot
2. Performing assembly operations by robot

Unit II

Grippers & End effectors: Mechanical Gripper, Grasping force, Engelberger-g-factors, mechanisms for actuation, Magnetic gripper, vacuum cup gripper, considerations in gripper selection & design, specifications. Selection of gripper based on Application.

Learning outcomes: After completion of this unit the students will be able to

1. ***Understand*** the mechanisms for grippers. **(L2)**
2. ***Explain*** the factors for gripper selection. **(L2)**

Applications:

1. Wall climbing robot
2. Vacuum cups

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- Assignment of frames, D-H Transformation Matrix, joint coordinates and world Coordinates, Forward and inverse kinematics.

Learning Outcomes: After completion of this unit the students will be able to

1. ***Apply*** basic rotation matrices to solve problems of spatial transformations in robotics. **(L3)**
2. ***Differentiate*** the forward and inverse kinematics. **(L2)**

Applications:

1. Robot trajectory generation by forward kinematics.
2. Welding robots by inverse kinematics by root multiplicity.

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: After completion of this unit the students will be able to

- ***Compare*** the robot actuators. **(L2)**
- ***Explain*** the sensors used in Robotics. **(L2)**

Applications:

1. Automated Assembly Lines in Automotive Manufacturing
2. Surgical Robotics (e.g., Da Vinci System)

Unit V

Robot Programming & Applications: 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: After completion of this unit the students will be able to

1. ***Describe*** the role of robotics in material handling in industries. **(L2)**
2. ***Understand*** the Robotic Programming methods. **(L2)**

Applications:

1. Automated Car Body Assembly
2. Electronics Manufacturing (e.g., PCB Assembly)

Text Books:

1. Industrial Robotics / Groover M P /Mc Graw Hill
2. Introduction to Robotics / John j.Craig / Pearson

References:

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

Web Resources:

1. https://onlinecourses.nptel.ac.in/noc23_me143/preview
2. https://www.youtube.com/results?search_query=1.%09Robotics+Programming+in+Just+30+Days!+%7C+Industrial+Robotics+Programming+in+Bangalore+%7C+RVM+CAD
3. https://www.youtube.com/watch?v=QiFbrmJTib4&t=11s
4. https://www.youtube.com/watch?v=hL_GKapQd1k

COURSE OUTCOMES VS POs MAPPING

[1-*slight* (low), 2 - *moderate* (*medium*) and 3- substantial (high)]

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	2	-	-	-	-	1	1	1	3	-
CO2	3	3	3	-	2	-	-	-	-	1	1	1	3	3
CO3	3	3	3	2	2	-	-	-	-	1	1	1	2	3
CO4	3	2	3	3	-	-	-	-	-	1	1	1	-	3
CO5	3	3	3	-	2	1	1	-	-	1	1	1	3	3
CO*	3	2	3	2	2	1	1	-	-	1	1	1	3	3

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-PC3204	**Heat Transfer Laboratory**	0	0	3	1.5

Course Objective: The objectives of the course are

- To determine the thermal conductivity of different materials and analyze heat transfer rates in composite and lagged systems.
- To evaluate convective heat transfer coefficients in both natural and forced convection conditions.
- To analyze and compare the effectiveness of extended surfaces (fins) and different types of heat exchangers under parallel and counter-flow conditions.
- To demonstrate and validate radiation heat transfer principles by determining the emissivity of surfaces and Stefan-Boltzmann constant.
- To examine and compare heat transfer rates in different condensation modes, including drop-wise and film-wise condensation

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

1. Determine the thermal conductivity of metals, insulating powders, and materials using different experimental setups. (l5)
2. Determine the heat transfer coefficients for materials, liquids and air. (l5)
3. Analyze the efficiency and effectiveness of pin fins under natural and forced convection using experimental data. (l4)
4. Compare the performance and effectiveness of parallel and counter low heat exchangers through experimentation (l5)
5. Apply stefan- boltzmann's law for determining the test plate surface emissivity and its effect on radiative heat transfer. (l3)

LIST OF EXPERIMENTS:

1. Determination of thermal conductivity of a metal rod.
2. Determination of heat transfer rate through a concentric sphere.
3. Determination of heat transfer rate through a lagged pipe.
4. Determination of overall heat transfer co-efficient of a composite Slab
5. Determination of heat transfer coefficient in natural convection.
6. Determination of heat transfer coefficient in forced convection.
7. Determination of efficiency of a pin-fin.
8. Determination of emissivity of a given surface.
9. Determination of Stefan Boltzmann constant
10. Determination of effectiveness of parallel and counter flow heat Exchangers
11. Determination of heat transfer rate in drop and film-wise Condensation

Course Code	Course Name	L	T	-	P	C
R23MEC-PC3205	**Machine Tools and Metrology Lab**	0	0	-	3	1.5

Course Objective: The objectives of the course are

- Execute step turning and knurling processes on a lathe machine to enhance machining skills.
- Perform drilling, shaper, slotting and planning machine with understanding its working principle and various operations
- Impart knowledge on operation of Milling and surface grinding machine working principle and various operations to prepare different shapes of products.
- Perform angle measurements using a bevel protractor and sine bar to ensure accurate angular dimensions.
- Demonstrate accurate measurement of screw threads using a toolmaker's microscope.

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

1. Identify and operate machine tools such as lathes, milling machines, and drilling machines. (L2)
2. Measure dimensions like length, height, and diameter using Vernier calipers, micrometers, and height gauges. (L2)
3. Apply metrology techniques to measure angles, bore, and surface roughness using dial indicators and bevel protractors. (L3)
4. Execute machining tasks such as threading, taper turning, and gear milling with precision. (L3)
5. Analyze surface flatness and roughness using spirit levels and Talysurf to ensure high-quality finishes. (L4)

ANY FIVE EXPERIMENTS FROM EACH PART

PART-A MACHINE TOOLS

List of Experiments :

1. Facing and Centre Drilling operations on a Lathe Machine
2. Step Turning and Knurling on Lathe Machine
3. Taper Turning and Threading on a Lathe Machine
4. Drilling and Tapping operations on the Radial Drilling Machine
5. Milling a Spur Gear on a Milling Machine
6. Slotting a Key Hole in a Pulley using a slotting machine
7. Perform ‘V’ and Dovetail Machining Using Shaping Machine
8. Perform Precision Grinding on M.S. Plate
9. Making of Single Point Cutting Tool using Tool and Cutter Grinding Machine
10. Machining Key Ways on Wood Using Planning Machine

PART-B METROLOGY

List of Experiments :

1. Measurement of Length, Height, and Diameter by Vernier Calipers, Vernier Height Gauge, and Micrometer
2. Measurement of Bore by Dial Indicator
3. Angle Measurement Using Bevel Protractor and Sine Bar
4. Measurement of Thickness of Gear Tooth by Vernier Tooth Calipers
5. Surface Roughness Measurement by Talysurf
6. Flatness of Surface Plate by Using Spirit Level
7. Measurement of Screw Thread by Toolmaker's Microscope

Learning outcomes:

1. Perform taper turning, threading, and knurling on a lathe machine, ensuring precise dimensions and surface finishes.
2. Mill a spur gear on a milling machine, understanding gear tooth geometry and achieving accurate gear profiles.
3. Slot a keyhole in a pulley using shaping machine techniques, demonstrating proficiency in shaping operations.
4. Measure length, height, and diameter using vernier calipers, micrometers, and height gauges with high accuracy.
5. Determine surface roughness using Talysurf to assess surface texture and quality.

COURSE OUTCOMES VS POs MAPPING

[1-*slight* (low), 2 - *moderate* (*medium*) and 3- substantial (high)]

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	3	3	1	1	-	1	-	1	-	1	-	2	2	3
CO2	3	3	1	2	-	2	-	1	-	1	-	2	2	2
CO3	3	3	1	1	-	2	-	1	-	1	-	2	2	2
CO4	3	3	1	1	-	2	-	1	-	1	-	2	2	2
CO5	3	3	1	1	-	2	-	1	-	1	-	2	2	2
CO*	3	3	1	1	-	2	-	1	-	1	-	2	2	2

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-SC3201	**Instrumentation and Control Systems (Skill Enhancement Course)**	0	1	2	2

Course objectives: The objectives of the course are

- To impart understanding of transducers and calibration methods used for measuring displacement, temperature, pressure, and speed.
- To equip students with knowledge of transducers and calibration techniques for accurately measuring displacement, temperature, pressure, and speed.
- To acquaint students with temperature and pressure measurement techniques, including the use of thermocouples, RTDs, and low-pressure measuring instruments.
- To Develop practical skills in speed and flow measurement using various types of instruments and calibration methods.
- To understanding of control systems and their implementation in real-time applications - elevators, traffic control systems, and water level regulation.

Course outcomes: By the end of this course, students will be able to:

1. ***explain*** the basic principles of measurement systems, their configurations, and the dynamic characteristics of measuring instruments. **(L2)**
2. ***select*** suitable piezoelectric, inductive, capacitive, and photoelectric transducers to detect displacement, and perform proper calibration to ensure precise measurements**. (L3)**
3. ***illustrate*** the various temperature measurement techniques including thermocouples, RTDs, and pyrometers, and explain their suitability for different ranges and applications**. (L2)**
4. ***measure*** the pressure and speed using mechanical, electrical, and non-contact instruments Bourdon gauges, McLeod gauges**. (L3)**
5. ***demonstrate*** control systems, including open-loop and closed-loop types, and Interpret block diagrams of servomechanisms used for regulating temperature, speed, and position**. (L2)**

Measurement of displacement:

Introduction– Basic principles of measurement – measurement systems, generalized configuration, dynamic performance characteristics – sources of error, classification and elimination of error.

Various transducers to measure displacement – piezo electric, inductive, capacitance, ionization and photo electric transducers, calibration procedures.

Measurement of temperature: Classification – ranges – various principles of measurement – expansion, electrical resistance – thermister – thermocouple – pyrometers – temperature indicators.

Measurement of pressure: Manometers, bourdon pressure gauges, bellows – diaphragm gauges. low pressure measurement –ionization pressure gauges, Mcleod pressure gauge

Measurement of speed: Mechanical tachometers – electrical tachometers – stroboscope, noncontact type of tachometer

Elements of control systems: Introduction, importance – classification – open and closed systems, servomechanisms–examples with block diagrams–temperature, speed & position control systems.

List of Experiments

1. Calibration of capacitive transducer for angular measurement.
2. Study and calibration of LVDT transducer for displacement measurement.
3. Study of resistance temperature detector for temperature measurement.
4. Calibration of thermistor for temperature measurement.
5. Calibration of thermocouple for temperature measurement.
6. Calibration of Pressure gauges.
7. Study and calibration of a rotameter for flow measurement
8. Study and calibration of photo speed pickups for the measurement of speed.
9. Study and calibration of magnetic speed pickups for the measurement of speed.
10. Calibration of McLeod gauge for low pressure.
11. Study and simulate the operation of a lift control system using sensors and actuators to manage floor selection and door operation.
12. Design and implement a traffic light control system to manage vehicle and pedestrian flow at an intersection using timing logic.
13. Test a water level control system using sensors and feedback mechanisms to maintain desired tank levels.

Text books:

1. Measurement Systems: Applications & design / D.S Kumar/
2. Mechanical Measurements / BeckWith, Marangoni, Linehard, Pearson

Reference books:

1. Measurement systems: Application and design/Doeblin Earnest. O. Adaptation/ TMH
2. Experimental Methods for Engineers / J.P.Holman/McGraw Hill
3. Mechanical and Industrial Measurements / R.K. Jain/ Khanna Publishers.
4. Instrumentation, measurement & analysis / B.C.Nakra & K.K.Choudhary/TMH

Web resources:

1. https://archive.nptel.ac.in/courses/112/107/112107242/
2. https://nptel.ac.in/courses/107106081

COURSE OUTCOMES VS POs MAPPING

[1-*slight* (low), 2 - *moderate* (*medium*) and 3- substantial (high)]

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	2		1	-	-	1	1	-	3	2	2
CO2	3	3	3	3		1	-	-	1	1	-	3	3	3
CO3	3	3	3	3		1	-	-	1	1	1	3	3	3
CO4	3	3	3	3		1	1	-	1	1	1	3	3	3
CO5	3	3	3	3		1	1	1	1	2	2	3	3	3
CO*	3	3	3	3	-	1	1	1	1	2	2	3	3	3

** For Entire Course, PO & PSO Mapping*

Course code	Course Name	L	T	P	Credits
R23MEC-MC3201	**Technical Paper Writing & IPR (Mandatory Course)**	2	0	0	0

Course Objectives:

- Build the knowledge on principles and characteristic soft technical writing, including clarity, conciseness, and precision. (L2)
- Formulate clear and focused research objectives and research proposal(L2)
- Outline the significance of Intellectual Properity Rights(L2)
- Provide knowledge of Copy right and patent law, registration process and grants, protects in India and abroad.(L3)
- Assessandmaintaintheprotectionoftrademarkandtradesecretintheorganisation and also emerging trends in cyber security (L2)

Course Outcomes:

1. Develop the technical writing skills, evaluate sources and properly cite references using appropriate citation styles.(L3)
2. Construct clear and focused research proposal that address a specific gap in the advancement of knowledge in their field of study.(L3)
3. Assess needful elements, agencies responsible for Registration of IPR elements(L3)
4. Analyze Copy right subject matters, Patent requirements, Infringement and Litigation.(L3)
5. Outline the registration Processes of Trade Mark and Legal procedure stop revent cyber crimes.(L2)

UNIT-I:

Introduction To Technica Lpaper Writing: Technical paper writing-Objectives- Components-Pre -requisites of good technical report-Format of technical report and its applicability-Significance of technical report and its applicability to end users-Types of technical writing

Application: Apply while preparing user manual, technical reports, proposals, online help documentations, and scientific articles.

UNIT-II:

Information and Communication of Technical paper writing: 7C'soft technicall writing-Difference between technical writer and technical editor-Lega land ethical communication and its description in technical paper-Usage of contemporary technologies in technical paper writing

Application: Analyse accurate in formation forehical decision making process.

UNIT-III:

Introduction to Intellectual Property Rights: Introduction to IPRs – International Instruments and IPR - WIPO - TRIPS -Laws Relating to IPR - IPR Tool Kit - Agencies for IPR Registration – Emerging trends in IPR.

Application: Applicability and relativity between elements of Intellectual property rights and Creating innovative ideas.

UNIT-IV:

Copyrights and Patents: Introduction to Copyrights– Principles of Copyright Protection– Copy Registration Process - Subject Matters of Copyright – Right to Copy rights – Copyright Infringement - Patents – Patent Search - Patent Registration and Granting of Patent - Infringement of Patent — Patent Cooperation Treaty – New developments in Patents.

Application:

- Practice of copyrights case and Identification of the in fringement.
- Checking the eligibility for several patents and suggest remedies for problems through case study.

UNIT-V:

Trademarks, Trade secrets and Cybercrimes: Introduction to Trade marks– Trade Mark Registration – Transfer of rights-Trademarks Claims and Infringement–Remedies- Trade Secrets – Physical Security – Employee Confidentiality Agreements–Breach of Contract – Trade Secret Litigation. Introduction to Cyber Law-Cyber Crimes - Prevention and Punishment.

Application:

- Compare and contrast different trademarks and know how to register trade mark
- Identify the physical protection of trade secret.
- Detect various cyber crimes protection in the society. Contemporary Practices:
- E-filing Applications
- Digital Piracy

Text Books:

1. Fundamentals of IPR for Engineers- Kompal Bansal & Parishit Bansal, B.S.Publications, first edition. 2013
2. Research Methodology-C.R.Kothari, GauravGarg, NEWAGE International Publishers, 4th edition, 2019.
3. Developing Research Proposals (Paperback-2023), PamDenicolo, Sage Publications, first edition, 2023
4. Intellectual Property- DeborahE.Bouchoux, Cengage Learning, New Delhi., 4th edition, 2012
5. V.Scople Vinod, Managing Intellectual Property ,Prentice Hall of India pv tLtd, 2nd edition, 2012
6. Essentials of Technical Communication- Elizabeth Tableaux SamDragga, Oxford University Press, 4th edition, 2017.

References Books:

1. Intellectual property rights- PrabuddhaGanuli. TataMcgrawhill, 2012.
2. Intellectual property rights M.Ashok kumar and Mohd.IqbalAli:,Serials Publications,2015
3. Developing Research Proposals- English, Paper back, DenicoloPam, Sage South Asia edition,2012
4. Intellectual Property Rights (Patents&CyberLaw), Dr.A.Srinivas. Oxford University Press, New Delhi, 2015.
5. Intellectual Property-Richard Stim, Cengage Learning, New Delhi, 2012.
6. S.V.Satakar,―Intellectual Property Rights and Copy Rights, EssEss Publications, New Delhi,2002
7. Technical Communication –Mike Markel- Publisher: Bedford/St.Martin's,12th Edition.

Web links:

1. http://www.ipindia.gov.in/patents.htm
2. http://www.ipindia.gov.in/trade-marks.htm
3. https://copyright.gov.in/
4. http://www.wipo.int/portal/en/index.html
5. https://indiankanoon.org/

DEPARTMENT OF MECHANICAL ENGINEERING

HONORS COURSE STRUCTURE AND SYLLABUS

(R23 REGULATION)

MEC (Honors)

Track- I (Manufacturing Technology)							
S.No	**Year & Semester**	**Course Code**	**Subject title**	**L**	**T**	**P**	**C**
1	II-II	R23MEC-HN2201	Material Characterization Techniques	3	0	0	3
2	III-I	R23MEC-HN3101	Product Design and Development	3	0	0	3
3	III-II	R23MEC-HN3201	Advanced Manufacturing Technology	3	0	0	3
4	IV-I	R23MEC-HN4101	Optimization and Reliability	3	0	0	3
5	II Year to IV Year	R23MEC-HM0001	Honors MOOCS-1	0	0	0	3
6	II Year to IV Year	R23MEC-HM0002	Honors MOOCS-2	0	0	0	3
Total							**18**
Track-II (Thermal Engineering)							
S.No	**Year & Semester**	**Course Code**	**Subject title**	**L**	**T**	**P**	**C**
1	II-II	R23MEC-HN2202	Advanced Fluid Dynamics	3	0	0	3
2	III-I	R23MEC-HN3102	Turbo Machinery	3	0	0	3
3	III-II	R23MEC-HN3202	Design of thermal Systems	3	0	0	3
4	IV-I	R23MEC-HN4102	Cryogenic Engineering	3	0	0	3
5	II Year to IV Year	R23MEC-HM0001	Honors MOOCS-1	0	0	0	3
6	II Year to IV Year	R23MEC-HM0002	Honors MOOCS-2	0	0	0	3
Total							**18**
Track III (Design Engineering)							
S.No	**Year & Semester**	**Course Code**	**Subject title**	**L**	**T**	**P**	**C**
1	II-II	R23MEC-HN2203	Advanced Mechanism Design	3	0	0	3
2	III-I	R23MEC-HN3103	Engineering Tribology	3	0	0	3
3	III-II	R23MEC-HN3203	Design for Fatigue and Facture	3	0	0	3
4	IV-I	R23MEC-HN4103	Design with advanced Material	3	0	0	3
5	II Year to IV Year	R23MEC-HM0001	Honors MOOCS-1	0	0	0	3
6	II Year to IV Year	R23MEC-HM0002	Honors MOOCS-2	0	0	0	3
Total							**18**
Track IV (Robotic Engineering)							
S.No	**Year & Semester**	**Course Code**	**Subject title**	**L**	**T**	**P**	**C**
1	II-II	R23MEC-HN2204	Mechanism and Robot Kinematics	3	0	0	3
2	III-I	R23MEC-HN3104	Flexible Manufacturing Systems	3	0	0	3
3	III-II	R23MEC-HN3204	AI and ML for Robotics	3	0	0	3
4	IV-I	R23MEC-HN4104	Autonomous Robot System	3	0	0	3
5	II Year to IV Year	R23MEC-HM0001	Honors MOOCS-1	0	0	0	3
6	II Year to IV Year	R23MEC-HM0002	Honors MOOCS-2	0	0	0	3
Total							**18**

 # NOTE: In addition to the four subjects mentioned in the table above, students are required to complete two MOOC programs (each with a duration of 12 weeks), as approved by the BOS Chairman

Honors Course Track Offered by Mechanical Department

Track: Manufacturing Technology

Course Code	Course Name	L	T	P	C
R23MEC-HN2201	**Material Characterization Techniques (Honors Course-1)**	**3**	**0**	**0**	**3**

Course Objectives:

- To introduce fundamental concepts relevant to materials analysis
- To enable the students to understand properties of engineering materials and various advanced characterization methods.
- To develop students understanding of best practice approaches to material characterization.

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

1. Apply light microscopy techniques for microstructure examination (L3)
2. Describe instrumentation and data acquisition used in X-ray diffraction methods (L2)
3. Explain electron microscopy techniques to investigate microstructure of materials (L2)
4. Explain various spectroscopic techniques (L2)
5. Describe techniques to determine thermal stability (L2)

UNIT I

Light Microscopy: Optical principles, image formation, resolution, effective magnification, brightness and contrast, instrumentation, steps to improve depth of field, specimen preparation, imaging modes, Bright field and dark field imaging, Phase-contrast microscopy, Polarized-light, confocal microscopy, working principles.

Learning Outcomes: At the end of this unit, the student will be able to 1.
describe the need of specimen preparation (L2)
2. Explain basic principle of Optical microscope (L2)
3. apply different imaging techniques to various microscopic techniques (L3)

UNIT II

X-ray Diffraction Methods: X-ray radiation, generation of X-rays, X-ray absorption, theoretical background of diffraction, diffraction geometry, Bragg's law, reciprocal lattice, diffraction intensity, X-ray diffractometry, samples and data acquisition, sample preparation, acquisition and treatment of diffraction data, distortions of diffraction spectra.

Learning Outcomes: At the end of this unit, the student will be able to
1. list the different types of X-ray diffraction methods (L1)
2. explain the samples and data acquisition (L2)
3. describe the distortions of diffraction spectra (L2)

UNIT III

Transmission Electron Microscopy: Instrumentation, electron sources, thermionic emission gun, field emission gun, electromagnetic lenses, specimen stage, specimen preparation, pre thinning, final thinning, electrolytic thinning.

Scanning Electron Microscopy: Instrumentation, optical arrangement, signal detection, detector, probe size and current, contrast formation, electron-specimen interactions, specimen preparation, preparation for micro composition examination.

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

1. list various electron microscopy techniques (L1)
2. describe the working principle of Scanning electron microscopy (L2)
3. describe the preparation for Micro composition examination (L2)

UNIT IV

Spectroscopy: Introduction, UltraViolet -visible light (UV-vis) Spectroscopy: Principle, sample preparation, basic instrumentation, applications. Infrared Spectroscopy (IR) : Basic theory, sample preparation, instrumentation, applications. Fourier Transform Spectrometry : Principle, applications. **Raman Spectroscopy :** Principle, instrumentation, applications. Anger Electron Spectroscopy : Principle, instrumentation, applications

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

1. list the various spectroscopic techniques (L1)
2. describe working principle of Fourier transform spectrometry (L2)
3. discuss instrumentation used in Raman spectroscopy (L2)

UNIT V

Thermal Analysis: Common characteristics, thermal events, enthalpy change, instrumentation, experimental parameters, differential thermal analysis and differential scanning calorimetry, working principles, experimental aspects, sample requirements, baseline determination, effects of scanning rate, measurement of temperature and enthalpy change, thermosgravimetry.

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

1. describe various thermal analysis techniques (L2)
2. explain working principle of differential thermal analysis (L2)
3. discuss about thermogravimetry (L2)

Textbooks:

1. YangLeng, *Materials Characterization Techniques*,2nd Edition, John Willey and Sons.

2. P.K.Mitra,*Characterization of Materials*,1st Edition,PHI Learning Pvt.Ltd.

Reference Books:

1. Li, Lin, Ashok Kumar, Sam Zhang, *Materials Characterization Techniques*; CRC Press.

2. B.D Cullity, and R.S.Stock, *Elements of X-Ray Diffraction*, Prentice-Hall.

3. W.W. Wendlandt, T*hermal Analysis*, John Willey & Sons.

Course Code	Course Name	L	T	P	C
R23MEC-HN3101	**Product Design and Development (Honors Course-2)**	**3**	**0**	**0**	**3**

Course Objectives:

The objectives of the course are

- Understand structured approaches to product development from customer needs to market launch.
- Introduce systematic concept generation, selection, and evaluation methods in product development.
- Develop skills in applying design for manufacturing (DFM), ergonomics, and quality aspects.
- Integrate legal, economic, and project management aspects of product development.
- Impart knowledge on innovation and creativity in new product design through team-based projects.

Course Outcomes (COs):

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

1. ***Describe*** the product development process and customer needs. (L2)
2. ***Apply*** QFD to develop the product as per the desired customer needs. (L3)
3. ***Analyze*** design for manufacturing, prototyping, and sustainability aspects. (L4)
4. ***Apply*** ergonomic and aesthetic needs in designing industrial products. (L3)
5. ***Explain*** project management tools, legal protection and IP rights in product development. (L2)

UNIT I

Introduction to Product Development: Product development processes and organization, identifying customer needs, establishing product specifications, concept generation, product architecture, applied ergonomics and human factors.

Learning Outcomes:

1. ***Understand*** the stages of product development and various organizational structures used in managing development processes. (L2)
2. ***Identify*** customer needs to translate them into clear and actionable product requirements. (L3)
3. ***Apply*** principles of product architecture, ergonomics, and human factors in designing user-centric and functionally efficient products. (L3)

Applications:

1. Medical Devices
2. Industrial Tools and Equipment

UNIT II

Systematic Product Design Approaches: Design objectives and functional analysis, QFD, generating and evaluating concepts, morphological charts, value engineering, weighted objectives method, design strategies.

Learning Outcomes:

1. ***Explain*** design objectives and conduct functional analysis to determine product requirements. (L2)
2. ***Apply*** tools like QFD, morphological charts, and value engineering to develop innovative and efficient design concepts. (L3)

Applications:

1. Automotive Engineering
2. Consumer Product Innovation
3. Renewable Energy Systems

UNIT III

Design for Manufacturing and Prototyping: Cost estimation, design for assembly/disassembly, environmental design, packaging, graphics, and planning effective prototyping strategies.

Learning Outcomes:

1. ***Understand*** cost estimation techniques to optimize product design and reduce manufacturing expenses. (L2)
2. ***Estimate*** manufacturing costs as per the specification of the product including packaging and environmental sustainability. (L3)

Applications:

1. Consumer Electronics (e.g., mobile phones, smartwatches)
2. Automotive Industry
3. Medical Devices
4. Packaging and Branding

UNIT IV

Industrial Design and Ergonomics: Aesthetic and ergonomic needs, quality in design, user-driven product design, management of technology, industrial design process steps.

Learning Outcomes:

1. ***Understand*** the importance of aesthetics and ergonomics in creating user-friendly, visually appealing, and functionally effective products. (L2)
2. ***Apply*** quality principles and standards to ensure product reliability, usability, and market acceptance. (L3)

Applications:

1. Consumer Products (e.g., kitchen appliances, smartphones)
2. Automotive Interiors
3. Medical Devices
4. Office Furniture and Equipment

UNIT V

Legal and Project Management Aspects: IP rights: patents, trademarks, copyrights, trade secrets. Design project management tools: Gantt charts, DSM, risk planning, budgeting, and scheduling.

Learning Outcomes:

1. ***Understand*** different forms of intellectual property (IP) such as patents, trademarks, copyrights, and trade secrets, and their role in protecting product innovations. (L2)
2. ***Apply*** tools like QFD, morphological charts, and value engineering to develop innovative and efficient design concepts. (L3)

Applications:

1. Product-Based Startups
2. Software and App Development
3. Medical and Biotech Devices
4. Consumer Product Development

Text books

1. Karl T. Ulrich and Steven D. Eppinger – Product Design & Development (TMH, Delhi)
2. Kevin Otto and Kristin Wood – Product Design (Pearson Education)

References

1. Kumar – Product Design: Creativity, Concepts and Usability (PHI, Delhi)
2. Chitale & Gupta – Product Design and Manufacturing (PHI, Delhi)

Web Resources:

1. https://onlinecourses.nptel.ac.in/noc21_me66/preview?utm_source=chatgpt.com
2. https://kcl.digimat.in/nptel/courses/video/112105316/lec11.pdf
3. https://archive.nptel.ac.in/courses/112/101/112101005/
4. https://onlinecourses.nptel.ac.in/noc24_hs79/preview?utm_source=chatgpt.com

5. https://onlinecourses.nptel.ac.in/noc25_mg71/preview?utm_source=chatgpt.com

COURSE OUTCOMES VS POs MAPPING

[1-slight (low), 2 - moderate (medium) and 3- substantial (high)]

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	2	-	1	1	1	2	2	2	1	1	2	2
CO2	3	3	3	2	2	-	-	-	-	-	-	2	3	2
CO3	3	3	3	3	2	2	2	-	-	-	-	2	3	3
CO4	3	2	2	-	-	-	-	3	2	-	-	2	2	2
CO5	2	2	2	2	1	3	3	3	3	2	2	3	2	3
CO*	3	2	2	2	1	2	2	2	2	2	2	2	2	2

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-HN3201	**Advanced Manufacturing Technology (Honors Course-3)**	**3**	**0**	**0**	**3**

Course Objectives:

The objectives of the course are

• Understand the principles and applications of advanced and hybrid machining systems for precision manufacturing.
• Comprehend advanced surface treatment and coating technologies for improved material performance.
• Gain knowledge of modern casting and forming processes for producing complex engineering components.
• Explore micromachining technologies for precision fabrication at micro and nano scales.
• Understand fabrication methods of microelectronic devices and the integration of e-manufacturing concepts.

Course outcomes:

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

CO1: Discuss the advanced machining processes (L2)
CO2: Explain surface treatments and surface coatings (L2)
CO3: Describe Advanced Casting and Forming processes (L2)
CO4: Discuss the Micromachining processes (L2)
CO5: Describe Fabrication of Microelectronic devices (L2)

UNIT- I

Advanced Machining processing: High-speed Machining, Ultraprecision Machining, Abrasive flow finishing (AFF) and its modelling. Hybrid Machining Systems-Magnetic abrasive finishing (MAF) and its modelling, Magnetorheological abrasive flow finishing (MRAFF) and its modelling and analysis, Magnetorheological finishing (MRF), Electric Discharge Grinding, Electric Discharge Diamond Grinding.

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

1. Describe High speed machining and ultra-precision machining (L2)
2. Discuss various Hybrid machining systems(L2)
3. Explain applications of Hybrid machining systems (L2)

UNIT- II

Surface treatments and surface coatings: Surface Treatments, Coatings, and Cleaning, Introduction, Mechanical Surface Treatments, Mechanical Plating and Cladding, Case Hardening and Hard Facing, Thermal Spraying, Vapor Deposition, Ion Implantation and Diffusion Coating, Laser Treatments, Electroplating, Electro less Plating, and Electroforming, Conversion Coatings, Hot Dipping, Porcelain Enameling; Ceramic and Organic Coatings, Diamond Coating and Diamond like Carbon, Surface Texturing, Painting Cleaning of Surfaces

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

1. Describe various advanced surface coatings (L2)
2. Explain the advanced surface treatments (L2)
3. Explain applications of advanced surface coatings and treatments (L2)

UNIT- III

Advanced Casting: Expendable-pattern Casting, Processes Permanent-mold Casting Processes, Casting Techniques for Single-crystal Components, Rapid Solidification.

Forming processes: High speed forging machines and Die materials -General, Requirements for Die Materials, Selection of Proper die materials, Common Die materials Semisolid metal, forming types (Thixocasting, Rheocasting, Thixomolding) Peen forming of sheet metals-Process, Super plastic forming-Material requirements, Forming and shaping glass-Flat Sheet, Rods and Tubes, Discrete Products, Glass Fiber.

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

1. Describe various advanced casting processes(L2)
2. Explain advanced forming processes(L2)
3. Discuss applications of advanced Casting and Forming processes (L2)

UNIT- IV

Micromachining: Conventional Micromachining, Diamond Micro turning, Micro drilling, Abrasive Micromachining, Micro grinding, Magnetic Abrasive Micro finishing, Micro-Superfinishing, Micro-lapping, Micro-Ultrasonic Machining,

Nonconventional Micromachining; Micro-machining by Thermal Erosion - Micro-EDM, Laser Micromachining, Micromachining by Electrochemical Erosion, Combined Micromachining Processes; Chemical-Assisted Mechanical Polishing, Mechanochemical Polishing, Electrolytic In-Process Dressing of Grinding Wheels.

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

1. Describe various Conventional Micromachining processes(L2)
2. Discuss various Non-conventional Micromachining processes (L2)
3. Explain micro- surface finishing processes (L2)

UNIT- V

Fabrication of Microelectronic devices: Crystal growth and wafer preparation, Film Deposition oxidation, lithography, bonding and packaging, reliability and yield, Printed Circuit boards, computer aided design in microelectronics, surface mount technology, Integrated circuit economics. E-Manufacturing,

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

1. Describe preparation of various microelectronic devices (L2)
2. Discuss E-Manufacturing and nanotechnology (L2)
3. Explain various micromachining applications (L2)

Text Books:

1. V.K. Jain, *Advanced Machining Processes,* 12th reprint, Allied Publishers Ltd.
2. S. Kalpakjain and S. R.Schmid, *Manufacturing Engineering and Technology*, 7th Edition,Pearson.

References:

1. Pandey P.C. and Shah H.S, *Modern Machining Processes*, 1st Edition, TMH
2. Amitabha Bhattacharyya, *New technology,* Institution of Engineers.
3. El-Hofy, Hassan Abdel-Gawad, *Advanced Machining Processes: Nontraditional and Hybrid Machining Processes*, McGraw-Hill.

Track: Thermal Engineering

Course Code	Course Name	L	T	P	C
R23MEC-HN2202	**Advanced Fluid Dynamics (Honors Course-1)**	3	0	0	3

Course Objectives

- Apply the principles of Reynolds equations of motion, Prandtl's mixing length and Vonkarman for solving the problems in turbulent flow regimes
- Analyze the differences in behavior and characteristics of laminar and turbulent boundary layers
- Understand the transition from subsonic to supersonic flow and its implications on fluid properties and behavior
- Apply the concept of area ratio as a function of Mach number to design the nozzle and diffuser
- Analyze the effects of shock waves on entropy, deflection angle, and downstream Mach number.

Course Outcomes: At the end of the course the student shall be able to

CO1: Analyze the concepts of turbulent flow for solving the fluid flow problems (L4)
CO2: Apply the concepts of boundary layer theory for solving the fluid flow problems (L3)
CO3: Analyze the effect of Mach number on the compressibility of fluids (L4)
CO4: Analyze the nozzle, diffuser and shock wave problems of compressible fluids (L4)
CO5: Apply Prandtl, Rankine-Hugniot equations for solving oblique shock (L3)

UNIT-I

Characteristics of turbulent flow - Reynolds equations of motion - turbulence modeling – Boussinesq Eddy viscosity concept – Prandtl's mixing length concept –Vonkaman similarity concept – Prandtl's universal velocity distribution-Karman – Prandtl velocity distribution power law for velocity in smooth pipes – Friction factor for smooth and rough pipes-Charts for friction factor in pipe flow.

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

1. explain the concepts of Boussinesq's eddy viscosity, Prandtl's mixing length and Vonkarmansimilarity concept. (L2)
2. analyze and apply Prandtl's universal distribution equation to solve turbulent flow problems inpipes. (L4)
3. use friction factor charts in pipe flows. (L3)

UNIT-II

Navier – Stokes Equations of motion – boundary layer over a flat plate – thickness of boundary layer –Prandtl's boundary layer equation – Vonkarmann momentum equation – shear stress anddrag force – laminar boundary layer – turbulent boundary layer –pressure distribution in the boundary layer –boundary layer separation – drag and lift force – lift on an airfoil.

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

1. explain the concepts of boundary layer formation (L2)
2. apply Von karman momentum equation to solve boundary layer problems (L3)
3. determine the drag and lift force on an airfoil (L3)

UNIT-III

Propagation of sound waves – Mach number – Mach angle – equation of sound wave. Energy equation – energy equation for non-flow and flow processes – adiabatic energy equation – stagnation enthalpy - stagnation temperature - stagnation pressure – stagnation velocity of sound– reference velocities – Bernoulli's equation – effect of Mach number on compressibility.

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

1. explain the propagation of sound waves in compressible fluid flow (L2)
2. determine the stagnation properties in compressible fluid flows(L3)
3. discuss the effect of Mach number on compressibility (L2)

UNIT- IV

Comparison of isentropic and adiabatic processes – Mach Number variation - expansion in nozzles – compression in diffusers – stagnation and critical states – area ratio as a function of Mach number – impulse function - mass flow rate, flow through nozzles - convergent nozzles – convergent-divergent nozzles – flow through diffusers. Development of a shock wave– governing equations, Prandtl-Meyer relation – Mach number downstream of the shock wave – static pressure ratio across the shock - temperature ratio across the shock – density ratio across the shock - stagnation pressure ratio across the shock

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

1. solve the expansion or compression of fluid flow problems in nozzles and diffusers (L3)
2. analyze the conditions for development of normal shock waves (L4)
3. determine downstream side properties of the of normal shock waves (L3)

UNIT-V

Nature of flow through oblique shock waves – fundamental relations - Prandtl's equation – Rankine- Hugoniot equation. variation of flow parameters - density ratio, temperature ratio, pressure ratio, stagnation pressure ratio, change of entropy, deflection angle, downstream Mach number. The Fanno curves – Fanno flow equations, variation of flow parameters – velocity, density, temperature, pressure, stagnation pressure, impulse function, change of entropy, variation of Mach number with duct length.

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

1. explain the formation of oblique shock waves (L2)
2. apply Prandtl and Rankine Hugoniot equations to solve oblique shock waves problems (L3)
3. determine variation of flow parameters due to Fanno flow (L3)

TEXT BOOKS:

1. P.Balachandran, Engineering Fluid Mechanics, 1st Edition, PHI Learning Private Limited,New Delhi.
2. S.M. Yahya, Fundamentals of Compressible Flow With Aircraft and Rocket Propulsion (SIUNITs), 5th Edition, New Age International Publishers, New Delhi.

REFERENCES:

1. Yunus A. Cengel and John M. Cimbala, Introduction to Fluid Mechanics, 2nd Edition, TataMcGraw-Hill.
2. S.W. Yuan, Foundations of Fluid Mechanics, Prentice-Hall.
3. Patrick H. Oosthuizen and William E. Carscallen, Compressible Fluid Flow, First Edition, McGraw-Hill Companies, Inc., New York.

Course Code	Course Name	L	T	P	C
R23MEC-HN3102	**Turbo Machinery (Honors Course-2)**	3	0	0	3

Course Objectives: The objectives of the course are:

- To impart knowledge of thermodynamic laws and fluid flow principles for analyzing energy transfer and performance in turbomachinery components such as nozzles, diffusers, turbines, and compressors.
- To develop an understanding of the working principles, velocity diagrams, and performance analysis of impulse and reaction turbine stages in axial flow turbines.
- To develop foundational knowledge of axial compressor stage design and performance, focusing on velocity triangles, flow through blade rows, efficiency, and associated losses.
- To introduce the principles governing centrifugal compressor operation, including stage components, flow characteristics, velocity diagrams, and performance evaluation.
- To provide an understanding of the design, classification, and performance parameters of axial and centrifugal fans used in various industrial and HVAC applications.

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

1. ***analyze*** the thermodynamic behavior and flow processes in turbomachinery components to evaluate work output and efficiency under various operating conditions. (L4)
2. ***analyze*** the performance of turbomachinery components such as turbines, compressors, nozzles, and diffusers by applying thermodynamic principles and fluid flow concepts. **(L4)**
3. ***analyze*** the performance of axial compressor stages, including velocity triangles, enthalpy-entropy diagrams, flow through blade rows, stage losses, efficiency, and stalling behavior **(L4)**
4. ***analyze*** the performance of centrifugal compressor stages, including elements of the stage, velocity triangles, enthalpy-entropy diagrams, impeller flow characteristics, slip factor, diffuser effects, and stage performance**. (L4)**
5. ***differentiate*** between axial and centrifugal fans based on stage design, operating principles, and performance characteristics, and apply design parameters to assess suitability for specific applications**. (L4)**

UNIT-I

Introduction to Turbo machinery: Definition of turbo machine, parts of turbo machines, Comparison with positive displacement machines, Classification of turbo machines, energy equation, adiabatic flow through nozzles, adiabatic flow through diffusers, work and efficiencies in turbine stages, workand efficiencies in compressor stages.

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

1. ***Apply*** basic laws of thermodynamics for a flow through nozzles, diffusers and turbomachines **(L3)**
2. ***Analyze*** various performance parameters of single and multi-stage turbo machines **(L4)**
3. ***Calculate*** the stage work, efficiency and other performance parameters of radial flowturbine. **(L3)**

Applications: Design, analysis, and performance optimization of energy conversion systems, propulsion units, power plants, and industrial fluid machinery, enabling efficient and reliable operation across aerospace, automotive, power generation, HVAC, and process industries.

UNIT-II

Impulse Turbines: Single stage impulse turbine, condition for maximum blade efficiency, stage efficiency, Need and methods of compounding, multi-stage impulse turbine, expression for maximum utilization factor

Reaction turbines: Parsons's turbine, condition for maximum utilization factor, reaction staging, enthalpy-entropy diagram, degree of reaction – zero-degree,

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

1. ***Describe*** the working of Axial turbine for an impulse and reaction stages **(L2)**
2. ***Analyze*** various performance parameters of an axial turbine stage by making use of stage velocity triangles & h-s diagram **(L4)**
3. ***Explain*** various losses and efficiencies across the axial turbine stages **(L2)**

Applications: Power generation, propulsion systems, industrial machinery, HVAC systems, and renewable energy, ensuring efficient energy conversion, flow control, and performance optimization in various practical applications.

UNIT-III

Axial flow compressor- stage velocity triangles, enthalpy-entropy diagram, flow through blade rows, Expression for pressure ratio developed in a stage – work done factor, efficiencies, and stalling.

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

1. ***Describe*** the working of axial compressor with help of velocity triangles and h-s diagram **(L2)**
2. ***Analyze*** various performance parameters of an axial compressor stage and List out various stage losses **(L3)**
3. ***Calculate*** various performance parameters of an axial compressor stage **(L3)**

Applications: Efficient fluid compression and energy conversion, including aerospace propulsion, power generation, HVAC systems, automotive turbocharging, and renewable energy systems, ensuring optimized performance, efficiency, and reliability in various industries

UNIT-IV

Centrifugal compressor - elements of centrifugal compressor stage, Stage velocity triangles, slip factor, power input factor, Stage work, Pressure developed, stage efficiency and surging

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

1. ***Explain*** the working of centrifugal compressor with help of velocity triangles and h-sdiagram **(L2)**
2. ***Analyze*** the performance of centrifugal compressors according to the nature of impellerfor different arrangements of diffuser blades. **(L4)**
3. ***Explain*** the performance characteristics of centrifugal compressor **(L2)**

Applications: Efficient fluid compression, enhancing performance in aerospace propulsion, automotive turbocharging, power generation, HVAC systems, industrial refrigeration, and chemical processing, ensuring optimized energy conversion and system efficiency in various industries.

UNIT-V

Axial flow fans- fan applications, axial fans, fan stage parameters, types of axial fan stages, types ofcentrifugal fans, centrifugal fan stage parameters, design parameters.
Centrifugal fans - fan applications, types of centrifugal fans, centrifugal fan stage parameters,design parameters.

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

1. ***Distinguish*** the working of fans, blowers and compressors **(L2)**
2. ***Analyze*** the axial and centrifugal fan stages **(L4)**
3. ***Compare*** the working principles of axial and centrifugal fans **(L2)**

Applications: Optimize airflow, ventilation, and cooling systems in applications such as HVAC, industrial ventilation, automotive cooling, power generation, aerospace systems, agriculture, and electronics, ensuring efficient operation and performance in a range of engineering processes.

Text Books:

1. S.M. Yahya, *Turbines, Compressors and fans*, Tata McGraw Hill.
2. Turbo machines M. S. Govind Gowda and A. M. Nagaraj M. M. Publications

Reference Books:

1. Maneesh Dubey, B.V.S.S.S. Prasad and Archana Nema, *Turbo Machinery*, McGraw HillEducation.
2. Charles A Parsons, *The steam turbine*, Cambridge University Press.
3. Seppo A. Korpela, *Principles of turbomachinery*, John Wiley & Sons.

Web Resources:

1. https://bbsbec.edu.in/wp-content/uploads/2020/01/Lecture-Notes-IC-engines-1-1.pdf
2. https://bmsit.ac.in/public/assets/pdf/mech/studymaterial/18ME54%20-%20Keerthi%20Kumar.pdf
3. https://gcoeara.ac.in/learning_material/mech/UNIT-III_Steam_Turbine.pdf
4. https://en.wikipedia.org/wiki/Degree_of_reaction
5. https://www.engineeringenotes.com/thermal-engineering/rotary-air-compressors/axial-flow-compressor/axial-flow-compressor-construction-operation-velocity-triangle-and-efficiency-thermodynamics/49647
6. https://courseware.cutm.ac.in/wp-content/uploads/2020/06/centrifugal-Compressor-stage-design.pdf
7. https://www.pcaeng.co.uk/knowledge_hub_files/GT2012-69151.pdf
8. https://pdhonline.com/courses/m213/m213content.pdf

CO OUTCOMES VS POs MAPPING

[1-slight (low), 2 - moderate (medium) and 3- substantial (high)]

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PS O1	PS O2
CO1	2	2	1	2	-	1	-	1	-	-	-	2	2	2
CO2	3	3	2	3	-	1	-	1	-	-	-	1	2	2
CO3	3	3	2	3	-	1	-	1	-	-	-	2	2	2
CO4	3	3	2	3	-	1	-	1	-	-	-	1	2	2
CO5	3	3	2	3	-	1	-	1	-	-	-	2	2	2
CO*	3	3	2	3	-	1	-	1	-	-	-	2	2	2

***** *For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-HN3202	**Design of thermal Systems (Honors Course-3)**	3	0	0	3

COURSE OBJECTIVES: The Objectives of the course are

- To Impart fundamental knowledge on various types of heat exchangers, their design methodology, and performance analysis.
- To Identify the factors affecting the overall effectiveness of condensers, including fouling, scaling, and other operational challenges, and propose solutions for their mitigation.
- To Explain the performance characteristics of cooling towers, including the factors affecting their efficiency and operation.
- To Evaluate the heat dissipation requirements and solutions for electronic equipment.
- To Explore advanced cooling methods, including conduction and air cooling, applicable in modern thermal management systems.

COURSE OUTCOMES: After completing the course students will be able to:

1. ***Apply*** LMTD and NTU methods in calculating the thermal performance of a different heat exchangers (L3)
2. ***Analyze*** different types of condensers considering heat transfer mechanisms, condensation types, and enhancement techniques (L4)
3. ***Select*** the appropriate techniques to augment boiling heat transfer and reduce pressure drop in evaporators (L3)
4. ***Design*** cooling towers and spray ponds by evaluating performance using thermodynamic diagrams and heat balance methods (L3)
5. ***Identify*** various cooling techniques for electronic equipment and air-cooling systems for thermal management in modern applications (L3)

UNIT – I

CLASSIFICATION OF HEAT EXCHANGERS: INTRODUCTION – Recuperation & Regeneration, Tubular heat exchangers: Double pipe, Shell and Tube heat exchangers, Plate heat exchanger Exchangers: Plate fin and Tubular fin heat exchangers
BASIC DESIGN METHODS OF HEAT EXCHANGERS: Basic equations in Design, Overall heat transfer coefficient, LMTD method for heat exchanger analysis: Parallel flow, Counter Flow, Multi Pass
CROSS FLOW HEAT EXCHANGER DESIGN CALCULATIONS – Effectiveness method (NTU), Keys and London charts, Compact Heat exchangers, Heat Transfer optimization

Applications
Power Plants, Waste heat recovery systems, HVAC systems, Power Generation

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

- **Explain** working principles and Applications of different heat exchangers such as recuperators, regenerators, shell and tube, plate and finned heat exchangers (L2)
- **Apply** the concept of LMTD and effectiveness–NTU method for analyzing the performance of heat exchangers (L3)

UNIT – II

DESIGN OF CONDENSERS: Types of Condensers, Air cooled condenser, Water cooled condensers, Evaporative condensers, Heat Transfer in condensers, Desuperheating condensers, Heat transfer coefficient, Condensation outside horizontal tubes, Condensation inside horizontal tubes, Water side coefficient, Fouling factor, Air side coefficient, Augmentation of condensing heat transfer coefficient, Influence of air inside condensers

Applications
HVAC, Power plants, Processing Industries

Learning outcomes
- **Identify** different types of condensers and their working principles (air-cooled, water-cooled and evaporative) (L2)
- **Analyze** the impact of air presence and fouling on condensation efficiency (L4)

UNIT – III

DESIGN OF EVAPORATORS: Types of Evaporators, Heat transfer in Evaporators, Pool boiling, Heat transfer coefficient for Nucleate pool boiling, Flow of refrigerant in boiling, Forced convection boiling correlations: Horizontal Vs. Vertical tube, Effect of oil in refrigerant on heat transfer, Extended surface evaporators, Cooling and dehumidifying coils, Augmentation of boiling heat transfer, Pressure drop in evaporators

Applications
Domestic Refrigerators, Thermal Desalination plants, HVAC, Electronic cooling
Learning outcomes
- **Compare** the performance of horizontal vs. vertical tube evaporators (L2)
- **Apply** boiling heat transfer correlations to determine heat transfer coefficients (L3)

UNIT – IV

DESIGN OF COOLING TOWERS AND SPRAY PONDS: Classification, performance of cooling towers, analysis of counter flow cooling towers, enthalpy, temperature diagram of air and water, cooling ponds, types of cooling ponds, cross flow cooling towers, procedure for calculation of outlet conditions.
Applications
Thermal power plants, Steel Industries, HVAC Systems

Learning outcomes
- **Classify** different types of cooling towers and spray ponds based on operation and flow arrangement (L2)
- **Apply** thermodynamic principles for the design and performance analysis of cooling towers (L3)

UNIT – V

COOLING OF ELECTRONIC EQUIPMENT:
The chip carrier, Printed circuit boards, Cooling load of Electronic equipment
CONDUCTION COOLING: Conduction in chip carriers, conduction in printed circuit boards, heat frames.
AIR COOLING: Natural convection and radiation, Forced convection, Fan selection, cooling personal computers and Heat Pipes.

Applications
Telecommunications, Mobile phones, Laptops, Satellites, Avionics

Learning outcomes
- **Explore** cooling techniques for chip carrier, printed circuit boards, personal computers and heat pipes (L3)
- **Understand** the working and applications of heat pipes in thermal management (L2)

Text books:
1. Design and Optimization of Thermal systems – Yogesh Jaluria, 2nd Edition, CRC Press
2. Design of thermal systems by W.F. Stocker, 3rd Edition, McGraw-Hill Education.

Reference books:

1. C.P. Arora, *Refrigeration & Air-Conditioning*, 3rd Edition, TMH.
2. A.P. Frass and M.N. Ozisik, *Heat Exchanger Design*, 2nd Edition, John Wiley & Sons, New York
3. Arora & Domkundwar, *Heat and Mass Transfer*, 2nd Edition, Dhanpat Rai and Company

Web Sources:

1. NPTEL-Heat Exchangers: Fundamentals and Design Analysis (IIT-Kharagpur) https://nptel.ac.in/courses/112/105/112105248

COURSE OUTCOMES VS POs MAPPING

[1-slight (low), 2 - moderate (medium) and 3- substantial (high)]

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	2	1	2	2	2	-	-	-	3	3	3
CO2	3	3	2	2	1	2	2	2	-	-	-	3	3	3
CO3	3	3	2	2	1	2	2	2	-	-	-	3	3	3
CO4	3	3	2	2	1	2	2	2	-	-	-	3	3	3
CO5	3	3	2	2	1	2	2	2	-	-	-	3	3	3

** For Entire Course, PO & PSO Mapping*

Track: Design Engineering

Course Code	Course Name	L	T	P	C
R23MEC-HN2203	**Advanced Mechanism Design (Honors Course-1)**	**3**	**0**	**0**	**3**

Course Objectives: The objectives of the course are to

- Understand the fundamentals of complex mechanisms and analyze their motion using graphical and analytical methods.
- Develop knowledge of planar mechanism synthesis through function, path, and motion generation techniques.
- Comprehend dynamic force analysis of mechanisms and apply elastic linkage modeling concepts.
- Understand spatial mechanism transformations and perform kinematic analysis using matrix and D–H parameters.
- Gain knowledge of parallel mechanisms and perform inverse kinematic analysis of planar and spatial manipulators.

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

1. Analyze planar complex mechanisms. (L4)
2. Apply method of complex numbers for synthesize of four bar and slider-crank mechanisms. (L3)
3. Analyze the forces in simple planar mechanisms. (L4)
4. Analyze simple spatial mechanisms such as RSSP etc. (L4)
5. Analyze planar 3-RRR manipulator and 6-SPS general Stewart-Gough platform. (L4)

UNIT-I

COMPLEX MECHANISMS: Types of planar, spherical and spatial mechanisms, Mobility or Degrees of freedom, Kutz-bach and Grubler's criteria, Velocity - Acceleration analysis of planar complex mechanisms by Hall & Ault's auxiliary point method and Goodman's indirect method.

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

1. identify degrees of freedoms for given mechanisms. (L1)
2. analyze complex mechanisms using Hall & Ault's method (L4)
3. apply Goodman's method for analysis of complex mechanisms (L3)

UNIT-II

SYNTHESIS OF PLANAR MECHANISMS: Type, number and dimensional synthesis. Function generation, path generation and rigid body guidance problems. Accuracy (precision) points, Chebyshev spacing, types of errors. Synthesis by method of complex numbers for motion, path, and function generation (three prescribed positions). Synthesis of four-bar and slider-crank mechanisms using Freudenstein's equation.

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

1. differentiate between type, number and dimensional synthesis. (L2)
2. apply method of complex numbers for perform synthesis of planar mechanism using motion/path/function generation (L3)
3. use Freudenstein's equation to synthesize four-bar and slider-crank mechanisms (L3)

UNIT-III

DYNAMIC FORCE ANALYSIS OF PLANAR MECHANISMS: Dynamic force analysis of

four bar and slider-crank mechanisms, Analysis of elastic mechanisms - beam element, displacement fields for beam element, element mass and stiffness matrices, system mass and stiffness matrices, Elastic linkage model. Equations of motion.

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

1. determine forces on different links of four bar mechanism (L3)
2. determine crank effort and force in connecting rod for slider-crank mechanism (L3)
3. analyze elastic members using beam element (L4)

UNIT-IV

SPATIAL MECHANISMS: Transformations describing planar finite displacements, planar finite transformations, identity transformation, rigid-body transformations, spatial transformations Denavit-Hartenberg parameters, Kinematic analysis by matrix method, Kinematic analysis of spatial Revolute-Spherical-Spherical-Revolute (RSSR) mechanism.

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

1. determine the transformation matrix for the given spatial mechanism (L3)
2. determine the rotation matrix for a link in space (L3)
3. analyze RSSR mechanism using D–H notation (L4)

UNIT-V

PARALLEL MECHANISMS: Types of Parallel mechanisms, Degree of freedom, Position and Velocity analyses (inverse kinematics only) of planar 3-RRR manipulator and 6-SPS general Stewart-Gough platform.

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

1. identify parallel mechanisms (L1)
2. analyze planar 3-RRR manipulator using inverse kinematics (L4)
3. analyze 6-SPS general Stewart-Gough platform using inverse kinematics (L4)

Text Books:

1. A. G. Erdman and G. N. Sandor, " *Mechanism Design - Analysis and Synthesis (Vol. 1 and 2)*", Prentice Hall, 1994 (for Unit I to IV).
2. Lung-Wen Tsai, "*Robot Analysis: The Mechanics of Serial and Parallel Manipulators*", John Wiley & Sons, Inc., 1999 (Unit V).

References:

1. Asok Kumar Mallik, Amitabha Ghosh, "*Kinematic Analysis and Synthesis of Mechanisms*", Gunter Dittrich, 1st Edn., CRC-Press, USA, 1994.
2. Robert L. Norton , "*Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines*", Tata McGraw-Hill, 4th Edn., 2008.

Course Code	Course Name	L	T	P	C
R23MEC-HN3103	**Engineering Tribology (Honors Course-2)**	**3**	**0**	**0**	**3**

Course Objectives: The objectives of the course are to

- Provide a comprehensive understanding of tribology, including friction, wear, and lubrication principles in engineering systems.
- Apply Theories Of Friction To Evaluate The Friction Behavior Of Engineering Materials For Applications In Modern Engineering Systems
- Solve Wear-Related Challenges By Evaluating Wear Characteristics Of Different Materials
- Impart Knowledge Of Different Types Of Lubricants And The Criteria For Their Selection In Engineering Applications
- Explore The Recent Advances In Tribology, And Emerging Technologies For Sustainable Lubrication Practices

Course Outcomes (COs): At the end of the course, the student will be able to

1. ***explain*** the fundamental concepts of tribology, engineering surface characteristics, and surface measurement methods. (L2)
2. ***apply*** friction theories and mechanisms to analyze frictional behavior in metallic and non-metallic materials using appropriate measurement techniques. (L3)
3. ***analyze*** the mechanisms and types of friction and wear in metallic and non-metallic materials under different operating conditions (L4)
4. ***select*** appropriate lubricants in engineering applications. (L3)
5. ***solve*** lubrication and tribology related issues in industrial systems through lubricant testing methods, sustainable practices(L3)

UNIT I – Introduction to Tribology

Definition and scope of tribology, importance in mechanical systems. Basic concepts of friction, wear, and lubrication. Engineering surfaces: surface topography and surface roughness, typical surface layers and their properties. Surface measurement methods include surface profilometry, optical microscopy, and scanning electron microscopy. Surface contact behavior: real versus apparent contact area.

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

1. ***understand*** scope of tribology, importance, and applications in engineering systems. (L2)
2. ***describe*** the basic concepts of friction, wear, and lubrication. (L2)

Applications:

1. Automotive: Surface roughness control in components like cylinder liners and piston rings.
2. Aerospace: Precision surface characterization of turbine blades and structural joints.

UNIT II –Theories of Friction

Mechanisms of friction: adhesion and deformation, stick-slip motion, and rolling friction. Friction behavior of engineering materials, including metals and non-metallic materials such as polymers and ceramics. Friction measurement techniques using various tribometers. Theoretical models and modern theories of friction.

Learning Outcomes: After completion of this unit, the student will able to

1. ***understand*** the basic mechanisms of friction, including adhesion, deformation, stick-slip motion, and rolling friction **(L2)**
2. ***explain*** the friction behavior of different engineering materials, such as metals, polymers, and ceramics. **(L2)**

Applications:

1. Brake systems: Friction modeling for disc and drum brakes in vehicles and trains.
2. Clutch and transmission: Friction control for effective power transfer.

UNIT III – Wear Mechanisms

Types of wear and their mechanisms: adhesive wear, abrasive wear, erosive wear, corrosive/oxidative wear, and fatigue wear. Wear characteristics of different materials, such as metals, ceramics, and polymers. Wear testing methods including pin-on-disc tribometer and reciprocating tribometer. Wear reduction techniques and the role of surface engineering.

Learning Outcomes: After completion of this unit, the student will able to

1. ***comprehend*** the wear characteristics of various materials, such as metals, ceramics, and polymers. **(L2)**
2. ***understand*** the different types of wear mechanisms, including adhesive, abrasive, erosive, corrosive/oxidative, and fatigue wear. **(L2)**

Applications:

1. Mining and construction: Wear-resistant coatings for tools like excavators and crushers.
2. Tool manufacturing: Abrasive and adhesive wear considerations in CNC tools and dies.
3. Biomedical: Wear prediction in hip and knee joint implants.

UNIT IV – Lubricants and Lubrication

Lubricants and the purpose of lubrication in mechanical systems. Types of lubricants: liquid, semi-solid, and solid lubricants. General properties of liquid lubricants. Detailed study of mineral oils, synthetic oils, animal and vegetable oils, blended oils, and their characteristics. Lubricant additives and their effects. Semi-solid lubricants or greases and solid lubricants. Criteria for selection of lubricants in engineering applications.

Learning Outcomes: After completion of this unit, the student will able to

1. ***describe*** the characteristics of different lubricants, including mineral oils, synthetic oils, animal and vegetable oils, and blended oils **(L2)**
2. ***apply*** the criteria for selecting appropriate lubricants in engineering applications based on system requirements. **(L3)**

Applications:

1. Automotive engines: Use of synthetic and blended oils to improve efficiency.
2. Gearboxes: EP lubricants for load-bearing gear mechanisms.

UNIT V – Lubricant Testing and Industrial Applications

Testing of lubricants using viscometer and four ball tester. Application of lubricants and tribology in industrial systems such as bearings, gears, cutting tools, and engines. Sustainable lubrication practices and introduction to green lubricants. Recent advances in tribology, including nanotribology, bio-lubricants, and smart lubrication systems.

Learning Outcomes: After completion of this unit, the student will able to

1. ***understand*** the working principles of lubricant testing instruments such as viscometers and four-ball testers. **(L2)**
2. ***explain*** the application of lubricants and tribology in industrial systems **(L2)**

Applications:

1. Lubricant manufacturers: Quality testing using viscometers and four-ball testers.
2. Hydraulic systems: Lubrication in presses, elevators, and construction equipment.

COURSE OUTCOMES VS POs MAPPING

[1-slight (low), 2 - moderate (medium) and 3- substantial (high)]

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1	-	2	1	2	-	-	-	-	3	3
CO2	3	2	3	1	-	2	1	2	-	-	-	-	3	3
CO3	3	2	3	2	-	2	1	2	-	-	-	-	3	3
CO4	3	2	3	2	-	2	1	2	-	-	-	-	3	3
CO5	3	3	3	2	-	3	2	2	-	-	-	-	3	3
CO*	3	3	3	2	-	2	1	2	-	-	-	-	3	3

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-HN3203	**Design for Fatigue and Facture (Honors Course-3)**	**3**	**0**	**0**	**3**

Course Objectives: The objectives of the course are to

- Understand the tools and techniques of failure analysis and sample preparation using various microscopy methods.
- Comprehend the mechanical aspects influencing fracture behavior, including ductile, brittle, fatigue, and creep failures.
- Gain knowledge of fatigue and environment-assisted fracture mechanisms and their effects on material performance.
- Understand the failure mechanisms in composite materials considering fiber–matrix interactions and strength characteristics.
- Apply finite element methods to analyze cracks and determine fracture parameters using direct and indirect approaches.

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

1. Apply the different tools for failure analysis. (L3)
2. Analyze the effect of strain rate and temperature. (L4)
3. Illustrate crack initiation, crack propagation. (L4)
4. Analyze the failure analysis of composites. (L4)
5. Apply the finite element method for finding cracks in solids. (L3)

UNIT-I

Tools of failure analysis: Introduction, Optical microscopy, transmission electron microscopy, scanning electron microscopy, comparison of Optical microscopy, transmission electron microscopy and scanning electron microscopy, related tools and techniques. Sample preparation: cleaning of surfaces, preparation of replicas for the TEM, preparation of samples for the SEM.

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

1. Examine failure analysis using SEM and TEM (L3)
2. Describe the working principle of Optical Microscopy(L2)
3. Explain the procedure for preparation of samples (L2)

UNIT-II

Mechanical aspects and macroscopic fracture surface orientation: Introduction, tensile test, principle stresses, stress concentration, tri-axial stress and constraint, effect of strain rate and temperature, meaning of ductile and brittle fracture, fatigue loading, creep deformation**.**

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

1. Analyze the macroscopic fracture in engineering materials (L4)
2. Explain the meaning of ductile and brittle fracture (L3)
3. Describe the concept of Creep deformation (L2)

UNIT-III

Fatigue failure: Introduction, fatigue failure, terminology, S-N curve, crack initiation, crack propagation, effectof an overload, crack closure, variable amplitude fatigue load.

Environment – assisted fracture: Introduction, micro mechanisms, test methods, major factors influencingenvironment assisted fracture, liquid metal embrittlement, design considerations.

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

1. Analyze the crack initiation and crack propagation in engineering materials (L4)
2. Explain the concept of micro mechanisms related to fatigue (L2)
3. Apply the design considerations for estimation of fatigue life (L3)

UNIT-IV

Failure analysis of composites: Polymer matrix composites: continuous versus discontinuous fibers, influence of fiber brittleness and compressive strength, longitudinal strength of uni-directional lamina, transverse tensile strength of uni-directional lamina, transverse compressive strength of uni-directional lamina, effect of fiber matrix interface on strength of fracture mechanism.

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

1. Analyze the influence of fiber brittleness in the failure analysis of composites (L4)
2. Determine the longitudinal and transverse strength of the composites (L3)
3. Describe the strength of fracture mechanism(L2)

UNIT-V

Finite element analysis of cracks in solids: Introduction, Finite element method, direct methods to determine fracture parameters, indirect methods to determine fracture parameters: J-integral method, energy release rate method, stiffness derivative method, singular element method.

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

1. Explain the direct methods to determine fracture parameters (L2)
2. Determine the fracture parameters by using J-integral method (L3)
3. Describe the energy release rate method(L2)

TEXT BOOKS:

1. Charles R.Brooks and Asok Choudhary, “Failure Analysis of Engineering Materials”, 2nd edition, TataMc Graw Hill publishers, 2002 (Unit I, II and V)
2. Prashant Kumar, “Elements of Fracture Mechanics”,Seventh Reprint, Tata Mc Graw Hill publishers,2014 (Unit – III and IV)

REFERENCE BOOKS:

1. David Broek, Fifthoff and Noerdhoff, “Elementary Engineering Fracture Mechanics”, 4th edition,Springer Publishers, 2013
2. Ewalds, H.L. and Wanhill, R.J.H., Fracture Mechanics, Edward Arnold Edition, 1999
3. Surjya Kumar Maiti, Fracture Mechanics - Fundamental and Applications, Cambridge University Press,Delhi 2015
4. Gope, P.C., Machine Design – Fundamentals and Applications –PHI Learning Private Limited, NewDelhi, 2012

Track: Robotic Engineering

Course Code	Course Name	L	T	P	C
R23MEC-HN2204	**Mechanism and Robot Kinematics (Honors Course-1)**	**3**	**0**	**0**	**3**

Course Objectives:

- Understand the fundamental concepts and components of robotics, including robot anatomy and configurations.
- Solve forward and inverse kinematics problems using matrix representations and the Denavit-Hartenberg method.
- Develop algorithms for generating joint trajectories and Cartesian path trajectories considering constraints and path specifications.
- Apply control system theories and techniques to manage and optimize robot arm movements using various control methods.
- Develop and debug robotic programs using various programming languages and tools, and implement task-level programming and planning.

Course Outcomes:

1. ***Understand*** the basic anatomy and configuration of robots, including the roles of links, joints, end effectors, and work volume. (Level 2)
2. ***Apply*** the Denavit-Hartenberg representation to solve the forward and inverse kinematics problems and determine the location of the end effector. (Level 3)
3. ***Design*** joint interpolated trajectories and Cartesian path trajectory plans using appropriate algorithms. (Level 4)
4. ***Utilize*** control system techniques such as servo mechanisms and computed torque to manage and optimize robot arm movements. (Level 3)
5. ***Develop*** robot programs using programming languages, and perform task-level programming and synthesis for effective robot task execution. (Level 3)

UNIT-1
Introduction to Robotics & Mechanisms
Introduction, Automation and Robotics, Robot anatomy and Robot configurations, Links and joints notations, Work volume and Obstacles, Overview of Robot drive systems and Control systems, Dynamic performance and Precision of movement, Applications in Robotics.

UNIT-2
Robot Arm Kinematics
Introduction, Forward or direct Kinematics Problem, Matrix Representations, Robot arm coordinates and Transformation matrix, Composite homogeneous transformation matrix, Denavit-Hartenberg representation, Kinematic equations, Location of end effector, Inverse kinematic problem, Geometric approach for solution of inverse kinematic problem.

UNIT-3
Trajectory Planning
Introduction, Constraints and Path specifications, Basic algorithm for generation of joint trajectory, joint interpolated trajectories, Cartesian path trajectory planning.

UNIT-4

Robot Arm Control.

Fundamentals of control system theory, Joint motion controls: Servo mechanism, Computed torque technique, Minimum time control, Variable structure control. Adaptive control modes.

UNIT-5

Robot Programming and Task Planning

Introduction, Characteristics of robotic programming languages, position and motion specification, development and debugging facilities, task-level programming and robot program synthesis, Robot intelligence and task planning.

TEXT BOOK(S):

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

REFERENCES:

1. Mikell P.Groover, *Industrial Robotics,* McGraw Hill Pvt. Ltd., New Delhi.
2. K. S. Fu, R. C. Gonzalez, C. S.G. Lee, *Robotics: Control, Sensing, Vision and Intelligence,* McGrawHill Book Company, Singapore, International Edition 1987.
3. Robert J. Schilling, *Fundamentals of Robotics: Analysis & Control*, Prentice-Hall of India Private Limited, New Delhi, 5th Reprint, 2003

Course Code	Course Name	L	T	P	C
R23MEC-HN3104	**Flexible Manufacturing Systems (Honors Course-2)**	**3**	**0**	**0**	**3**

Course Objectives: The objectives of the course are to

- Provide an understanding of the components, characteristics, and applications of Flexible Manufacturing Systems (FMS).
- Explore FMS's design, layout, and optimization, considering factors such as scalability, modularity, and system integration.
- Examine quality control methods, including Statistical Process Control (SPC) and Taguchi methods, and their role in FMS.
- Study maintenance strategies for FMS and their impact on performance, efficiency, and system reliability.
- Explore advanced topics in FMS, including JIT, Lean Manufacturing, automation, robotics, and the role of AI and machine learning in future trends.

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

1. ***Define*** Flexible Manufacturing Systems (FMS) and its key characteristics**[L1]**
2. ***Identify*** the basic principles involved in FMS design and integration**[L1]**
3. ***Explain*** the concept of quality and its various characteristics in manufacturing**[L2]**
4. ***Describe*** the application of Statistical Process Control (SPC) and Taguchi methods in Flexible Manufacturing Systems (FMS)**[L2]**
5. ***Apply*** Just-In-Time (JIT) principles within FMS to minimize waste and streamline production flow**[L3]**

Unit-I

Introduction to Flexible Manufacturing Systems (FMS)

Overview of Manufacturing Systems, Traditional vs. Modern manufacturing systems, Definition and characteristics of Flexible Manufacturing Systems (FMS), Components of an FMS: Workstations, Robots, Conveyors, Control Systems, and Computers, Benefits and limitations of FMS, Types of FMS: Dedicated, Random, and Mixed-model, **FMS Classification and Applications,** Different types of FMS based on flexibility, Role of FMS in various industries.

Applications:

- **Aerospace Industry**: Utilises FMS for the high-precision machining of complex aluminium and titanium components used in aircraft and spacecraft.
- **Medical Devices**: Employs flexible manufacturing systems to produce customised implants and high-quality surgical instruments with consistent precision.
- **Defence**: Adopts FMS with flexible routing capabilities to manufacture precision-engineered components for advanced weaponry and military equipment.

Learning outcomes:

1. ***Define*** manufacturing systems and distinguish between traditional and modern manufacturing approaches **[L1]**
2. ***List*** the primary components of an FMS such as workstations, robots, conveyors, control systems, and computers **[L1]**

Unit -II

FMS Layout, Design, and Optimisation

FMS Layout-Types of FMS layouts: Linear, Circular, and U-shaped layouts, Factors influencing layout design: Floor space, material handling, workstations, and control systems, **FMS Design and Integration,** Design principles: Standardization of equipment, scalability, and modularity, Integration of robots, automated guided vehicles (AGVs), conveyors, and storage systems into FMS

Applications:

- **Medical Device Manufacturing**: The use of cleanroom-compatible AGVs and modular workstations facilitates the contamination-free production of medical implants and instruments.
- **Aerospace Industry**: Circular layouts enable the precise machining of components such as turbine blades, supported by centralized control systems and automated storage/retrieval systems (AS/RS)

Learning outcomes:

1. **List** the different types of FMS layouts, such as Linear, Circular, and U-shaped**[L1]**
2. **Identify** the key factors that influence the design of an FMS layout, including floor space, material handling, workstations, and control systems**[L1**

Unit-III
MANUFACTURERS' DRIVING FORCE

QUALITY: Definition, quality characteristics, Quality improvements, Importance of Quality to cells and systems, Quality of teamwork, Methods for getting and keeping quality under control, statistical process control and Taguchi methods. Just In-Time (JIT) Manufacturing, Benefits of JIT

Applications:

- **Automotive Industry**: JIT is commonly used in the automotive industry, where parts are delivered directly to the assembly line at the time of need, reducing the need for warehouse storage.
- **Electronics**: Companies like **Apple** utilize JIT to ensure components are available just in time for assembly, reducing inventory costs.

Learning outcomes:

1. ***Understand*** the definition of quality in a manufacturing context and its importance in meeting customer expectation**s[L2]**
2. ***Explain*** **the concept of quality and its various characteristics in the manufacturing context[L2]**

Unit-IV
Quality Control, Maintenance, and Performance Evaluation in FMS

Quality Control in FMS - Statistical Process Control (SPC) and Taguchi methods in FMS Application of Six Sigma and Total Quality Management (TQM) in FMS environments **Maintenance of FMS-** Types of maintenance strategies: Preventive, predictive, and reactive maintenance, Importance of maintenance in FMS to avoid downtime and improve efficiency.

Applications:

- Used to monitor machine performance and ensure that the process stays within set control limits.
- Focus on reducing variation, optimising machine performance, and improving product quality.

Learning outcomes:

1. **Explain** the application of Statistical Process Control (SPC) and Taguchi methods in quality control within FMS**[L2]**
2. **Describe** the roles of Six Sigma and Total Quality Management (TQM) in improving quality in FMS environments**[L2]**

Unit-V **Just-In-Time (JIT) and Lean Manufacturing in FMS-** Integration of JIT principles in FMS to reduce waste and optimize flow, Role of Lean Manufacturing in FMS efficiency, Case studies of JIT implementation in FMS, **Automation and Robotics in FMS-**Advanced automation techniques: Autonomous robots, collaborative robots (cobots)

Applications:

- Autonomous robots in FMS can adjust their routes in real time based on the availability of machines or workstations, ensuring optimal utilization of resources.
- Lean principles applied to FMS reduce waste in areas such as overproduction, waiting times, unnecessary transportation, excess inventory, defects, and non-value-added motion.

Learning outcomes:

1. ***Apply*** JIT principles in an FMS setup to reduce waste and improve production flow **[L3]**
2. ***Demonstrate*** the use of Lean Manufacturing techniques to enhance the efficiency of FMS operations **[L3]**

Text books:

1. H.K. Shivanand, M.M. Benal, V. Koti, *Flexible Manufacturing Systems,* New Age International Pvt. Ltd. Publishers.
2. Joseph Talavage, *Flexible Manufacturing Systems in Practice: Design, Analysis, and Simulation,* CRC Press.

References:

1. Zubair M. Mohamed, *Flexible Manufacturing Systems: Planning Issues and Solutions,* Routledge.
2. MengChu Zhou, *Modelling, Simulation, and Control of Flexible Manufacturing Systems,* World Scientific Publishing.

Web sources:

1. https://www.slideshare.net/slideshow/flexible-manufacturing-systemfms/39704164
2. https://www.slideshare.net/slideshow/flexible-manufacturing-systems-fms-121512178/121512178
3. https://calemhrdc.amu.ac.in/leap_round_2/prof_n_selvaraj.pdf
4. http://ndl.ethernet.edu.et/bitstream/123456789/87808/6/Flexible%20Mnfg%20System- HK%20Shivanand.pdf

COURSE OUTCOMES VS POs MAPPING
[1-slight (low), 2 - moderate (medium) and 3- substantial (high)]

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	1	-	1	-	1	-	1	1	-	2	2	2
CO2	3	2	2	-	2	-	2	-	1	1	1	2	3	2
CO3	3	2	2	1	2	1	2	1	2	2	1	2	2	3
CO4	3	2	2	2	3	1	1	1	1	1	1-	2	3	3
CO5	3	3	3	2	3	1	3	1	2	2	2	3	3	3
CO*	3	2	2	1	2	1	2	1	2	2	1	2	3	3

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-HN3204	**AI and ML for Robotics (Honors Course-3)**	**3**	**0**	**0**	**3**

Course Objectives: The objectives of the course are to

- Introduce foundational concepts of Artificial Intelligence and its relevance in Robotics.
- Explore both uninformed and informed search strategies for problem-solving in robotics.
- Impart knowledge of Machine Learning and Deep Learning techniques applicable to robotic systems.
- Equip with practical skills in applying AI/ML methods to real-world robotic tasks.
- Develop the ability to integrate AI and ML techniques with robotic hardware systems for autonomous decision-making and adaptive control

Course Outcomes (COs): At the end of this course, students will be able to:

1. *explain* the fundamental principles of AI and its applications in robotics **(L2)**
2. *apply* uninformed and informed search algorithms for robotic problem-solving **(L3)**
3. *analyze* the machine learning techniques for robotic control and decision-making **(L4)**
4. *apply* deep learning methods for vision and sensor-based robotics applications **(L3)**
5. *develop* and simulate intelligent robotic systems using AI tools and frameworks **(L4)**

UNIT - I

Introduction to AI in Robotics: Overview of Artificial Intelligence and Robotics, Intelligent agents and environments, Robotic perception and reasoning, Rule-based systems, expert systems in robotics.

Case studies:

1. Simulate 3-line sensors and rule-based movement logic by using python programming.
2. Simulate a robot reacting to obstacle information by python programming.

Learning Outcomes:

- Explain the basic concepts of AI and how it integrates with robotic systems **(L2)**
- Describe the working of intelligent agents and rule-based systems **(L2)**

Applications:

1. Intelligent warehouse robots
2. Amazon Kiva robots

UNIT – II

Uninformed Search Strategies: Breadth-First Search, Uniform Cost Search, Depth-First Search, Analysis of Search Methods.

Case studies:

1. A robot finds the path from a start point to goal in a maze using BFS by using python programming.
2. Task allocation by using multi-criteria optimization for human-robot collaboration by using python programming.

Learning Outcomes:

- Apply uninformed search strategies such as BFS, DFS, and Uniform Cost Search to robotic path finding problems**(L3)**

- Apply different search methods and demonstrate their use in solving robotic problems. **(L3)**

Applications:
1. Maze-solving robots
2. Cost-efficient paths in large warehouses.

UNIT-III
Informed Search Strategies: Heuristic Functions, Best-First Search, Greedy Search, A* Algorithm, Optimal Solution by A* Algorithm.
Case studies:
1. Facility layout design for an assembly task using advanced AI algorithms (Greedy algorithm).
2. Designing a facility layout for an assembly task by determining the distances between facilities using the A* algorithm

Learning Outcomes:
- Implement informed search strategies including A* and Greedy search in robotics scenarios**(L3)**
- Analyze heuristic functions and determine optimal solutions using the A* algorithm. **(L4)**

Applications:
1. Autonomous vehicle route planning
2. Drone delivery optimization

UNIT-IV
Machine Learning for Robotics: Introduction to supervised and unsupervised learning**,** Classification and regression techniques**,** Reinforcement Learning basics**,** Applications in sensor data processing and control.
Case studies:
1. Assignment of certain portions of tasks to robots to leverage human intelligence and robotic capabilities by machine learning algorithms.
2. Human-robot task allocation by Nelder mead simplex optimization algorithm for any assembly case study.

Learning Outcomes:
- Explain supervised and unsupervised learning techniques and their application in robotics. **(L2)**
- Implement ML algorithms for classification and regression using sensor data. **(L3)**

Applications:
1. Object classification from sensor data
2. Robot navigation in unknown environments

UNIT-V
Deep Learning in Robotics: Neural Networks fundamentals**,** Convolutional Neural Networks (CNNs) for vision**,** Recurrent Neural Networks (RNNs) for temporal tasks**,** Object detection, tracking, and image segmentation for robots.
Case studies:
1. Simulate a visual input as a 2D grid where different pixel patterns represent different object types by python programming lab.
2. Simulate a 2D grid where some cells are obstacles, and a robot must plan a safe path from a start to a goal using simple logic inspired by the A* pathfinding algorithm. With help of python programming.

Learning Outcomes:

- Describe the architecture and functioning of CNNs and RNNs. **(L2)**
- Apply CNNs for image-based tasks such as object detection and tracking in robotics. **(L3)**

Applications:

1. Vision-based robotic grasping
2. Robot surveillance systems

Text Books:

1. Russell Stuart, Norvig Peter, "Artificial Intelligence Modern Approach", Pearson Education series in AI, 3rd Edition, 2010.
2. Machine Learning, Tom Mitchell, McGraw Hill, 1997
3. Artificial Intelligence – Structures and Strategies for Complex Problem Solving, George F Luger, Addison Wesley, Fifth Edition

Reference Books:

1. Francis X. Govers, Artificial Intelligence for Robotics, Packt Publishing.
2. Dan.W.Patterson, "Introduction to Artificial Intelligence and Expert Systems", PHI Learning,2009.
3. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press.
4. Practical Machine Learning with Python, Dipanjan Sarkar, Raghav Bali, Tushar Sharma, A Press, 2018.

Web Source References:

1. https://nptel.ac.in/courses/106105079
2. https://nptel.ac.in/courses/112101098
3. https://nptel.ac.in/courses/106105079
4. https://nptel.ac.in/courses/106106139
5. https://nptel.ac.in/courses/106106202
6. https://nptel.ac.in/courses/106106213

Course Articulation Matrix:

[1-slight (low), 2 - moderate (medium) and 3- substantial (high)]

CO / PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO 1	3	2	-	-	-	-	-	-	-	-	-	2	3	1
CO 2	3	3	2	2	2	-	-	-	-	2	-	2	3	1
CO 3	3	3	3	3	3	-	-	-	2	2	-	3	3	2
CO 4	3	3	3	3	3	-	-	-	2	2	-	3	3	2
CO 5	3	3	3	3	3	-	-	-	3	3	2	3	3	2
CO	3	3	3	3	3	-	-	-	2	2	2	3	3	2

** For Entire Course, PO & PSO Mapping*

DEPARTMENT OF MECHANICAL ENGINEERING

MINOR DEGREE TRACKS OFFERED BY MECHANICAL DEPARTMENT TO OTHER DEPARTMENTS

S.No.	Course Code	Year & Semester	Course Title	L	T	P	Credits
1	R23MEC-MN2201	II-II	Computer Aided Design	3	0	0	3
2	R23MEC-MN2202	II-II	Computer Aided Design Laboratory	0	0	3	1.5
3	R23MEC-MN3101	III-I	Additive Manufacturing	3	0	0	3
4	R23MEC-MN3102	III-I	3D Printing Technology Laboratory	0	0	3	1.5
5	R23MEC-MN3201	III-II	Industrial Engineering	3	0	0	3
6	R23MEC-MN4101	IV-I	Thermal Comfort Systems	3	0	0	3

NOTE: In addition to the Six Courses mentioned in the table above, students are required to complete **One MOOC programme** (each with a duration of 12 weeks), as approved by the BOS Chairman.

Course Code	Course Name	L	T	P	C
R23MEC-MN2201	**Computer Aided Design**	**3**	**0**	**0**	**3**

Course objectives

The objectives of the course are to

- Understanding the computers improves efficiency and precision throughout the manufacturing and product development process.
- Implement various 2D transformations to manipulate objects in computer graphics.
- Utilize shading and coloring methods to achieve realistic visual effects in computer graphics.
- Identify the curves that are represented and classified in computer graphics for various applications.
- Explain the concept of half-spaces and the role of Boolean operations in geometric modeling.

Course outcomes

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

1. ***explain*** the role of computers in manufacturing, CAD/CAM hardware, display devices, coordinate systems, and data standards. *(L2)*
2. ***develop*** 2D geometric transformations and projections using homogeneous representation in CAD systems. *(L3)*
3. ***apply*** techniques for visual realism including hidden element removal, shading, coloring, and animation in CAD models. *(L3)*
4. ***apply*** curve and surface modelling techniques, including algorithms and spline representations, in CAD applications. *(L3)*
5. ***apply*** B-rep, CSG, and Sweep representation schemes in the drafting and manipulation of 3D models. (L3*)*

UNIT–I

Introduction: A typical product cycle, CAD tools for the design process of product cycle, CAD / CAM system evaluation criteria, Input / Output devices; Graphics Displays: Refresh display, DVST, Raster display, pixel value and lookup table, estimation of graphical memory, LCD, LED fundamentals. Concept of Coordinate Systems: Working Coordinate System, Model Coordinate System, Screen Coordinate System. Graphics exchange standards

Learning Outcomes:

1. ***Explain*** the role of computers in industrial manufacturing and the product cycle. *(L2)*
2. ***Describe*** various CAD/CAM hardware components and their functions. *(L2)*
3. ***Explain*** different computer graphics display devices and their working principles. *(L2)*

Applications:

1.CAD tools design parts in automobiles.
2. Gaming and animation for realistic visuals.

UNIT–II

Geometric Transformations: Homogeneous representation; Translation, Scaling, Reflection, Rotation, Shearing in 2D and 3D; Orthographic and perspective projections. Window to View-port transformation.

Learning Outcomes:

1. ***Explain*** the concept of homogeneous coordinates in geometric transformations. *(L2)*
2. ***Understand*** homogeneous representation and its role in 2D and 3D transformations. (L2)
3. ***Apply*** translation, scaling, reflection, rotation, and shearing transformations in both 2D and 3D spaces. *(L3)*

Applications:

1.Animate and render 3D objects in video games.
2. Realistic 3D architectural visualizations.

UNIT-III

Visual Realism: Hidden – Line-Surface-Solid removal algorithms – shading – colouring – computer animation.

Learning Outcomes:

1. ***Explain*** the concept of visual realism in computer graphics. *(L2)*
2. ***Describe*** algorithms for hidden line, surface, and solid removal. *(L2)*
3. ***Apply*** shading and coloring techniques for realistic rendering. *(L3)*

Applications:

1. 3D animation and CGI for movies
2. Realistic 3D walkthroughs of buildings and spaces.

UNIT–IV

Curves and Surfaces: Parametric representation of circle, Ellipse, parabola and hyperbola. Synthetic Curves: Concept of continuity, Cubic Spline: equation, properties and blending. Bezier Curve: equations, properties; Properties and advantages of B-Splines and NURBS. Various types of surfaces along with their typical applications

Learning Outcomes:

1. ***Explain*** the classification of curves in computer graphics. *(L2)*
2. ***Apply*** DDA and Bresenham's algorithms for line and curve generation. *(L3)*
3. ***Describe*** the concept of continuity in synthetic curves. *(L2)*

Applications:

1.Design smooth, Aerodynamic car body shapes.
2. Cubic splines and NURBS create smoothness.

UNIT–V

Mathematical representation of solids: Geometry and Topology, Comparison of wireframe, surface and solid models, Concept of Half-spaces, Boolean operations. Schemes: B-rep, CSG, Sweep representation.

Learning Outcomes:

1. ***Explain*** the mathematical representation of solids including geometry and topology. *(L2)*
2. ***Compare*** wireframe, surface, and solid modeling techniques. *(L2)*
3. ***Apply*** Boolean operations (union, intersection, difference) on solid models to create complex geometries. *(L3)*

Applications:

1.Designing precise product models in CAD software.
2. 3D printing for creating solid models.

Text Books

1. Ibrahim Zied, CAD / CAM: Theory and Practice, McGraw-Hill

2. Hearn E J and Baker M P, Computer Graphics, Pearson.

3. Chandrupatla T A and Belegundu A D, Introduction to Finite Elements in Engineering, PHI.

Reference Books

1. CAD / CAM / CIM / Radhakrishnan and Subramanian / New Age Publishers

2. Principles of Computer Aided Design and Manufacturing / Farid Amirouche/ Pearson Edu
3. CAD/CAM: Concepts and Applications/Alavala/ PHI Publishers Computer Numerical Control Concepts and programming / Warren S Seames / Thomson Publishers

4. CAD / CAM – P N RAO McGraw Hill Publications

WEB SOURCE REFERENCES:

1.https://archive.nptel.ac.in/courses/112/102/112102101/
2.https://archive.nptel.ac.in/courses/112/102/112102101/
3.https://archive.nptel.ac.in/courses/112/102/112102101/
4.https://archive.nptel.ac.in/courses/112/102/112102101/
5.https://archive.nptel.ac.in/courses/112/102/112102101/

COURSE OUTCOMES VS POs MAPPING

[1-slight (low), 2 - moderate (medium) and 3- substantial (high)]

COs \ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO10**	**PO11**	**PO12**	**PSO 1**	**PSO 2**
CO1	2	1	1	1	2	-	-	-	-	1	1	2	2	2
CO2	2	2	3	2	3	-	-	-	-	1	2	2	2	2
CO3	3	3	3	2	2	-	-	-	-	1	1	2	2	3
CO4	2	2	3	2	3	-	-	1	-	1	1	2	2	2
CO5	2	1	3	1	3	-	-	1	-	1	2	2	2	2

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-MN2202	**Computer Aided Design Laboratory**	**3**	**0**	**0**	**3**

Course Objectives:

The objectives of the lab are

- To familiarize students with advanced CAD software tools like CATIA and Pro-E for 3D part and assembly modeling.
- To enable students to apply surface and Boolean-based modeling techniques in product design.
- To train students in modeling and analysis of consumer products and industrial robots using CAD tools.
- To develop proficiency in applying Geometric Dimensioning and Tolerancing (GD&T) for design accuracy and functional fit.
- To introduce students to the fundamentals of simulating mechanical systems using software such as MS Adams.

Course Outcomes:

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

1. ***Design*** 3D Models of parts with CATIA Software. *(L6)*
2. ***Develop*** consumer products and Industrial robots. *(L6)*
3. ***Apply*** Boolean based Modelling features for Surface Modelling. *(L3)*
4. ***Make use*** **of** Computer Aided Modelling software for Modelling, Tolerance and GD&T Analysis of a product. *(L3)*
5. ***Model*** Assembly Modelling of the required products using any CAD Software. *(L3)*

DRAFTING:

1. Development of part drawings for various components in the form of orthographic and isometric.

PART MODELING:

1. Generation of various 3D Models through pad, shaft, shell sweep.
2. Feature based and Boolean based modeling surface and Assembly Modeling. Design simple components.
3. Setting up of drawing environment by setting drawing limits, drawing units, naming the drawing, naming layers, setting line types for different layers using various types of lines in engineering drawing, saving the file with .dwg extension.
4. To make an isometric dimensional drawing of a connecting rod.
5. Draw different types of bolts and nuts with internal and external threading in Acme and Square threading standards. Save the bolts and nuts as blocks suitable for insertion.
6. To model and assemble the flange coupling as per the dimensions given and also convert the 3D model into different views.
7. To model and assemble the Screw jack as per the dimensions given and also convert the 3D model into different views.
8. To model and assemble the strap joint of Gib & cotter as per the dimensions given and also convert the 3D model into different views.

9. Various Dimensioning and tolerancing techniques on typical products using CAD software.
10. Simulation of Kinematic Mechanism using MS Adams Package.

COURSE OUTCOMES VS POs MAPPING

[1-slight (low), 2 - moderate (medium) and 3- substantial (high)]

COs \ POs	**PO 1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	3	3	1	-	3	-	-	1	2	1	-	3	3	2
CO2	3	3	2	-	3	-	-	2	2	2	-	3	3	2
CO3	3	3	3	-	3	-	-	2	2	2	-	3	3	2
CO4	3	3	3	-	3	-	-	2	2	2	-	3	3	2
CO5	3	3	3	-	3	-	-	2	2	2	-	3	3	2
CO*	3	3	3	-	3	-	-	2	2	2	-	3	3	2

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-MN3101	**Additive Manufacturing**	**3**	**0**	**0**	**3**

Course Objectives:
The main objectives of this course are to

1. Understand the fundamentals, evolution, and need for Additive Manufacturing in modern product development.
2. Learn the principles and process chains of various liquid-based, solid-based, and powder-based AM technologies.
3. Compare AM techniques with traditional manufacturing methods in terms of process, flexibility, and efficiency.
4. Explore industry-specific applications of AM in aerospace, automotive, medical, and consumer products.
5. Foster innovation through customization, prototyping, and production using advanced AM systems.

Course Objectives:
After the end of the course, the student will be able to:

1. ***Explain*** the fundamentals, of AM, and compare it with conventional manufacturing methods. *(L2)*
2. ***Describe*** the working principles, materials, and applications of liquid-based AM systems. *(L2)*
3. ***Illustrate*** and compare the processes, advantages, and limitations of solid-based AM systems. *(L3)*
4. ***Analyze*** powder-based AM processes with respect to their working mechanisms and industrial use cases. *(L4)*
5. ***Evaluate*** the applications of AM in various industries such as aerospace, automotive, medical, and others. *(L5)*

UNIT I - ADDITIVE MANUFACTURING FUNDAMENTALS
Need for time compression in product development, Need for Additive Manufacturing (AM), Historical development, Fundamentals of Additive Manufacturing, AM Process Chain, Advantages and Limitations of AM, Classification of AM process, Comparison of AM with CNC and other technologies.

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

- **distinguish** between 3D printing and CNC machining. *(L1)*
- **classify** the various 3D printing processes and systems. *(L2)*
- **summarize** the benefits and limitations of Additive Manufacturing. *(L2)*
- **identify** key milestones in the development of 3D printing technologies. *(L1)*

UNIT II- LIQUID-BASED AM SYSTEMS
Stereo lithography Apparatus (SLA): Models and specifications, Process, working principle, photopolymers, photo polymerization, Layering technology, Laser scanning, Applications, Advantages and Limitations, Case studies. Solid Ground Curing (SGC): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case

studies. Polyjet: Process, working principle, Applications, Advantages and Limitations, Case studies. Introduction to microfabrication.

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

- **understand** the basic principles of liquid-based 3D printing systems. *(L2)*
- **explain** the working of Stereo Lithography Apparatus (SLA). *(L2)*
- **illustrate** the laser scanning and layering technologies in SLA. *(L2)*
- **list** the advantages and limitations of SLA, SGC, and PolyJet techniques. *(L1)*

UNIT III SOLID-BASED AM SYSTEMS
Laminated Object Manufacturing (LOM): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case studies. Fused Deposition Modelling (FDM): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case studies. Multi-Jet Modelling (MJM): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case studies. Introduction to Direct Metal Deposition (DMD), Electron Beam Based Metal Deposition and Directed Energy Deposition Processes

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

- **elucidate** the basic principle of solid-based AM systems such as LOM and FDM. *(L2)*
- **explain** the process and components of Fused Deposition Modelling (FDM). *(L2)*
- **identify** suitable applications for solid-based systems. *(L1 ember)*

UNIT IV - POWDER-BASED AM SYSTEMS
Selective laser sintering (SLS): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case studies. Three-dimensional Printing (3DP): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case studies. Laser Engineered Net Shaping (LENS): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case studies. Electron Beam Melting (EBM): Models and specifications, Process, working principle, Applications, Advantages and Limitations, Case studies.

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

- **illustrate** the working principles of Selective Laser Sintering (SLS). *(L2)*
- **explain** the process of Three Dimensional Printing (3DP) and its applications. *(L2)*
- **describe** the LENS and Electron Beam Melting (EBM) processes. *(L2)*
- **compare** powder-based systems based on material, resolution, and cost. *(L4)*

UNIT V - AM APPLICATIONS
Applications of AM- Prototyping- Tooling- Production- Customization and Personalization- Spare Parts, Maintenance and Repair- Art, Design, and Architecture- Evaluating the Adoption of AM- Applications in Aerospace Industry, Automotive Industry, Jewellery Industry application. AM in Medical and |Bioengineering Applications: Planning and simulation of complex surgery, Customised Implants & Prosthesis, Design and Production of Medical Devices.

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

- **apply** knowledge of 3D printing to real-life medical and healthcare applications. *(L3)*
- **select** appropriate AM materials and techniques for specific biomedical use cases. *(L2)*
- **discuss** the limitations and future trends of 3D printing in medicine. *(L2)*
- **analyze** the role of AM in creating implants, prosthetics, and surgical models. *(L4)*
- **evaluate** business opportunities and customization potential of AM. *(L5)*

Text Books

1. Olaf Diegel, "A Practical Guide to Design for Additive Manufacturing", Springer.
2. Martin Leary, "Design for Additive Manufacturing", Elsevier.

Reference Books

1. Ben Redwood, "The 3D Printing Handbook: Technologies, Design and Applications",3D Hubs.
2. Rapid prototyping: Principles and Applications - Chua C.K., Leong K.F. and LIM C.S, World Scientific publications.
3. Rapid Manufacturing – D.T. Pham and S.S. Dimov, Springer.
4. Wholers Report 2000 – Terry Wohlers, Wohlers Associates.
5. Rapid Prototyping & Engineering Applications – Frank W.Liou, CRC Press, Taylor & Francis Group.
6. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing", 2nd Edition, Springer.

Online Resources

1. **Coursera – Additive Manufacturing by University of Illinois:** Comprehensive course on AM principles, processes, and applications.
   🔗 https://www.coursera.org
2. **edX – Additive Manufacturing by MIT:** High-level understanding of AM technologies and materials.
   🔗 https://www.edx.org
3. **MIT OpenCourseWare – How to Make (Almost) Anything:** MIT's legendary course on 3D printing and digital fabrication.
   🔗 https://fab.cba.mit.edu/classes/863.21/
4. **Hubs Knowledge Base (formerly 3D Hubs):** Industry-grade guides on design, materials, and AM processes.
   🔗 https://www.hubs.com/knowledge-base/
5. **Autodesk Design Academy – Fusion 360 for 3D Printing:** Learn CAD and DfAM with hands-on tutorials using Fusion 360.
   🔗 https://academy.autodesk.com
6. **ASTM AM Center of Excellence (AM CoE):** Research, webinars, and global standards in additive manufacturing.
   🔗 https://amcoe.org
7. **YouTube – Maker's Muse / Thomas Sanladerer / Additive Manufacturing Media:** Practical insights and technology reviews in AM.
   🔗 https://www.youtube.com

COURSE OUTCOMES VS POs MAPPING
[1-slight (low), 2 - moderate (medium) and 3- substantial (high)]

CO/ PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2
CO1	**3**	**1**	1	1	**2**	–	**1**	–	–	–	–	**1**
CO2	**3**	**2**	1	1	**2**	–	1	–	–	–	–	**1**
CO3	**3**	**2**	**2**	1	**2**	–	–	–	**1**	–	–	**1**
CO4	**3**	**3**	**2**	**2**	**3**	**1**	1	–	–	–	**1**	**1**
CO5	**2**	**2**	**3**	**2**	**2**	**3**	**2**	**1**	**1**	**1**	**2**	**1**
CO*	**3**	**2**	**2**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**2**	**1**

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-MN3102	**3D Printing Technology Laboratory**	**3**	**0**	**0**	**3**

Course Objectives:

The objectives of the course are

1. To introduce students to additive manufacturing processes, tools, and workflows.
2. To enable students to design 3D printable parts using CAD software.
3. To provide hands-on experience with FDM and SLA 3D printers.
4. To train students in slicing, support structures, and print parameter optimization.
5. To familiarize students with 3D scanning, mesh repair, and part duplication.

Course Objectives:

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

1. Design components suitable for 3D printing using CAD tools. *(L3)*
2. Prepare models for printing using slicing software. *(L4)*
3. Operate and troubleshoot FDM and SLA 3D printers. *(L3)*
4. Use 3D scanning tools for reverse engineering and duplication. *(L3)*
5. Evaluate surface quality, dimensional accuracy, and post-processing needs. *(L5)*

List of Experiments

1. Design a keychain with text and patterns using TinkerCAD/Fusion 360.
2. Design interlocking parts or snap-fit joints and perform tolerance testing.
3. Model a basic assembly (e.g., gears, pulley system) and test 3D printability.
4. Slice a CAD model using Cura/PrusaSlicer and analyze infill, layer height, supports, and time.
5. Compare the effects of different support strategies (tree, linear, custom) on a complex part.
6. Print a mechanical part using PLA filament on an FDM printer.
7. Test different infill densities (20%, 50%, 100%) and measure mechanical performance.
8. Print a functional part like a phone stand, wrench, or turbine and evaluate dimensional accuracy.
9. Print a high-resolution object using an SLA printer.
10. Post-process SLA parts: UV curing, alcohol cleaning, and support removal.
11. Scan a simple object (e.g., toy or mechanical part) using a 3D scanner.
12. Repair scanned mesh (STL) using Meshmixer/Blender and make it 3D printable.

Textbooks:

1. **Ben Redwood, Filemon Schöffer, Brian Garret,** *The 3D Printing Handbook: Technologies, Design and Applications*, 3D Hubs.
2. **Andreas Gebhardt,** *Understanding Additive Manufacturing*, Hanser Publications.
3. **Dr. L. Jayakumar**, *Additive Manufacturing (3D Printing) Technologies*, Vikas Publishing.

Reference Books:

1. **Liza Wallach Kloski, Nick Kloski,** *Getting Started with 3D Printing*, Maker Media.
2. **Rafiq I. Noorani,** *3D Printing: Technology, Applications, and Selection*, CRC Press.
3. **Dr. K. Venkataraman** , *Introduction to Additive Manufacturing*, Scitech Publications.

Online Resources:

1. Autodesk Design Academy – 3D Printing & Fusion 360

   https://academy.autodesk.com
   Free tutorials and projects on 3D design and slicing workflows.

2. Ultimaker Cura Training – YouTube & Manuals

   https://ultimaker.com/learn
   Complete guide on slicing parameters, troubleshooting, and settings.

3. Prusa Knowledge Base & Blog

   https://help.prusa3d.com
   Advanced and beginner tips on FDM printing, materials, and maintenance.

4. MIT Fab Academy – Additive Fabrication Module

   https://fabacademy.org
   Open-source course notes and experiments on FDM, SLA, and laser cutting.

5. Instructables – 3D Printing Projects

   https://www.instructables.com/howto/3d+printing
   DIY project ideas and step-by-step guides for all skill levels.

COURSE OUTCOMES VS POs MAPPING
[1-slight (low), 2 - moderate (medium) and 3- substantial (high)]

CO/PO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**
CO1	2	–	3	–	3	–	–	–	2	–	–	1	1	1
CO2	2	1	3	–	3	–	–	–	–	–	–	2	-	-
CO3	2	–	2	–	3	–	–	–	2	–	–	2	-	-
CO4	2	2	3	–	3	–	–	–	2	–	–	2	-	1
CO5	3	2	2	3	3	–	–	–	–	–	–	3	2	2

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-MN3201	**Industrial Engineering**	**3**	**0**	**0**	**3**

Course objectives:

The objectives of the course are

- Comprehend the knowledge of industrial engineering and best practices in the manufacturing industries
- Develop problem-solving and decision-making skills relevant to challenges in quality engineering
- Evaluate the ethical and social responsibility considerations in industrial engineering practices, including environmental sustainability and community impacts.
- Apply principles and techniques in the development of integrated production systems
- Evaluate the ethical and social responsibility considerations in industrial Engineering practices, including environmental sustainability and community impacts.

Course outcomes:

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

1. ***explain*** the principles and techniques of industrial engineering to design the facility layouts**(L2)**
2. ***apply*** the principles of inventory control to deterministic and probabilistic inventory control models to optimize the total inventory control costs. **(L3)**
3. ***determine the*** optimal strategy for scheduling in make to order systems for the specified time elements required to fabricate the job orders. **(L3)**
4. ***apply*** quality control tools and techniques to control the quality parameters in manufacturing process. **(L3)**
5. ***determine*** the operations decisions to manage the Supply Chain issues **(L3)**

UNIT–I

Introduction to Industrial Engineering: Definition, Objectives of industrial Engineering, Techniques of Industrial Engineering, Types of production systems, characteristics, Principles of facility layout principles, types, design of layouts -travel chart, assembly line balancing. Sustainability in facility design. Computer based methods for facility layout design, Computerized Relative Allocation of Facilities Technique, Automated Layout Design Program, Computerized Relationship Layout Planning, case studies.

Learning Outcomes:

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

1. ***Compare*** the characteristics of Job and Mass Production systems (L2)
2. ***Explain*** Computer based methods for facility layout design (L2)

Applications: Facility design in manufacturing industries, Planning work stations for assembly lines.

UNIT-II

Inventory control: Objectives, functions, ethics in purchasing materials, costs associated with inventory control, infinite rate of replenishment model, Selective Inventory control methods, reorder level in practical inventory system with variable demand and lead time, simulation and software tools to design inventory systems, case studies.

Learning Outcomes:

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

1. ***Explain*** *the* significance of Inventory Management. **(L2)**
2. ***Determine*** optimal inventory quantities *to* optimize cost of inventory control. **(L3)**

Applications:
1.Stores inventory management in manufacturing plants.
2.Design the practical inventory control systems for cost optimization

UNIT-III

Production planning and control — objectives and functions. process planning, Forward, backward scheduling, Scheduling in job production system, flow shop scheduling, dispatching rules- Mean flow time, mean latenessof the job orders, application of software modules in production planning and control

Learning outcomes:

After completion of this unit, students will be able to

1. ***Explain*** the functions of Production planning and control **(L2)**
2. ***Compare*** Forward and backward scheduling methods **(L3)**

Application: Scheduling in make to order industries

UNIT-IV

Quality Control: Inspection and Quality control, Process capability, Quality control tools and techniques, Control chart for variables –Mean chart, Range chart. Attribute control charts, Acceptance Sampling-Single sampling plan, Emerging Trends in Quality Control

Learning Outcomes:

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

1. ***Explain*** the Quality control tools and techniques. **(L2)**
2. ***construct*** control charts for variables and attributes**(L3)**

Application:

1. Quality management practices in manufacturing industries
2. Understand the process capability for the manufacturing processes

UNIT–V

Decision making in Supply Chain– Applications of Supply Chain Management, Supplier selection, Vendor rating Method, Sustainable Quantitative Procurement and Transportation Practices. Warehouse inventory management system-exercises, simulation tool in Supply Chain Management, Product data management –Reverse logistics, green supply chain– Cases in Automobile industry, electronic industry

Learning Outcomes:

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

- ***Develop*** simulation model for Warehouse inventory management (L3)
- ***Explain*** the role of reverse logistics for sustainable development (L2)

Application:

1. Warehouse management in manufacturing plants, Automobile industry
2. Machine tools industry, electronic goods industry

Text Books

1. Industrial Engineering & Production Management–Martand Telsang, S.Chand&Co
2. Production and *Operations Management*. R. *Panneerselvam*,. Prentice Hall India Pvt. Ltd.

References

1. Production and Operations Management - K Aswathappa
2. Elements of Production Planning and Control,Samuel Eilon, Universal Book Corp.

Web Source References:

1.https://onlinecourses.nptel.ac.in/ noc22_me04
2.https://nptel.ac.in/courses/ 112107292
3. https://cursa.app/en/free-course/principle-of-industrial-engineering
4.https://onlinecourses.nptel.ac.in/noc20_me30
5. https://www.udemy.com/course/production-operations-management

COURSE OUTCOMES VS POs MAPPING

[1-*slight* (low), 2 - *moderate* (*medium*) and 3- substantial (high)]

CO/ PO	PO1	PO 2	PO 3	PO4	PO 5	PO 6	PO7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	3	2	2	-	-	1	-	1	-	-	2	2	3	3
CO2	3	3	3	2	1	1	-	1	-	-	2	2	3	3
CO3	3	3	2	2	1	1	-	1	-	-	2	2	3	3
CO4	3	3	3	2	1	1	-	1	-	-	2	2	3	3
CO5	3	3	3	2	-	1	-	1	-	-	2	2	3	3
CO*	3	3	3	2	1	1	-	1	-	-	2	2	3	3

** For Entire Course, PO & PSO Mapping*

Course Code	Course Name	L	T	P	C
R23MEC-MN4101	Thermal Comfort Systems	**3**	**0**	**0**	**3**

Course Objective:

The objectives of the course are

- Familiarize the operating cycles and different systems of refrigeration.
- Evaluate the cooling capacity and coefficient of performance (COP) of various refrigeration systems for energy-efficient and sustainable operation.
- Empower students with the skills to design, optimize, and maintain sustainable refrigeration systems using modern refrigerants and components for industrial and commercial applications.
- Equip students with psychrometric analysis and air-conditioning system design skills for developing energy-efficient HVAC solutions compliant with ASHRAE standards.
- Familiarize students with refrigeration and air-conditioning system components enabling them to design, operate and maintain efficient thermal management systems.

Course Outcomes:

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

1. ***Apply*** the thermodynamic principles and performance metrics (COP, efficiency) of refrigeration cycles, including Carnot, Bell-Coleman, Aircraft and Vapour Compression (VCRS). **(L3)**
2. ***Explain*** the selection criteria for refrigerants and refrigeration system components based on thermodynamic properties, environmental impact, and functional requirements. **(L2)**
3. ***Analyze*** vapor absorption, steam-jet, and thermoelectric refrigeration systems through performance calculations, and component selection. **(L4)**
4. ***Apply*** psychrometric principles to interpret air-conditioning processes and analyze system requirements using standard charts and parameters. **(L2)**
5. ***Analyze*** different air-conditioning systems (central, unitary, packaged) by evaluating their configurations, components, and load calculation methodologies. **(L4)**

Unit 1: Air Refrigeration and Vapour Compression Refrigeration Systems

Air Refrigeration: Air Refrigeration Cycles, reversed Carnot cycle, Bell-Coleman cycle analysis, Air Refrigeration systems, merits and demerits, analysis. Vapour Compression Refrigeration System (VCRS): Vapour Compression Refrigeration system, Carnot Vapour compression refrigeration cycle, Working and analysis, Limitations, Standard Vapour

Compression Refrigeration system, Working and analysis, Effects of sub cooling and super heating, Numerical Problems, Multi-Pressure or Compound Vapour Compression Refrigeration Systems.

Learning Outcomes:

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

1. **Explain** the working principles of Carnot, Bell-Coleman, and VCRS cycles. (L2)
2. **Calculate** COP and efficiency for different refrigeration cycles. (L3)
3. **Illustrate** the effects of subcooling/superheating in VCRS. (L2)

Application Areas:

1. Transport Refrigeration: Reefer containers for perishable goods (using VCRS with subcooling)
2. Aircraft Cooling: Air-cycle refrigeration (Bell-Coleman cycle) in cabin air conditioning
3. Industrial Cold Storage: Multi-stage VCRS with flash intercooling for large-scale food preservation

Unit 2: Refrigerants and Refrigeration System Equipment

Refrigerants: Classification, Selection of Refrigerants and Nomenclature of refrigerants, Desirable Properties of an ideal refrigerant, A discussion on Ozone layer Depletion and Global Warming. Refrigeration systems Equipment: Refrigeration System Equipment, Compressors, Condensers, Expansion Devices and Evaporators,

Learning Outcomes:

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

1. ***Explain*** refrigerants impact environmental impact. **(L2)**
2. ***Describe*** the functions of compressors, condensers, expansion devices, and evaporators. **(L2)**
3. ***Explain*** the selection criteria for refrigerants and components. **(L2)**

Application Areas:

1. HVAC Systems: Eco-friendly refrigerant selection (e.g., R,32/R,290) for residential Acs.
2. Commercial Refrigeration: Scroll compressors and microchannel condensers in supermarket freezers.
3. Ozone Protection: Retrofitting R-22 systems with low-GWP alternatives (e.g., R-454B).

Unit 3: Vapour Absorption and Other Refrigeration Systems

Vapour Absorption systems: Other types of Refrigeration systems, Vapour Absorption Refrigeration Systems, Absorbent, Refrigerant combinations, Water-Ammonia Systems, Water-Lithium Bromide System, Contrast between the two systems, Modified Version of Aqua-Ammonia System with Rectifier and Analyser Assembly, Numerical Problems. Other refrigeration systems: (i) Steam-Jet refrigeration system and (ii) Thermoelectric refrigeration system.

Learning Outcomes:

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

1. ***Differentiate*** water, ammonia and LiBr, water absorption systems. **(L2)**
2. ***Compare*** operational advantages of VARS, steam, jet, and thermoelectric systems. **(L2)**
3. ***Identify*** key components in modified aqua-ammonia systems. **(L2)**

Application Areas:

1. Industrial Waste Heat Recovery: LiBr-H_2O absorption chillers in chemical plants
2. Solar Cooling: Ammonia-water systems for off-grid refrigeration
3. Electronics Cooling: Thermoelectric refrigeration in PCR devices and laser diodes

Unit 4: Psychrometry and Fundamentals of Air-Conditioning

Psychrometry: Introduction to Air-Conditioning, Basic Definition, Classification, ASHRAE Nomenclature pertaining to Air-Conditioning, Applications of Air-Conditioning, Psychrometry, Air-water vapour mixtures, Psychrometric Properties, Psychrometric or Air-Conditioning processes, Psychrometric Chart, Numerical Problems.

Learning Outcomes:

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

1. ***Utilize*** psychrometric charts to examine air-conditioning processes. **(L3)**
2. ***Implement*** ASHRAE-compliant temperature/humidity ranges for thermal comfort systems. **(L2)**

Application Areas:

1. Data Center Cooling: Psychrometric analysis for humidity control in server rooms
2. Hospital HVAC: Precision air-conditioning for operating theatres (dew point control)
3. Textile Industry: Humidification processes using adiabatic cooling

Unit 5: Air-Conditioning Systems and Components

Air-Conditioning: Mathematical Analysis of Air-Conditioning Loads, Related Aspects, Numerical Problems, Different Air-Conditioning Systems, Central, Station Air-Conditioning System, Unitary Air-Conditioning System, Window Air-Conditioner and Packaged Air-Conditioner, Components related to Air-Conditioning System.

Learning Outcomes:

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

1. ***Estimate*** cooling loads for central, unitary, and packaged air-conditioning systems to determine required system capacity. **(L3)**
2. ***Distinguish*** between central, unitary, and packaged systems. **(L2)**
3. ***Explain*** methodologies for system configuration selection. **(L2)**

Application Areas:

1. Building HVAC Design: Load calculations for central AC systems in skyscrapers
2. EV Thermal Management: Packaged AC units in electric vehicle cabins
3. Cleanrooms: Unitary systems for pharmaceutical manufacturing

Text books:

1. Arora, C. P., Refrigeration and Air-Conditioning, Tata McGraw - Hill, New Delhi.
2. Prasad, M., Refrigeration and air conditioning. New Age International.

Reference books:

1. Khurmi, R.S and Gupta, R. K., Textbook of refrigeration and air conditioning. S. Chand Publishing.
2. Rajput, R. K., Refrigeration and Air-Conditioning. S.K. Kataria & Sons.

Web Resources:

1. https://archive.nptel.ac.in/courses/112/105/112105129/
2. https://www.youtube.com/playlist?list=PLiSPNzs4fD9utSvnF9GxzWA7vCehPTtT0
3. https://www.geeksforgeeks.org/refrigeration-and-air-conditioning/
4. https://www.youtube.com/watch?v=FEWF9N1LE6g&list=PLEaHqdgEVu6rgimtDDFGVeCfMPLp1q-TQ

COURSE OUTCOMES VS POs MAPPING

[1-*slight* (low), 2 - *moderate* (*medium*) and 3- substantial (high)]

CO/ PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	3	2	1	1	1	2	-	-	-	-	2	2	3
CO2	3	1	1	1	1	3	3	-	-	-	-	2	3	3
CO3	3	2	2	2	1	2	2	-	-	-	-	2	3	3
CO4	3	3	2	1	1	1	2	2	-	-	-	2	1	3
CO5	3	3	2	2	1	2	2	-	-	-	-	2	3	3

** For Entire Course, PO & PSO Mapping*

R23_Open Electives Courses for ME

Offering Department: Electronics and Communications Engineering						
S.No	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**
1	R23ECE-OE0001	Basics of Communication Systems	3	0	0	3
2	R23ECE-OE0002	Micro Processors and Interfacing	3	0	0	3
3	R23ECE-OE0003	Digital System Design using Verilog	3	0	0	3
4	R23ECE-OE0004	Fundamentals of Digital Image Processing	3	0	0	3
5	R23ECE-OE0005	Introduction to Internet of Things	3	0	0	3
6	R23ECE-OE0006	Wireless Sensor Networks	3	0	0	3
7	R23ECE-OE0007	Satellite Communication	3	0	0	3
8	R23ECE-OE0008	Fundamentals of Embedded Systems	3	0	0	3

Offering Department: Electrical and Electronics Engineering						
S.No	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**
1	R23EEE-OE0001	Renewable Energy Sources	3	0	0	3
2	R23EEE-OE0002	Energy Conservation and Management	3	0	0	3
3	R23EEE-OE0003	Electrical Safety & Standards	3	0	0	3
4	R23EEE-OE0004	Utilization of Electrical Energy	3	0	0	3

Offering Department: Computer Science and Engineering & Allied Branches						
S.No	**Course Code**	**Course Name**	**L**	**T**	**P**	**Credits**
1	R23CSE-OE0001	Python Programming	3	0	0	3
2	R23CSE-OE0002	Data Structures Using C	3	0	0	3
3	R23CSE-OE0003	Operating System Concepts	3	0	0	3
4	R23CSE-OE0004	Introduction to Java Programming	3	0	0	3
5	R23CSE-OE0005	Database Management Systems Concepts	3	0	0	3
6	R23CSE-OE0006	Unix & Shell Programming	3	0	0	3
7	R23CSE-OE0007	Software Engineering	3	0	0	3
8	R23CSE-OE0008	Introduction to Data mining	3	0	0	3
9	R23CSE-OE0009	Fundamentals of Web Technologies	3	0	0	3
10	R23CSE-OE0010	Fundamentals of Computer Networks	3	0	0	3
11	R23CSE-OE0011	Basics of Cloud Computing	3	0	0	3
12	R23CSE-OE0012	Introduction to Machine Learning	3	0	0	3
13	R23CSE-OE0013	Essentials of Cyber Security	3	0	0	3
14	R23CSE-OE0014	Introduction to React JS	3	0	0	3
15	R23CSE-OE0015	Deep Learning	3	0	0	3
16	R23CSE-OE0016	DevOps	3	0	0	3
17	R23CSE-OE0017	Mobile Computing	3	0	0	3
18	R23CSE-OE0018	Java Full Stack Development	3	0	0	3
19	R23CSE-OE0019	Human Computer Interface	3	0	0	3
20	R23CSE-OE0020	Cryptography and Network Security	3	0	0	3
21	R23CSE-OE0021	Quantum Computing	3	0	0	3
22	R23CSE-OE0022	Big data Analytics	3	0	0	3
23	R23CSE-OE0023	Block Chain Technology	3	0	0	3
24	R23CSE-OE0024	Multimedia Application Development	3	0	0	3
25	R23CSE-OE0025	Mobile Adhoc Networks	3	0	0	3
26	R23CSS-OE0001	Operating Systems	3	0	0	3
27	R23CSS-OE0002	Redhat Linux	3	0	0	3
28	R23CSS-OE0003	Cloud Computing	3	0	0	3
29	R23CSS-OE0004	Distributed Operating System	3	0	0	3
30	R23CIT-OE0001	Basics of Computer Networks	3	0	0	3
31	R23CIT-OE0002	Cryptography and Network Security	3	0	0	3
32	R23CIT-OE0003	Mobile Computing	3	0	0	3
33	R23CIT-OE0004	Wireless sensor networks	3	0	0	3
34	R23CSM-OE0001	An Introduction to Artificial Intelligence	3	0	0	3
35	R23CSM-OE0002	Introduction to Machine Learning with Python	3	0	0	3
36	R23CSM-OE0003	Foundation of Deep Learning for Engineering Applications	3	0	0	3
37	R23CSM-OE0004	Natural Language Processing- Frontiers Approach	3	0	0	3

OPEN ELECTIVES

Course code	Course Title	L	T	P	Credits
R23ECE-OE0001	Basics of Communication Systems **(Open Elective)**	3	0	0	3

Course Objectives:

- Introduce the fundamental principles of analog and digital communication systems.
- Understand the representation and transmission of signals.
- Learn the basics of amplitude, frequency, and phase modulation techniques.
- Study noise performance in communication systems.
- Introduce multiplexing and multiple access techniques.

Course Outcomes:

1. Understand the fundamental elements of communication systems. (L2)
2. Explain various analog and digital modulation techniques. (L2)
3. Analyze the effect of noise on communication signals. (L4)
4. Understand bandwidth and power requirements in modulation schemes. (L2)
5. Describe basic multiplexing techniques and system applications. (L2)

UNIT – I

Introduction to Communication Systems: Basic block diagram of a communication system, types of communication (analog and digital), electromagnetic spectrum, frequency bands, and applications in daily life.

UNIT – II

Amplitude Modulation: Principles of amplitude modulation (AM), modulation index, power and bandwidth of AM, generation and detection of AM signals, DSB-SC and SSB modulation.

UNIT – III

Angle Modulation: Frequency modulation (FM) and phase modulation (PM), modulation index, bandwidth of FM (Carson's Rule), generation and demodulation techniques of FM signals.

UNIT – IV

Noise and Performance Analysis: Types of noise, noise figure, signal-to-noise ratio (SNR), effect of noise on AM and FM systems, pre-emphasis and de-emphasis.

UNIT – V

Multiplexing and Digital Communication Basics: Time Division Multiplexing (TDM), Frequency Division Multiplexing (FDM), basic digital communication concepts (PCM, ASK, FSK, PSK), comparison of analog and digital systems.

Textbooks

1. Simon Haykin, Communication Systems, Wiley.
2. B.P. Lathi, Modern Digital and Analog Communication Systems, Oxford University Press.
3. Sanjay Sharma, Communication Systems, S.K. Kataria & Sons. (Indian Author)

Course code	Course Title	L	T	P	Credits
R23ECE-OE0002	Micro Processors and Interfacing **(Open Elective)**	3	0	0	3

Course Objectives: students are provided with

- 8085 8-bit architecture and register organization.
- 8086 architecture, memory segmentation & organization and features of minimum and maximum mode operations.
- Programming of 8086 in assembly language and tools.
- Interfacing memory and various peripheral control devices with 8086.

Course Outcomes: Student is able to

1. Outline the architecture and working diagram of 8085 microprocessors. **(L2)**
2. Interpret the 8086 functioning in minimum mode and maximum mode with its architecture, memory segmentation and organization. **(L2)**
3. Construct Assembly language program for 8086 using assembler directives, addressing modes and instruction set. **(L3)**
4. Develop Interface circuits with various peripheral control ICs for 8086 system. **(L3)**
5. Desing various memory interfacing Circuits with 8086 system.**(L3)**

UNIT 1

Introduction to 8085 Microprocessor: Basic microprocessor system-working, 8085 Microprocessor Architecture, register organization, Pin Diagram, Flag Register, Instruction Cycle, Timing Diagram, Interrupts of 8085.

UNIT 2

8086 Microprocessor: Evolution of Microprocessors, Register Organization of 8086, Architecture, Pin Diagram, Memory segmentation and organization, Stack implementation, Interrupt structure of 8086. minimum and maximum mode microprocessor system, Timing diagram and General Bus operation.

UNIT 3

8086 Programming: Addressing Modes, Instruction Set of 8086, Assembly Language Programming: Assembler Directives, Simple programs, Procedures and Macros Program.

UNIT 4

Data Transfer Schemes and Principle Interfacing: IO Interfacing: Programmable Peripheral Interface 8255 and its applications, Programmable Interrupt Controller 8259 with examples, Programmable Communication Interface 8251 USART, DMA Controller 8257, Programmable Keyboard and Display Interface 8279.

UNIT-5

Memory and IO Interfacing 8086: Address decoding techniques, Interfacing Static RAM and ROM chips, ADC and DAC Interfacing.

Text Books:

1. Microprocessor Architecture Programming and Applications with the 8085, 6th edition, Ramesh S Gaonkar, Penram International Publishing, 2013
2. Advanced Microprocessors and Peripherals, 3e, K M Bhurchandi, A K Ray, McGraw Hill Education, 2017.

References:

1. The Intel Microprocessors: Architecture, Programming and Interfacing, Barry B.Brey, PHI, 6th Edition.
2. Microprocessors and Interfacing, 2e, Douglas.V.Hall, Tata McGrawhill.

Course code	Course Title	L	T	P	Credits
R23ECE-OE0003	Digital System Design using Verilog **(Open Elective)**	3	0	0	3

Course Objectives:

- To introduce the basics and programming fundamentals of Verilog HDL
- To describe the primitive instances of gates and explain the various modeling constructs of Verilog.
- To familiarize various behavioral modeling constructs of Verilog essential for designing digital circuits.
- To Design and implement various combinational logic circuits in Verilog HDL
- To Design and implement various sequential logic circuits in Verilog HDL.

Course Outcomes:

At the end of the Course, the Student will be able to:

1. Understand the fundamentals of Digital System Design flow using Verilog HDL. (L2)
2. Construct logic circuits with the concept of Gate Level and Dataflow modelling (L3)
3. Construct logic circuits with the concept of Behavioral modelling. (L3)
4. Make use of Verilog programming to design Combinational digital circuits. (L3)
5. Develop synthesizable Verilog codes for sequential digital circuits. (L3)

UNIT-I

Introduction to Verilog HDL: Introduction, Verilog as HDL, Basic elements: Keywords, Identifiers, Comments, Tasks and functions, Numbers, Strings, Logic Values, Data Types, Scalars and Vectors, Parameters, Operands and Operators. Simulation and Synthesis Tools.

UNIT-II

Gate Level Modeling: Introduction, Module Structure, Different Gate Primitives, Array of Instances of Primitives, Illustrative Examples,

Data Flow Modeling: Introduction, Continuous Assignment Structure, Delays, and Assignment to Vectors, Operators and different Examples.

UNIT-III

Behavioral Modeling: Blocking and Non-Blocking Assignments, Simulation Flow : if and if-else constructs, case statement, Assign-De-Assign construct, different loop constructs, Examples

UNIT IV

Design of combinational circuits Elements using HDL models: Logic gates, Half Adders, Full Adders, Subtractors, Decoders, Encoders, Multiplexers, and De-multiplexers & Comparators,

UNIT-V

Design of Sequential circuits Elements using HDL models: RS, D, T, JK Latches & Flip Flops, Registers and Counters.

Text Books

1. T.R Padmanabhan, B.Bala Tripura Sundari Design through Verilog HDL, Wiley India Publications, 2009
2. J.Bhaskar, A Verilog HDL Primer, BS Publications, 3rd Edition.

Reference Books

1. Verilog HDL – Samir Palnitkar, 2nd Edition, Pearson Education, 2009
2. John F.Wakerly , Digital Design, Pearson, 4th Edition.
3. Zainalabdien Navabi, Verilog Digital System Design, TMH, 2nd Edition.

Course code	Course Title	L	T	P	Credits
R23ECE-OE0004	Fundamentals of Digital Image Processing **(Open Elective)**	3	0	0	3

Course Objectives:

- Introduce the basic concepts and techniques of digital image processing.
- Understand image acquisition, sampling, and quantization processes.
- Study image enhancement and filtering techniques in spatial and frequency domains.
- Explore image segmentation and representation techniques.
- Learn the basics of morphological processing and image compression.

Course Outcomes:

1. Understand image formation, sampling, and quantization techniques. (L2)
2. Apply spatial and frequency domain enhancement methods. (L3)
3. Analyze filtering and edge detection techniques. (L4)
4. Understand image segmentation and morphological operations. (L2)
5. Identify compression techniques and their applications. (L2)

UNIT – I

Introduction and Image Fundamentals: Definition of digital image, image sensing and acquisition, image sampling and quantization, basic relationships between pixels, color image fundamentals, and image file formats.

UNIT – II

Image Enhancement in Spatial Domain: Intensity transformations, histogram processing, spatial filtering, smoothing and sharpening filters, and contrast enhancement techniques.

UNIT – III

Image Enhancement in Frequency Domain: Fourier Transform, frequency domain filtering, low-pass and high-pass filters, homomorphic filtering, and enhancement using Discrete Cosine Transform (DCT).

UNIT – IV

Image Segmentation and Morphology: Edge detection using gradient operators, thresholding techniques, region-based segmentation, morphological operations like dilation, erosion, opening, and closing.

UNIT – V

Image Compression and Representation: Lossless and lossy compression techniques, run-length coding, Huffman coding, JPEG, wavelet-based compression, and basics of image representation and description.

Textbooks:

1. Rafael C. Gonzalez & Richard E. Woods, Digital Image Processing, Pearson.
2. Anil K. Jain, Fundamentals of Digital Image Processing, PHI Learning. (Indian Author)
3. S. Jayaraman, S. Esakkirajan, and T. Veerakumar, Digital Image Processing, McGraw-Hill. (Indian Author)

Course code	Course Title	L	T	P	Credits
R23ECE-OE0005	Introduction to Internet of Things **(Open Elective)**	3	0	0	3

Course Objectives:

- To Understand the Architectural Overview of IoT and layers involved in Architecture.
- To Understand Real World Design Constraints of IOT and Various Protocols.
- To familiarize the students to the basics of Internet of things and protocols.
- To expose the students to some of the hardware and Software applications areas where Internet of Things can be applied.

Course Outcomes:

The students should be able to:

1. Understand the architecture of IoT systems, including the components and their roles.(L2)
2. Interface various electronic components, including LEDs, push buttons, buzzers, and LCD displays, with the Arduino board.(L3).
3. Establish remote access to the Raspberry Pi for control and management.(L3)
4. Apply knowledge to develop basic IoT applications using the ESP8266.(L3)

Understand the fundamentals of virtualization and cloud computing architecture.(L2)

UNIT - I

Introduction to IOT: Understanding IoT fundamentals, IOT Architecture and protocols, Various Platforms for IoT, Real time Examples of IoT , Overview of IoT components and IoT Communication Technologies ,Challenges in IOT.

UNIT - II

Arduino Simulation Environment: Arduino Uno Architecture, Setup the IDE, Writing Arduino Software, Arduino Libraries, Basics of Embedded C programming for Arduino, Interfacing LED, push button and buzzer with Arduino, Interfacing Arduino with LCD. Sensor & Actuators with Arduino

UNIT - III

Raspberry Pi Programming: Installing and Configuring the Raspberry Pi, Getting Started with the Raspberry Pi,Using the Pi as a Media Centre, Productivity Machine and Web Server, Remote access to the Raspberry Pi. Preparing Raspberry Pi for IoT Projects.

UNIT - IV

Basic Networking with ESP8266 WiFi module : Basics of Wireless Networking, Introduction to ESP8266 Wi-Fi Module ,Various Wi-Fi library , Web serverintroduction, installation, configuration ,Posting sensor(s) data to web server .IoT Protocols ,M2M vs. IOT Communication Protocols.

UNIT - V

Cloud Platforms for IOT : Virtualization concepts and Cloud Architecture , Cloud computing, benefits ,Cloud services -- SaaS, PaaS, IaaS , Cloud providers & offerings ,Study of IOT Cloud platforms , ThingSpeak API and MQTT , interfacing ESP8266 with Web services

Text Books:

1. Simon Monk, Programming Arduino: Getting Started with Sketches, Second Edition McGraw- Hill Education
2. Peter Waher,Learning Internet of Things,Packt publishing.
3. OvidiuVermesan,PeterFriess, IoT-From Research and Innovation to Market deployment, River Publishers

Reference Books:

1. Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stefan Avesand, StamatisKarnouskos, David Boyle, “From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence”, 1st Edition, Academic Press, 2014.
2. Peter Waher, “Learning Internet of Things”, PACKT publishing, BIRMINGHAM – MUMBAI
3. Bernd Scholz-Reiter, Florian Michahelles, “Architecting the Internet of Things”, ISBN 978-3- 642-19156-5 e-ISBN 978-3-642-19157-2, Springer.

Course code	Course Title	L	T	P	Credits
R23ECE-OE0006	Wireless Sensor Networks **(Open Elective)**	3	0	0	3

Course Objectives:

- Emphasize the basic WSN technology and sensor node architecture with its unique constraints and challenges in design of WSN for different applications.
- Summarize the transceiver design and network technologies used in wireless sensor and networks.
- Explains various key MAC protocols for sensor networks with their merits and demerits.
- Provide knowledge of different routing protocols with their advantages.
- Create awareness on transport layer protocols, security considerations, sensor network platforms and tools with a brief study of different WSN applications.

Course Outcomes:

1. Illustrate the wireless sensor node architectures.
2. Outline the physical layer design.
3. Inspect MAC protocols of wireless sensor and networks.
4. Inference various network layer routing protocols of wireless sensors.
5. Summarize the network security requirements.

UNIT-I

Overview of Wireless Sensor Networks: Key definitions of sensor networks, advantages of sensor networks, unique constraints and challenges, driving application, enabling technologies for wireless sensor networks.

Architectures:

Single-node architecture - hardware components, energy consumption of sensor nodes, operating system and execution environments, network architecture- sensor network scenarios, optimization goals and figures of merit, gateway concepts.

UNIT - II

Networking Technologies: Physical layer and transceiver design consideration, personal area networks (PANs), hidden node and exposed node problem, topologies of PANs, MANETs, and WANETs.

UNIT - III

MAC Protocols for Wireless Sensor Networks: issues in designing a MAC protocol for Ad Hoc Wireless Networks, Design goals of a MAC protocol for Ad Hoc Wireless Networks, Classifications of MAC Protocols, Contention -Based Protocols, contention - based protocols with reservation mechanism, contention - based MAC protocols with scheduling Mechanisms, MAC protocols that use directional antennas, others MAC protocols.

UNIT - IV

Routing Protocols: introduction, issues in designing a routing protocols for Ad Hoc Wireless Networks, classification of routing protocols, table- driven routing protocols, On-Demand routing protocols, Hybrid routing protocols, routing protocols with efficient flooding mechanisms, hierarchical routing protocols, power- aware routing protocols, proactive routing.

UNIT-V

Transport Layer and Security Protocols: Introduction, issues in designing a transport layer protocol for Ad Hoc wireless networks, design goals of a transport layer protocol for Ad Hoc wireless networks, Security in Ad Hoc wireless networks, network security requirements, issues and challenges in security provisioning, network security attacks, key management, secure routing in Ad Hoc wireless Networks.

Sensor Network Platforms and Tools:

Sensor node hardware - Berkeley motes, programming challenges, node- level software platforms, node-level simulators, state - centric programming.

Textbooks

1. Ad Hoc wireless networks: Architectures and protocols - C.Siva Ram Murthy and B.S.Manoj, 2004, PHI.
2. Wireless Ad - Hoc and Sensor Networks: Protocols, Performance and Control - Jagannathan Sarangapani, CRC Press.
3. Holger Karl & Andreas Willig, Protocol and Architectures for Wireless Sensor Networks, John Wiley, 2005.

References

1. Kazem Sohraby, Daniel Minoli, & Taieb Zanti, "Wireless Sensor Networks - Technology, Protocols and Applications", John Wiley, 2007.
2. Feng Zhao & Leonidas J.Guibas, “Wireless Sensor Networks - An Information Processing Approach", Elsevier, 2007.
3. Ad Hoc Mobile Wireless Networks: Protocols & Systems, C.K.Toh, 1ed, Pearson Education.
4. Wireless Sensor Networks - C.S.Raghavendra, Krishna M.Sivalingam, 2004, Springer.
5. Wireless Sensor Networks - S Anandamurugan, Lakshmi Publications

Course code	Course Title	L	T	P	Credits
R23ECE-OE0007	Satellite Communication **(Open Elective)**	3	0	0	3

Course Objectives:

- Introduce the basic concepts and architecture of satellite communication systems.
- Understand satellite orbits, launch methods, and positioning techniques.
- Study satellite subsystems including transponders and antennas.
- Learn about satellite link design and signal propagation.
- Explore multiple access techniques and satellite applications.

Course Outcomes:

1. Understand satellite system architecture and functions. (L2)
2. Analyze orbital mechanics and satellite positioning. (L4)
3. Understand the design and working of satellite subsystems. (L2)
4. Analyze satellite link budgets and signal propagation. (L4)
5. Understand access techniques and applications in communication systems. (L2)

UNIT – I

Overview of Satellite Communications: Introduction to satellite communication, advantages and limitations, types of satellites, satellite applications in communication, broadcasting, navigation, and remote sensing.

UNIT – II

Orbital Mechanics and Launchin: Kepler's laws, orbital elements, types of satellite orbits (LEO, MEO, GEO), look angle determination, eclipse effects, and satellite launching methods.

UNIT – III

Satellite Subsystems: Space segment and ground segment, transponders, antenna systems, telemetry, tracking and command (TT&C), and power systems.

UNIT – IV

Satellite Link Design and Propagation: Link power budget, system noise temperature, C/N ratio, G/T ratio, propagation effects such as rain attenuation, free-space loss, and ionospheric effects.

UNIT – V

Access Techniques and Applications: FDMA, TDMA, CDMA in satellite communication, VSAT systems, satellite mobile communication, GPS, and DTH systems.

Textbooks:

1. Dennis Roddy, Satellite Communications, McGraw-Hill.
2. Timothy Pratt et al., Satellite Communications, Wiley India.
3. T. K. Bandopadhyay, Satellite Communication, PHI Learning. (Indian Author)

Course code	Course Title	L	T	P	Credits
R23ECE-OE0008	Fundamentals of Embedded Systems **(Open Elective)**	3	0	0	3

Course Objectives

- Basic fundamentals and components of a typical embedded system.
- Embedded system development as a hardware design and firmware design methodologies, tools and integration.
- Understand the need and development of hardware software codesign.
- Aware of the interrupt service mechanism and device driver programming.
- Understand the working of real time operating systems.

Course Outcomes

1. Illustrate the working of various components of a typical embedded system. (L2)
2. Develop hardware and firmware design methodologies, tools and integration for a embedded system. (L3)
3. Discuss the importance and development using hardware software codesign. (L2)
4. Summarize the interrupt service mechanism and device driver programming. (L2)
5. Outline the real time operating system functions and study of a deployed RTOS. (L2)

UNIT-I

Introduction to Embedded System: Embedded System, Embedded System Vs General Computing System, History of Embedded Systems, Classification of Embedded System, major Application Areas, Purpose of Embedded system, Core of Embedded System, Memory, Sensors and Actuators, Communication Interface, other System components, PCB and passive components, Characteristics of Embedded System, Quality Attributes of Embedded System, application and domain specific embedded systems.

UNIT-II

Embedded system Development: Analog and Digital Electronic components, VLSI and IC Design, EDA tools, PCB Fabrication, Embedded Firmware Design approaches, embedded firmware development languages, Integration of Hardware and Firmware, Board Bring up, Embedded System Development Environment – IDE, Types of File Generated on Cross Compilation- Disassembler/ Decompiler, Simulator, Emulator and Debugging, Target hardware Debugging, Boundary Scan,

UNIT-III

Hardware Software Co-design and program modelling: Fundamental Issues in Hardware and Software Co-Design, Computational Models in Embedded Design, Introduction to Unified Modelling Language (UML), hardware Software Trade-offs, embedded product development life cycle- objectives, different phases, approaches of EDLC.

UNIT-IV

Device Drivers and Interrupt service mechanism: Programmed I/o, busy-wait approach without interrupt service mechanism, ISR concepts, interrupt sources, interrupt service handling mechanism, multiple interrupts, context and periods for context switching, interrupt latency and deadline. Classification of processors interrupt service mechanism from context saving, direct memory access, device driver programming.

UNIT-V

Real time operating system: operating system basics, types of operating systems, tasks, process and threads, multiprocessing and multitasking, task scheduling, threads, processes and scheduling, task communication, task synchronization, how to choose an RTOS, case study of ucos-II and vxworks.

Textbooks:

1. Introduction to Embedded System, Shibu K.V, Tata McGraw-Hill, 2014.

References:

1. Embedded Systems- Architecture, programming and Design, 2e, Raj kamal, McGraw Hill Education (India) Private Limited.
2. Embedded System Design- Frank vahid, Tony Givargis, Wiley publications, 2002.

Course code	Course Title	L	T	P	Credits
R23EEE-OE0001	Renewable Energy Sources **(Open Elective)**	3	0	0	3

Course Objectives:

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

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

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

UNIT–I

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

UNIT–II

Solar Thermal Systems: Liquid flat plate collectors: Performance analysis –Transmissivity–Absorptivity product collector efficiency factor – Collector heat removal factor – Numerical problems. Introduction to solar air heaters – Concentrating collectors, solar pond and solar still – solar thermal plants.

UNIT–III

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

UNIT–IV

Wind Energy and Geothermal Energy: Sources of wind energy - Wind patterns – Types of turbines –Horizontal axis and vertical axis machines - Kinetic energy of wind – Betz coefficient – Tip–speed ratio – Efficiency – Power output of wind turbine – Selection of generator (synchronous, induction) – Maximum power point tracking – wind farms.

Geothermal: Classification – Dry rock and hot acquifer – Energy analysis – Geothermal based electric power generation

UNIT–V

Tidal Power, Biomass and Fuel Cells: Tidal power – Basics – Kinetic energy equation – Turbines for tidal power – Numerical problems – Wave power – Basics – Kinetic energy equation – Wave power devices.

Biomass Energy: Fuel classification – Pyrolysis – Direct combustion of heat – Different digesters and sizing.

Fuel cell: Classification of fuel for fuel cells – Fuel cell voltage– Efficiency – V-I characteristics

Text Books:

1. Solar Energy**:** Principles of Thermal Collection and Storage, S. P. Sukhatme and J. K. Nayak, TMH, New Delhi, 3rd Edition.
2. Renewable Energy Resources, John Twidell and Tony Weir, Taylor and Francis - second edition,2013.

Reference Books:

1. Energy Science**:** Principles, Technologies and Impacts, John Andrews and Nick Jelly, Oxford University Press.
2. Renewable Energy- Edited by Godfrey Boyle-oxford university.press,3rd edition,2013.
3. Handbook of renewable technology Ahmed and Zobaa, Ramesh C Bansal, World scientific, Singapore.
4. Renewable Energy Technologies /Ramesh & Kumar /Narosa.
5. Renewable energy technologies – A practical guide for beginners – Chetong Singh Solanki, PHI.
6. Non-conventional energy source –B.H.khan- TMH-2nd edition.

Weblinks:

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

Course code	Course Title	L	T	P	Credits
R23EEE-OE0002	Energy Conservation and Management **(Open Elective)**	3	0	0	3

Course objectives:

- To make the students aware of global energy scenario
- To apply good engineering practices in energy conservation activities
- To summarize the salient features of energy conservation Act 2001.
- To study about energy management and 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: At the end of the Course the student shall be able to

1. Understand the classification of Energy and global energy scenario(L3)
2. Understand the importance of Energy Conservation. (L2)
3. Understand the schemes of energy conservation act 2001 (L3)
4. Analyze the performance of electrical utilities and their efficient improvement approaches (L3)
5. Analyze the life cycle coasting and return on investment of energy efficient technologies(L2)

UNIT – I

ENERGY SCENARIO: Classification of Energy – Primary and Secondary Energy, Commercial Energy and Non-commercial Energy and Renewable & Non-renewable energy; commercial energy production, final energy consumption, energy needs of growing economy, energy intensity on purchasing power parity (PPP), energy consumption in various sectors, long term energy scenario, Indian energy scenario, energy pricing.

UNIT - II

ENERGY CONSERVATION: Energy conservation and its importance – need of energy conservation, energy strategy for the future, energy efficiency and its benefits. Energy security – definition, purpose of implementing national energy security policy. Energy conservation systems- short, medium, long term energy conservation. Energy conservation equipments - Automatic power factor controller (APFC) - Intelligent power factor controller(IPFC).

UNIT - III

ENERGY CONSERVATION ACT – 2001: Energy conservation act – 2001 and its features, power and function of bureau, responsibilities and duties of state designated agencies, schemes of BEE under energy conservation act 2001 – Energy conservation building codes – standards and labelling – demand side management – Bachat lamp yojana(BLY) – promoting energy efficiency in small and medium enterprises – designated consumers – certification of energy auditors and managers (introduction only).

UNIT - IV

ENERGY MANAGEMENT: Energy management – energy management program, function of energy manager, principles of energy management and quality of energy manger, Energy management techniques in transformers and motors - Transformer losses& Energy efficient transformers. - Distribution losses in industrial systems. Assessment of transmission and distribution losses in power systems. - Economics of energy efficient motors and systems. Material and Energy balance: Facility as an energy system, methods for preparing process flow, material and energy balance diagrams.

UNIT - V

ECONOMIC ASPECTS AND ANALYSIS: Electricity billing, electrical load management and maximum demand control, Benefits of demand side management- Harmonics-causes-effects-overcoming - Economics Analysis – Depreciation Methods – Time value of money – Rate of return – Present worth method – Replacement analysis – Life cycle costing analysis.

Text books:

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 Butterworth, Elsevier publications. 2012
2. S.C.Tripathy, "Utilization of Electrical Energy and Conservation", McGraw Hill, 1991.
3. Doty, Steven; Turner, Wayne C, Energy Management Hand book (8th Edition), Fairmont Press, Inc., 978-0-88173-707-3

Web Links:

1. www.energy.gov/energy saver/blower-door-tests.
2. https://beeindia.gov.in/content/energy auditor.
3. www.pcra.org/pages/display180-energy-audit
4. https://www.myscheme.gov.in/schemes/peacedea

Course code	Course Title	L	T	P	Credits
R23EEE-OE0003	Electrical Safety & Standards **(Open Elective)**	3	0	0	3

Course Objectives:

- To Explain the importance of electrical safety and security measures.
- To Demonstrate the principles of safe electrical wiring and fitting practices.
- To Demonstrate the importance of issuing safety clearance notices before energizing equipment.
- To Classify hazardous zones and the associated risks in electrical environments.
- To Explain regulations regarding physical clearances in electrical installations.

Course Outcomes: At the end of this course, students will be able to

1. Explain the principles and scope of electrical safety, including its relevance across residential, commercial, and industrial sector. (L2)
2. Understand the Indian power sector organization and Electricity rules, electrical safety in residential, commercial, agriculture, hazardous areas. (L2)
3. Outline the electrical safety during installation, testing and commissioning procedure. (L2)
4. Make use of specification of electrical plants and classification of safety equipment for various hazardous locations. (L2)
5. Understand Safety Management & Standards in Electrical Systems. (L2)

UNIT-I

Introduction to Electrical Safety, Shocks and its Prevention: Terms and definitions, objectives of safety and security measures, Hazards associated with electric current and voltage, who is exposed, principles of electrical safety, Approaches to prevent Accidents, scope of subject electrical safety. Primary and secondary electrical shocks, possibilities of getting electrical shock and its severity, medical analysis of electric shocks and its effects, shocks due to flash/ Spark over's, prevention of shocks, safety precautions against contact shocks, flash shocks, burns, residential buildings and shop.

UNIT-II

Electrical Safety in Residential, Commercial and Agricultural Installations: Wiring and fitting –Domestic appliances –water tap giving shock –shock from wet wall –fan firing shock – multi-storied building –Temporary installations – Agricultural pump installation –Do's and Don'ts for safety in the use of domestic appliances.

UNIT-III

Electrical Safety during Installation, Testing and Commissioning: Preliminary preparations –safe sequence –risk of plant and equipment –safety documentation –field quality and safety -personal protective equipment –safety clearance notice –safety precautions – safeguards for operators –safety.

UNIT–IV

Electrical Safety in Hazardous Areas: Hazardous zones –class 0,1 and 2 – spark, flashovers and corona discharge and functional requirements – Specifications of electrical plants, equipment's for hazardous locations – Classification of equipment enclosure for various hazardous gases and vapours – classification of equipment/enclosure for hazardous locations.

UNIT-V

Safety Management of Electrical Systems and Standards: Principles of Safety Management, Management Safety Policy, Safety organization, safety auditing, Motivation to managers, supervisors, employees. Review of IE Rules and Acts, their Significance: Objective and scope – ground clearances and section clearances – standards on electrical safety - safe limits of current, voltage –Rules regarding first aid and firefighting facility. The Electricity Act, 2003,

Textbooks

1. Rao, S. and Saluja, H.L., "Electrical Safety, Fire Safety Engineering and Safety
2. Management", Khanna Publishers, 1988.
3. Pradeep Chaturvedi, "Energy management policy, planning and utilization", Concept

Publishing company, New Delhi, 1997

Reference Books

1. Cooper.W.F, “Electrical safety Engineering”, Newnes-Butterworth Company, 1978.
2. John Codick, “Electrical safety hand book”, McGraw Hill Inc., New Delhi, 2000.
3. Nagrath, I.J. and Kothari, D.P., “Power System Engineering”, Tata McGraw Hill, 1998.
4. Wadhwa, C.L., “Electric Power Systems”, New Age International, 2004.

Web Links:

1. https://onlinecourses.nptel.ac.in/noc20_mg43
2. https://onlinecourses.swayam2.ac.in/nou20_cs08/preview
3. https://www.udemy.com/course/electrical-safety

Course code	Course Title	L	T	P	Credits
R23EEE-OE0004	Utilization of Electrical Energy **(Open Elective)**	3	0	0	3

Course Objectives:

- To study the laws of illumination and their applications for various lighting schemes.
- To explain the various methods of Electric heating.
- To explain the various electric traction systems 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: At the end of this course, students will be able to

1. Apply the concepts of illumination to Calculate the illumination levels required for various lighting schemes (L3).
2. Explain the appropriate heating techniques for different applications (L2).
3. Apply the concepts of D.C and A.C traction systems (L3).
4. Apply speed-time curves and the energy consumption of different services under various operating conditions (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, Numerical Problems.

UNIT-II

Electric Heating: Electrical Heating: Advantages, Modes of heat transfer, Design of heating Element, Methods of Electric Heating – Resistance, Arc heating, Induction and Dielectric Heating, Applications of electric heating, Numerical Problems.

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, and Motor Coaches for Track Electrification, DC Equipment, AC Equipment, Overhead Equipment, Numerical Problems.

UNIT–IV

Electric Traction – II: Introduction to Speed-Time Curves of Different Services, Calculations of Tractive Effort Mechanics of Train Movement, Adhesive Weight and Dead Weight, and Coefficient of Adhesion, Numerical Problems.

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.

Textbooks:

1. E. Openshaw Taylor, Utilisation of Electric Energy, Universities Press, Penram International Publishers, 2010
2. N.V. Suryanarayana, Utilisation of Electrical power including Electric drives and Electric Traction, New Age Publishers, 2017.

Reference Books:

1. H. Partab, Art & Science of Utilization of Electric Energy, Dhanpat Rai & Sons, 1998.
2. J. B Gupta, Utilization of Electric Power & Electric Traction S.K. Kataria & Sons, Reprint 2020, 10th Edition.
3. Generation, distribution and utilization of electrical energy, C.L Wadhwa, Wiley Eastern Limited.
4. Electrical Power Systems, S. L. Uppal, Khanna publishers.

Web Links:

1. https://onlinecourses.nptel.ac.in/noc22_ee94/preview
2. https://archive.nptel.ac.in/courses/108/105/108105060/
3. https://archive.nptel.ac.in/courses/112/103/112103263/
4. https://archive.nptel.ac.in/courses/112/107/112107090/
5. https://onlinecourses.nptel.ac.in/noc23_ag06/preview

Course Code	Subject Name	L	T	P	C
R23CSE-OE0001	**PYTHON PROGRAMMING**	3	0	0	3

Course Objectives:

- Understand the structure and data types of Python script.
- Implement iterations and functions in Python.
- Implement modules and understand packages.
- Implement data structures using mutable & immutable objects.
- Understand object-oriented concepts and Exception handling.

Course Outcomes:

- Implement Basic Python programming Fundamentals for Computation of Expression [L3]
- Apply Iterators and functions in data processing.[L3]
- Understand modules and packages to leverage powerful libraries for data science tasks.[L2]
- Implement sequences and data structures for data organization.[L3]
- Implement object-oriented principles in Python, handling run-time errors.[L3]

Unit I: **Hours:10**

Introduction: History of Python, Features of Python, Applications, Python Using the REPL (Shell), Running Python Scripts, Variables, Assignment forms, Keywords, Input-Output, Indentation.

Operators and Type Conversion: Data Types: Numeric, Booleans, Sequence, Strings, Type Conversions, Operators, Operator Precedence, Evaluation of Expressions.

Learning Outcomes: After completing this chapter, students will be able to

- Understand the environment of Python. (L2)
- Write and run simple scripts in Python. (L3)
- Implement Type conversion techniques. (L3)

Unit II: **Hours:10**

Control Flow: Conditional statements (if, else, elif), Looping structures (for, while, for-else, while-else)Transfer Control Statements**:** break, continue, pass.

Functions: Defining Functions, Calling Functions, Types of Arguments: Keyword Arguments, Default Arguments, Variable-length arguments, Fruitful Functions (Function Returning Values), Scope of the Variables in a Function - Global and Local Variables, Anonymous Functions, Lambda, map, reduce and filter.

Learning Outcomes: After completing this chapter, students will be able to

- Understand the iterations using looping structures.(L2)
- Implement Python functions.(L3)

Unit III: **Hours:9**

Modules: Creating modules, import statement, from import statement, namespace, built-in modules- OS, random, Math, JSON, request, date, RegEx, itertools

Packages: Introduction to PIP**,** Installing packages using PIP.

Exploring Data Science Libraries: NumPy, Pandas,Data visualization: Matplotlib

Learning Outcomes: After completing this chapter, student will be able to

- Understand modules (L2)
- Understand data science libraries.(L2)

Unit IV: **Hours:10**

Strings & Data Structures: String**,** String Formatting**,** List, String and List Slicing, Tuple, Sets, Frozen Sets, Dictionaries, Comprehensions, Built-in methods of all sequences, File Handling: Reading and writing files,File modes and file objects

Learning Outcomes: After completing this chapter, student will be able to

- Implement different data structures in Python.(L3)
- Understand different file handling Operations.(L2)

Unit V: **Hours:09**

Object Oriented Programming OOP in Python: Classes, 'self- variable', Methods, Constructor, Inheritance, Polymorphism, and Data Abstraction.

Errors and Exceptions: Syntax Errors, Exceptions, Exception Handlers, Raising Exceptions, User-defined Exceptions.

Learning Outcomes: After completing this chapter, student will be able to

- Understand Object oriented concepts with real world scenarios.(L2)
- Implement exceptions in Python.(L3)

TEXT BOOKS:

1. Let Us Python by Yashavant Kanetkar ,Aditya Kanetkar ,6th edition, BPB Publication
2. Python Programming: Using Problem Solving Approach by Reema Theraja, 2nd edition, Oxford publications.

REFERENCE BOOKS:

1. Python Programming: A Modern Approach, Vamsi Kurama, Pearson.
2. Learning Python, Mark Lutz, Orielly.
3. Python Programming, S Sridhar, J Indumathi, V M Hariharan, 2nd Edition, Pearson, 2024

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH:3; MEDIUM:2; LOW:1**):**

COs	PO1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO11	PO12	PSO1	PSO2	PSO3
	3	2	2	2	3				3			1	2	3	3
	3	3	2	2	3				3			1	2	3	3
	3	3	2	2	3				3			1	2	3	3
	3	3	3	2	3				3			1	2	3	3
	3	3	3	3	3				3			1	2	2	3
	3	3	3	2	3				3			1	2	3	3

** For Entire Course, PO & PSO Mapping*

Course Code	Subject Name	L	T	P	C
R23CSE-OE0002	**DATA STRUCTURES USING C**	3	0	0	3

Course Objectives:

1. To teach efficient storage mechanisms of data for an easy access.
2. To develop application using data structures.
3. To improve the logical ability

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

1. Compare the performances of various Searching and Sorting techniques in terms of time and space complexities.
2. Illustrate the applications of Stacks.
3. Implement various types of Queues and their efficient operations.
4. Demonstrate the advantages of dynamic memory allocation via linked lists.
5. Implement the basic operations, search and traversals on Trees.

UNIT-I

Time and space complexity, Data Structures – Introduction to Data Structures, abstract data types, Searching and Sorting – Sorting- selection sort, bubble sort, insertion sort, quick sort, merge sort, shell sort, radix sort, Searching-linear and binary search methods, comparison of sorting and searching methods.

UNIT –II

Linear list – singly linked list implementation, insertion, deletion and searching operations on linear list, circular linked list implementation, Double linked list implementation, insertion, deletion and searching operations. Applications of linked lists.

UNIT-III

Stacks-Operations, array and linked representations of stacks, stack applications -infix to postfix conversion, postfix expression evaluation, recursion implementation.

UNIT-IV

Queues-operations, array, and linked representations. Circular Queue operations, Dequeues, applications of queues.

UNIT-V

Trees – Definitions, tree representation, properties of trees, Binary tree, Binary tree representation, binary tree properties, binary tree traversals, binary tree implementation, applications of trees.

Text Books:

1. Fundamentals of Data structures in C, 2nd Edition, E.Horowitz, S.Sahniand Susan Anderson-Freed, Universities Press, 2008.
2. Data structures A Programming Approach with C, 2nd Edition D.S.Kushwaha and A.K.Misra, PHI, 2007.

References:

1. Data structures: A Pseudocode Approach with C, 2nd edition, R.F.GilbergAndB.A.Forouzan, CengageLearning.
2. Data structures and Algorithm Analysis in C, 2nd edition, M.A.Weiss, Pearson.
3. Data Structures using C& C ++,2nd Edition A.M.Tanenbaum,Y. Langsam, M.J.Augenstein, Pearson.
4. Data structures and Program Design in C, 2nd edition, R.Kruse, C.L.TondoandB.Leung,Pearson

Course Code	Subject Name	L	T	P	C
R23CSE-OE0003	**OPERATING SYSTEM CONCEPTS**	3	0	0	3

Course Objectives

1. Provide knowledge about the services rendered by operating systems.
2. Present detail discussion on processes, threads and scheduling algorithms.
3. Discuss various file-system implementation issues and memory management techniques.

Course Outcomes:

1. Understand the importance of operating systems and different types of system calls.
2. Analyze the communication between processes and various process scheduling algorithms.
3. Understand the process synchronization, different ways for deadlocks handling.
4. Analyze various memory mapping techniques and different page replacement methods.
5. Evaluate various file allocation and disk scheduling algorithms.

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.

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.

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 from Deadlock.

UNIT-IV: Memory Management:

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

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

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.

Text Books:

1. Silberschatz A, Galvin P B, and Gagne G, Operating System Concepts, 10 th edition, Wiley, 2013.
2. Tanenbaum A S, Modern Operating Systems, 4th edition, Pearson Education, 2008. (forInterprocess Communication and File systems).

References:

i. Tanenbaum A S, Woodhull A S, Operating Systems Design and Implementation, 3rd edition, PHI, 2006.

ii. Dhamdhere D M, Operating Systems A Concept Based Approach, 3rd edition, Tata McGraw-Hill, 2012.

iii. Stallings W, Operating Systems -Internals and Design Principles, 6th edition, Pearson Education, 2009.

iv. Nutt G, Operating Systems, 3rd edition, Pearson Education, 2004.

Course Code	Subject Name	L	T	P	C
R23CSE-OE0004	**INTRODUCTION TO JAVA PROGRAMMING**	3	0	0	3

Course Objectives

1. Understand the structure and environment of Java.
2. Implement the relationship between objects.
3. Understand the Strings and Organize data using different data
4. Implement text processes and error handling.
5. Understand to create multi threading applications and GUI applications.

Course Outcomes:

1. Understand the environment of JRE and Control Statements. (L2)
2. Implement real world objects using class Hierarchy (L3)
3. Implement generic data structures for iterating distinct objects (L3)
4. Implement error handling through exceptions and file handling through streams. (L3)
5. Design thread-safe GUI applications for data communication between objects (L4)

Unit I: Java Environment and Program Structure (10 Hours)

History of Java, Features, Applications, Java Installation - JDK and JRE, JVM Architecture, OOPS Principles, Class and Object, Naming Convention, Data Types, Type Casting, Type Conversion, Wrapper classes, Operators, instance of operator, Command Line Arguments, Decision making, Arrays, and Looping statements.

Learning Outcomes: Student will be able to

1. Understand architecture of Java Virtual Machine. (L2)
2. Understand the structure of java program and its environment. (L2)

Unit II: Class Hierarchy & Data Hiding (10 Hours)

Property, Method, Constructor, Inheritance (IS-A) , Aggregation and Composition (HAS-A), this and super, static and initialize blocks, Method overloading and overriding, static and final keywords, Types of Inheritance, Compile time and Runtime Polymorphism, Access Specifiers and scope, packages and access modifiers, Abstract class, Interface, Interface Inheritance, Achieving Multiple Inheritance, Class casting, Object Cloning, Inner Classes.

Learning Outcomes: Student will be able to

1. Understand the class hierarchy and their scope. (L2)
2. Implement relationship between objects. (L3)
3. Understand data hiding and nested classes. (L2)
4. Implement data type casting and cloning of objects. (L3)

Unit III: Strings and Collections (10 Hours)

String: Methods, StringBuffer and StringBuilder, StringTokenizer

Collections: Exploring java.util.*, Scanner, Iterable, Collection Hierarchy, Set, List, Queue and Map, Comparable and Comparator, Iterators: foreach, Enumeration, Iterator and ListIterator.

Learning Outcomes: Student will be able to

1. Understand the usage of String and its properties and methods.(L2)
2. Understand data structures and Iterators. (L2)
3. Create the data structures and implement different utility classes. (L3)

Unit IV: IO and Error Handling (10 Hours)

IO Streams: Exploring java.io.*, Character and Byte Streams, Reading and Writing, Serialization and De-serialization, Error Handling: Error vs Exception, Exception hierarchy, Types of Exception, Exception handlers, User defined exception, Exception propagation.

Learning Outcomes: Student will be able to

1. Understand character and byte streams. (L2)
2. Understand the hierarchy of errors and exceptions. (L2)
3. Implement data streams and exception handlers. (L3)

Unit V: Threads and GUI (8 Hours)

Multi-Threading: Process vs Thread, Thread Life Cycle, Thread class and Runnable Interface, Thread synchronization and communication.

GUI: Component, Container, Applet, Applet Life Cycle, Event delegation model, Layouts, Menu, MenuBar, MenuItem.

Learning Outcomes: Student will be able to

1. Understand the Thread Life Cycle and its scheduling.(L2)
2. Implement the synchronization of threads. (L2)

TEXT BOOKS:

1. The complete Reference Java, 8th edition, Herbert Schildt, TMH.
2. Programming in JAVA, Sachin Malhotra, SaurabhChoudary, Oxford.
3. Introduction to java programming, 7th edition by Y Daniel Liang, Pearson.
4. Java: How to Program, 9th Edition (Deitel) 9th Edition.
5. Core Java: An Integrated Approach, Java 8 by R. Nageswara Rao.

REFERENCE BOOKS:

1. Swing: Introduction, JFrame, JApplet, JPanel, Componets in Swings, Layout Managers
2. Swings, JList and JScrollPane, Split Pane, JTabbedPane, JTree, JTable, Dialog Box.

Weblinks:

1. https://www.javapoint.com/
2. https://www.sitesbay.com/java/index
3. https://www.tutorialspoint.com/java/index.htm
4. https://www.w3schools.com/java/
5. https://www.programiz.com/java-programming

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1**):**

SNO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	3	2	1	2				1			1	3	1	2
CO2	3	3	2	2	2				2			1	3	1	2
CO3	3	3	2	1	2				2			1	3	1	2
CO4	3	3	2	1	2				2			1	3	1	2
CO5	3	3	2	1	2				2			1	3	1	2

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0005	**DATA BASE MANAGEMENT SYSTEMS CONCEPTS**	**3**	**0**	**0**	**3**

Course Objectives:

1. Train in the fundamental concepts of database management systems, database modeling and design, SQL, PL/SQL, and System implementation techniques.
2. Enable students to model ER diagram for any customized applications.
3. To learn the principles of systematically designing and using large scale Database Management Systems for various applications.

Course Outcomes:

1. Understand the usage of Key Constraints on Database.
2. Describe ER model and normalization for database design.
3. Create, maintain, and manipulate a relational database using SQL.
4. Understand efficient data storage and retrieval mechanism, recovery techniques.
5. Design and build database system for a given real world problem.

UNIT-I:

An Overview of Database Management: Introduction- Importance of Database System, Data Independence- Relation Systems and Others- Summary, Database system architecture, Introduction-The Three Levels of Architecture-The External Level- the Conceptual Level- the Internal Level-Mapping- the Database Administrator-The Database Management Systems- Client/Server Architecture.

UNIT-II:

The E/R Models: The Relational Model, Relational Calculus, Introduction to Database Design, Database Design and ER Diagrams-Entities Attributes, Entity Sets-Relationship and Relationship Sets-Conceptual Design with the ER Models.

The Relational Model: Integrity Constraints Over Relations- Key Constraints –Foreign Key Constraints-General Constraints, Relational Algebra and Calculus, Relational Algebra- Selection and Projection- Set Operation, Renaming – Joins- Division- More Examples of Queries, Relational Calculus - Tuple Relational Calculus, Domain Relational Calculus.

UNIT-III:

Queries, Constraints, Triggers: The Form of Basic SQL Query, Union, Intersect, and Except, Nested Queries, Aggregate Operators, Null Values, Complex Integrity Constraints in SQL, Triggers and ActiveDatabase.

Schema Refinement (Normalization) : Purpose of Normalization or Schema Refinement, Concept of Functional Dependency, Normal Forms Based on Functional Dependency(1NF, 2NF and3 NF), Concept of Surrogate Key, Boyce-Codd Normal Form(BCNF), Lossless Join and Dependency Preserving Decomposition, Fourth NormalForm(4NF).

UNIT-IV:

Transaction Management and Concurrency Control:

Transaction, Properties of Transactions, Transaction Log, Transaction Management with SQL using Commit Rollback and Save Point, Concurrency Control for Lost Updates, Uncommitted Data, Inconsistent Retrievals, and the Scheduler.

Concurrency Control with Locking Methods: Lock Granularity, Lock Types, Two Phase Locking For Ensuring Serializability, Deadlocks, Concurrency Control with Time Stamp Ordering: Wait/Die and Wound/Wait Schemes, Database Recovery Management : Transaction Recovery.

UNIT-V:

Overview of Storages and Indexing: Data on External Storage- File Organization and Indexing – Clustered Indexing – Primary and Secondary Indexes, Index Data Structures, Hash-Based

Indexing – Tree- Based Indexing, Comparison of File Organization.

Text Books:

1. Introduction to Database Systems, 8th Edition CJ Date, Pearson, 2004.
2. Data base Management Systems, Raghurama Krishnan, Johannes Gehrke, TATAMcGraw Hill 3rd Edition.

References Books:

1. Data base Systems design, Implementation, and Management, Peter Rob & Carlos Coronel13th Edition.
2. Fundamentals of Database Systems, 7 th Edition ElmasriNavrate Pearson Education.
3. Database Systems - The Complete Book, 2nd edition H G Molina, J D Ullman, J WidomPearson.
4. Data base System Concepts, 7thedition ,Silberschatz, Korth,Mcgraw Hill (TMH).

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0006	**UNIX and Shell Programming**	3	0	0	3

Course Objectives:

- To provide an overview of the history, development, and significance of UNIX/Linux in computing.
- To provide skills in diagnosing common problems, log analysis, and troubleshooting techniques in a UNIX/Linux environment.
- To provide an overview of system administration tasks such as user management, backup and restore, system monitoring, and software installation.
- To explain file systems, mounting, disk usage, file permissions (chmod), and file attributes (chown).

Course Outcomes:

- Understand the architecture and features of UNIX. (L2)
- Apply the commands for implementation of the File System. (L3)
- Understand the Streams, Pipes and Filters. (L2)
- Apply the pattern reorganization commands and scripting concepts. (L3)
- Implementation of system calls for file system. (L3)

Unit 1 (10 Hours)

Introduction to Unix:

Introduction to Unix-Brief History-What is Unix-Unix Components-Using Unix-Commands in Unix-Some Basic Commands-Command Substitution-Giving MultipleCommands.

Learning Outcomes: Student will be able to

- Understand the origins and development of Unix. (L2)
- Learn the key milestones in the evolution of Unix (L3)
- Learn how to use command substitution to streamline tasks. (L3)

Unit 2 (8 Hours)

Unix Utilities:

Introduction to Unix file system, vi editor, file handling utilities, security by file permissions, process utilities, disk utilities, networking commands, unlink, du, df, mount, unmount, find, unmask, ulimit, ps, w, finger, Arp, ftp, telnet, rlogin. Text processing utilities and backup utilities , detailed commands to be covered are tail, head , sort, nl, uniq, grep, egrep, fgrep, cut, paste, join, tee, pg, comm, cmp, diff, tr, awk, cpio

Learning Outcomes: Student will be able to

1. Learn the organization and layout of the Unix directory hierarchy. (L2)

2. File Attributes and Permissions: Understand the various file attributes and how permissions work. (L2)

Unit 3 (10 Hours)

Introduction to Shells:

Using the Shell-Command Line Structure-Met characters- Creating New Commands-Command Arguments and Parameters-Program Output as Arguments-Shell Variables- -More on I/O Redirection-Looping in Shell Programs.

Filters:

Filters and Pipes, Concatenating files, Display Beginning and End of files, Cut and Paste, Sorting, Translating Characters, Files with Duplicate Lines, Count characters, Words or Lines, Comparing Files.

Learning Outcomes: Student will be able to

1. Understand the role and management of variables in the Unix shell. (L2)
2. Gain advanced knowledge of input/output redirection in Unix. (L3)
3. Learn how to implement loops in shell scripts. (L3)

Unit 4 (12 Hours)

Grep: Operation, grep Family, Searching for File Content.

Sed: Scripts, Operation, Addresses, commands, Applications, grep and sed.

Shell Programming:

Basic Script concepts, Expressions, Decisions: Making Selections, Repetition, special Parameters and Variables, changing Positional Parameters, Argument Validation, Debugging Scripts, Script Examples.

Learning Outcomes: Student will be able to

1. Understand the basics of awk for pattern scanning and text processing (L2)
2. Learn best practices for creating and using effective filters and well-structured files in Unix. (L3)

Unit 5 (8 Hours)

File Management:

File Structures, System Calls for File Management – create, open, close, read, write, lseek, link, symlink, unlink, stat, fstat, lstat, chmod, chown, Directory API – opendir, readdir, closedir, mkdir, rmdir, umask.

Learning Outcomes: Student will be able to

1. Learn how to change file ownership using the chown command.(L2)
2. Understand how to change the group ownership of a file using the chgrp command.(L2)

TEXT BOOKS:

1. Unix and shell Programming Behrouz A. Forouzan, Richard F. Gilberg.Thomson
2. Your Unix the ultimate guide, Sumitabha Das, TMH. 2nd Edition.

REFERENCE BOOKS:

- Unix for programmers and users, 3rd edition, Graham Glass, King Ables, Pearson Education.
- Unix programming environment, Kernighan and Pike, PHI. / Pearson Education.
- The CompleteReference Unix, Rosen, Host, Klee, Farber, Rosinski, Second Edition, TMH.

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1**):**

Cos	**PO1**	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO1 0**	**PO1 1**	**PO1 2**	**PSO 1**	**PSO 2**	**PSO 3**
CO1	3	2	2	1	3				1		1	1	2	3	3
CO2	3	2	2	1	3				1		1	1	2	3	3
CO3	3	3	3	2	3				1		1	2	3	3	3
CO4	3	3	3	2	3				2		1	2	3	3	3
CO5	2	2	2	2	2				2		1	1	2	2	2

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0007	**SOFTWARE ENGINEERING**	3	0	0	3

Course Objectives:
1. Explain the phases of Software Development.
2. Teach the customer requirement gathering techniques.
3. Teach Software Design techniques
4. Demonstrate coding standards
5. Apply the testing techniques on software

Course Outcomes:
Students will be able to:
1. Understand the need of Software Life Cycle Models (L1)
2. Demonstrate the Requirements of the Software Systems process (L2)
3. Summarize the system models of software engineering (L2)
4. Choose appropriate software architecture style for real-time software projects (L3)
5. Analyze various testing techniques, Risk management and Software quality of the software products(L4)

UNIT-1
Introduction: Introduction to Software Engineering, Evolving role of Software, Software Crisis,Changing Nature of Software, Software myths, Process Models for Software Development, Waterfall, prototyping Evolutionary models: Incremental model, Spiral model, Agile developmental process.
Learning Outcomes:
At the end of the module, students will be able to:
1. List the steps involved in software development. (L1)
2. Explain myths of software. (L2)
3. Apply various software process models (L3)

UNIT-2
Software Requirements Engineering: Functional & Non-functional requirements, Feasibility studies, Requirements Elicitation and Analysis, requirements validation, Software Requirements Specification, Process and System Models, context models, behavioural model, Data model.
Learning Outcomes:
At the end of the module, students will be able to:
1. Explain software development model (L2)
2. Define functional and non-functional requirements for software development (L1)
3. Analyse user requirementsfor a software(L4)

UNIT-3
Design Engineering: Design concepts, data design, software architecture, Architectural styles and patterns, User interface design - Golden rules, User interface analysis and design, Effective Modular Design.
Learning Outcomes:
At the end of the module, students will be able to:
1. List the software architecture style for the given problem. (L1)
2. BuildGoldenrulesfor the given problem (L3)
3. User Interface Analysis and Design (L5)

UNIT-4

Coding&Testing: Coding standards, code review and verification, Testing levels: Unit testing, integration testing, system testing . alpha and beta testing, black box and white box testing, debugging.

Learning Outcomes:

At the end of the module, students will be able to:

1. Implementation of coding standards(L6)
2. Apply different Testing concepts (L3)

UNIT-5

Risk Management: Risk types, strategies, Estimation and Planning. Software Quality .McCall Quality factors, Six Sigma for Software Quality, Quality Assurance and its techniques.

Applications: analyze the risks in any software project

Learning Outcomes:

At the end of the module, students will be able to:

1. Evaluate different Risk management techniques. (L5)

Text books:

1. Roger S. Pressman, Software Engineering, A practitioner.s Approach, 7thEdition, McGraw-Hill International Edition, 2009
2. Rajib Mal, Fundamentals of software Engineering, 3rdEdition, Eastern Economy Edition, 2009

Reference books:

1. Sommerville, Software Engineering, 7thEdition, Pearson education, 2004
2. K KAggarwal and Yogeshsingh, Software engineering,3rd Edition,New age International publication,2008

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0008	**Introduction to Data Mining**	3	0	0	3

COURSE OBJECTIVES:

- Students will be enabled to understand and implement classical models and algorithms in data warehousing and data mining.
- They will learn how to analyze the data, identify the problems, and choose the relevant models and algorithms to apply.
- They will further be able to assess the strengths and weaknesses of various methods and algorithms and to analyze their behavior.

COURSE OUTCOMES:

- Understand the process of knowledge discovery from data.
- Analyze the Data Pre-processing techniques.
- Apply classification techniques to various data sets.
- Apply the association rule mining to real time applications
- Apply the clustering algorithms to various data sets.

UNIT –I:

Introduction: Why Data Mining? What Is Data Mining? What Kinds of Data Can Be Mined? What Kinds of Patterns Can Be Mined? Which Technologies Are Used? Which Kinds of Applications Are Targeted? Major Issues in Data Mining. Data Objects and Attribute Types, Basic Statistical Descriptions of Data, Data Visualization, Measuring Data Similarity and Dissimilarity

Learning Outcomes: Student should be able to

1. Summarize the process of Data mining.(L2)
2. Classify various kinds of Data Mining techniques.(L2)
3. Memorize different visualization techniques.(L1)
4. Differentiate a data warehouse with data mining(L4)

UNIT –II:

Data Pre-processing: Data Preprocessing: An Overview, Data Cleaning, Data Integration, Data Reduction, Data Transformation and Data Discretization

Learning Outcomes: Student should be able to

1. Recognize various steps in Data Preprocessing.(L1)
2. Identify the process of handling noisy data.(L1)

UNIT –III:

Classification: Basic Concepts, General Approach to solving a classification problem, Decision Tree Induction: Working of Decision Tree, building a decision tree, methods for expressing an attribute test conditions, measures for selecting the best split, Algorithm for decision tree induction.

Classification: Alterative Techniques, Bayesian Classifier: Bayes theorem, using bayes theorem for classification, Native Bayes Classifier: Bayes error rate, Bayesian Belief Networks: Model representation, model building (Tan)

Learning Outcomes: Student should be able to

1. Summarize the process of classification.(L2)
2. Apply the process of classification on sample data.(L3)
3. Construct a decision tree for any sample data.(L3)
4. Calculate Bayes probability for any given data(L3)
5. Calculate Naïve Bayes probability.(L3)

UNIT –IV:

Association Analysis: Basic Concepts and Algorithms: Problem defination, Frequent Item Set generation, Rule generation, compact representation of frequent item sets, FP-Growth Algorithm. **(Tan &Vipin)**

Learning Outcomes: Student should be able to

1. Apply the Apriori algorithm on any sample data.(L3)
2. Construct an FP tree for any sample data. (L3)

UNIT –V

Cluster Analysis: Basic Concepts and Algorithms: Overview: What Is Cluster Analysis? Different Types of Clustering, Different Types of Clusters; K-means: The Basic K-means Algorithm, K-means Additional Issues, Bisecting K-means, Strengths and Weaknesses; Agglomerative Hierarchical Clustering: Basic Agglomerative Hierarchical Clustering Algorithm DBSCAN: Traditional Density Center-Based Approach, DBSCAN Algorithm, Strengths and Weaknesses. **(Tan &Vipin)**

Learning Outcomes: Student should be able to

1. Identify the data objects and partition them into different clusters.(L2)
2. Apply the different clustering techniques on sample data.(L3)
3. Acquire the knowledge of The strenthg and weakness of clustering algorithms.(L2)

TEXT BOOKS:

1. Introduction to Data Mining: Pang-Ning Tan & Michael Steinbach, Vipin Kumar, Pearson.
2. Data Mining concepts and Techniques, 3/e, Jiawei Han, Michel Kamber, Elsevier.

REFERENCE BOOKS:

1. Data Mining Techniques and Applications: An Introduction, Hongbo Du, Cengage Learning.
2. Data Mining : VikramPudi and P. Radha Krishna, Oxford.
3. Data Mining and Analysis - Fundamental Concepts and Algorithms; Mohammed J. Zaki,Wagner Meira, Jr, Oxford
4. Data Warehousing Data Mining & OLAP, Alex Berson, Stephen Smith, TMH.

MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1):

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	2	2				1			2	2	1	2
CO2	2	3	2	1	2				1			2	2	1	1
CO3	3	2	2	1	2				1			2	2	1	1
CO4	3	3	2	2	2				1			2	2	1	3
CO5	3	2	3	1	2				1			2	2	1	2

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0009	**FUNDAMENTALS OF WEB TECHNOLOGIES**	3	0	0	3

COURSE OBJECTIVES:

1. Creating Web User Interfaces
2. Creating dynamic Web pages
3. Implementing the usage of Scripts in Web Pages
4. Analyzing real world objects into Web Pages as Scripts Handlers
5. Analyzing look and feel kind of applications which are useful for real world
6. Web framework implementation using Model View Controller
7. Writing background scripts to run the virtual machines and servers

COURSE OUTCOMES:

1. Demonstrate knowledge on web page design elements.
2. Design web pages with dynamic content
3. Create Responsive layout with customized forms
4. Implement simple client-side scripts using AJAX
5. Build web applications using PHP

UNIT-I:

HTML: Introduction: Fundamentals of HTML, Working with text, Organizing text in HTML, Working with links and URLs, Creating tables, Working with images, Canvas, Forms, Frames and Multimedia.
HTML5: Introduction, HTML5 document structure, Creating editable content, Checking spelling mistakes.

Learning Outcomes:

After completion of this unit, student will be able to

- Identify basic steps that are followed to develop web applications [L2]
- Understand the functions of different HTML5 tags and how to use them [L2]
- Design and develop basic web pages using HTML5[L3]

UNIT-II:

CSS AND JAVASCRIPT: CSS: Introduction, CSS selectors, Inserting CSS in an HTML document, Backgrounds, Fonts and Text styles, Creating boxes, Displaying, Positioning and floating elements, Features of CSS3,Media queries. JavaScript: Overview of JavaScript, JavaScript functions, Events, Image maps and animations, JavaScript objects, working with browser and document objects.

Learning Outcomes:

After completion of this unit, student will be able to

- Learn the basic syntax of the CSS Style rule[L2]
- Get an idea about different CSS Selectors[L2]
- Use style rules to apply styles to different elements[L3]
- Understand HTML5 DOM object hierarchy[L2]
- Understand java script event handling mechanism[L2]

UNIT -III:

JQUERY and BOOTSTRAP: JQuery: Introduction, JQuery selectors, Events, Methods to access HTML elements and attribute. Bootstrap: Getting started with Bootstrap, Creating responsive layouts using Bootstrap CSS - Basic HTML structure for Bootstrap, Responsive classes, Rendering images, the grid system, Constructing data entry forms.

Learning Outcomes:

After completion of this unit, student will be able to

- Understanding the Bootstrap file structure[L2]
- Learning the basics of responsive design[L2]
- Understanding the all-important grid system in Bootstrap[L2]
- Introduce Bootstrap as a responsive design framework[L2]

UNIT –IV:

XML: Document type Definition, XML schemas, Document object model, XSLT, DOM and SAX Approaches, AJAX A New Approach: Introduction to AJAX, Integrating PHP and AJAX.

Learning Outcomes:

After completion of this unit, student will be able to

- Learn the basic building blocks of XML Documents [L1]
- Understand how name clashes are avoided using namespaces [L2]
- Learn how to create forms dynamically [L2]
- Learn how to generate dynamic tables[L2]
- Write interactive web applications using AJAX [L3]

UNIT-V:

INTRODUCTION TO PHP: Introduction, Data types, Variables, Constants, Expressions, String interpolation, Control structures, Functions, Arrays, Embedding PHP code in web pages, Object Oriented PHP.PHP Web forms: PHP and web forms, Sending form data to a server, Working with cookies and session handlers PHP with MySQL: Interacting with the database, Prepared statement, Database transactions.

Learning Outcomes:

After completion of this unit, student will be able to

- Examine the relationship between PHP and MySQL L2]
- Plan a PHP Web application [L4]
- Create and use a Logon Window [L6]
- Manage User sessions using cookies and sessions [L3]

Text Books:

1. Kogent Learning Solutions Inc, HTML 5 Black Book: Covers CSS3, JavaScript, XML, XHTML, AJAX, PHP and JQuery, Dreamtech Press, Second Edition, 2016.
2. W. Jason Gilmore, Beginning PHP and MySQL, APress, Fourth Edition, 2011.

Reference Books:

1. Snig Bahumik, Bootstrap Essentials, PACKT Publishing, 2015 (e-book).
2. Thomas A. Powell, The Complete Reference: HTML and CSS, Tata McGraw Hill, Fifth Edition, 2010
3. Andrea Tarr, PHP and MySQL, Willy India, 2012.
4. Ruby on Rails Up and Running, Lightning fast Web development, Bruce Tate, Curt Hibbs, Oreilly (2006)

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1):

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	2	2				1			2	2	1	2
CO2	2	3	2	1	2				1			2	2	1	1
CO3	3	2	2	1	2				1			2	2	1	1
CO4	3	3	2	2	2				1			2	2	1	3
CO5	3	2	3	1	2				1			2	2	1	2

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0010	**FUNDAMENTALS OF COMPUTER NETWORKS**	3	0	0	3

Course Objectives:

1. To introduce the fundamental various types of computer networks.
2. To understand state-of-the-art in network protocols, architectures, andapplications.
3. To explore the various layers of OSI Model.

Course Outcomes:

The students can

1. Understand OSI and TCP/IP reference models with an emphasis to Physical Layer, Data Link Layer and NetworkLayer.
2. Analyze the issues related to data link, medium access and transport layers by using channel allocation and connection management schemes. Analyze MAC layer protocols and LANtechnologies.
3. Solve problems related to Flow control, Error control, Congestioncontroland Network Routing.
4. Design and compute subnet masks and addresses for networkingrequirements.
5. Understand how internet works

UNIT-I:

Introduction: Network Hardware and software Reference models- The OSI Reference Model- the TCP/IP Reference Model - A Comparison of the OSI and TCP/IP Reference Models, Examples of Networks: Novell Networks, Arpanet, Internet, Network Topologies WAN, LAN, MAN.

Physical Layer: Guided Transmission Media, Digital Modulation and Multiplexing: frequency division multiplexing, wavelength division multiplexing, synchronous time division multiplexing, statistical time division multiplexing.

UNIT-II:

The Data Link Layer - Design Issues, Services Provided to the Network Layer – Framing – Error Control – Flow Control, Error Detection and Correction – Error-Correcting Codes – Error Detecting Codes, Elementary Data Link Protocols, Sliding Window Protocols.

Channel allocation methods: TDM, FDM, ALOHA, Carrier sense Multiple access protocols, Collision Free protocols – IEEE standard 802 for LANS – Ethernet, Token Bus, Token ring, Bridges and IEEE 802.11 and 802.16. Data link layer switching, virtual LANs.

UNIT-III:

Network layer Routing Algorithms: Design Issues, Routing Algorithms-Shortest path, Flooding,

Flow based Distance vector, Link state, Hierarchical, Broadcast routing, Congestion Control algorithms-General principles of congestion control, Congestion prevention polices, Choke packets, Load shedding, and Jitter Control.

Internet Working: Tunnelling, internetworking, Fragmentation, Network layer in the internet– IP protocols, IP address, Subnets, Internet control protocols, OSPF, BGP, Internet multicasting, Mobile IP, IPV6.

UNIT IV:

The Transport Layer: Elements of transport protocols – addressing, establishing a connection, releasing connection, flow control and buffering and crash recovery, End to end protocols: UDP, Real Time Tran sport Protocol.

The Internet Transport Protocol: TCP- reliable Byte Stream (TCP) end to end format, segment format, connection establishment and termination, sliding window revisited, adaptive retransmission, TCP extension, Remote Procedure Call.

UNIT – V:

Application Layer: WWW and HTTP: Architecture- Client (Browser), Server, 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.

The Domain Name System: The DNS Name Space, Resource Records, Name Servers, Electronic Mail: Architecture and Services, The User Agent, Message Formats, Message Transfer, Final Delivery.

Text Books:

1. Data Communications and Networks – Behrouz A. Forouzan, Third Edition ,TMH.
2. Computer Networks, 5ed, David Patterson,Elsevier
3. Computer Networks: Andrew S Tanenbaum, 5th Edition. PearsonEducation/PHI
4. Computer Networks, Mayank Dave, CENGAGE

References:

1. Tanenbaum and David J Wetherall, Computer Networks, 5th Edition, Pearson Edu, 2010
2. Computer Networks: A Top Down Approach, Behrouz A. Forouzan, FirouzMosharraf, McGraw Hill Education
3. An Engineering Approach to Computer Networks-S.Keshav, 2nd Edition, PearsonEducation.
4. Understanding communications and Networks, 3rd Edition, W.A. Shay, ThomsonThe TCP/IP Guide, by Charles M. Kozierok, Free online Resource,http://www.tcpipguide.com/free/index.htm.

Subject Code	|Subject Name	L	T	P	C
R23CSE-OE0011	**BASICS OF CLOUD COMPUTING**	**3**	**0**	**0**	**3**

Course Objective :

1. To provide students with the fundamentals and essentials of Cloud Computing.
2. To provide students a sound foundation of the Cloud Computing so that they are able to start using and adopting Cloud Computing services and tools in their real life scenarios.
3. To enable students exploring some important cloud computing driven commercial systems and applications.

Course Outcomes :

Upon completion of the course, it is expected that student will be able to:

1. Understand and analyze different computing paradigms
2. Understand the basics of cloud computing and different cloud deployment models.
3. Understand different cloud implementation and management strategies.
4. Understand and evaluate different cloud service models.
5. Identify, analyze and use different cloud services /applications/tools available from key cloud providers.

UNIT-I:

Computing Paradigms: High-Performance Computing, Parallel Computing, Distributed Computing, Cluster Computing, Grid Computing, Cloud Computing, Bio computing, Mobile Computing, Quantum Computing, Optical Computing, Nano computing..

UNIT-II:

Cloud Computing Fundamentals: Motivation for Cloud Computing, The Need for Cloud Computing, Defining Cloud Computing, Definition of Cloud Computing, Cloud Computing is a Service, Cloud Computing is a Platform, Principles of Cloud computing, Five Essential Characteristics, Four Cloud Deployment Models

UNIT-III:

Cloud Computing Architecture and Management: Cloud architecture, Layer, Anatomy of the Cloud, Network Connectivity in Cloud Computing, Applications on the Cloud, Managing the Cloud, Managing the Cloud Infrastructure, Managing the Cloud Application, Migrating Application to Cloud, Phases of Cloud Migration Approaches for Cloud Migration.

UNIT-IV:

Cloud Service Models: Infrastructure as a Service, Characteristics of IaaS. Suitability of IaaS, Pros and Cons of IaaS, Summary of IaaS Providers, Platformas a Service, Characteristics of PaaS, Suitability of PaaS, Pros and Cons of PaaS, Summary of PaaS Providers, Software as a Service, Characteristics of SaaS, Suitability of SaaS, Pros and Cons of SaaS, Summary of SaaS Providers, Other Cloud Service Models.

UNIT-V:

Cloud Providers and Applications : EMC, EMC IT, Captiva Cloud Toolkit, Google Cloud Platform, Cloud Storage, Google Cloud Connect, Google Cloud Print, Google App Engine, Amazon Web Services, Amazon Elastic Compute Cloud, Amazon Simple Storage Service, Amazon Simple Queue service, Microsoft, Windows Azure, Microsoft Assessment and Planning Toolkit, SharePoint, IBM, Cloud Models, IBM Smart Cloud, SAP Labs, SAP HANA Cloud Platform, Virtualization Services Provided by SAP, Sales force, Sales Cloud, Service Cloud: Knowledge as a Service, Rack space, VMware, Manjra soft, Aneka Platform**.**

Text Book:

i. Essentials of Cloud Computing, K. Chandra sekhran, CRC press.

Reference Books:

i. Cloud Computing: Principles and Paradigms, Rajkumar Buyya, James Broberg and Andrzej M. Goscinski,Wiley.
ii. Distributed and Cloud Computing, Kai Hwang, Geoffery C. Fox, Jack J. Dongarra, Elsevier.
iii. Cloud Security and Privacy: An Enterprise Perspective on Risks and Compliance, Tim Mather, Subra Kumara swamy, Shahed Latif, O 'Reilly.

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0012	**INTRODUCTION TO MACHINE LEARNING**	3	0	0	3

Course Objectives:

- To familiarize with a set of well-known Machine Learning (ML) algorithms.
- The ability to implement machine learning algorithms.
- To understand how machine learning algorithms are evaluated.
- To formulate machine learning problems corresponding to different applications.
- To understand a range of machine learning algorithms with their pros and cons.

Course Outcomes:

- Illustrate the characteristics of machine learning algorithms.
- Summarize the process of classification using decision tree approach.
- Apply Bayesian classifier to label data points an ML approach.
- Understand computational and instance-based learning.
- Understand advanced computational and types of learning.

UNIT I: (10 Hours)

Introduction: Well- posed learning problems, designing a learning system, perspectives, and issues in machine learning. Applications of machine learning. **Concept Learning:** Concept learning and the general to specific ordering. Concept learning task, Concept learning as search, Find-s: finding a maximally specific hypothesis, version spaces and the candidate elimination algorithm, Remarks on version spaces and candidate elimination, Inductive bias.

Learning Outcomes: Student will be able to

- Summarize the process of machine learning.
- Recognize various machine learning Applications.
- Understand various candidate elimination algorithms

UNIT II: (09 Hours)

Decision Tree Learning: Decision tree representation, Appropriate problems for decision tree learning, the basic decision tree learning algorithm, Hypothesis space search in decision tree learning, Inductive bias in decision tree learning, Issues in decision tree learning

Learning Outcomes: Student will be able to

- Summarize the process of classification.
- Construct a decision tree for any sample data.

UNIT III: (11 Hours)

Bayesian learning: Bayes theorem, Byes theorem and concept learning, Maximum likelihood and least squared error hypotheses, Maximum likelihood hypotheses for predicting probabilities, Bayes optimal classifier, An example learning to classify text, Bayesian belief networks

Learning Outcomes: Student will be able to

- Calculate Bayes probability for any given data.
- Calculate Naïve Bayes probability.
- Distinguish the process of Bayes and Naïve Bayes probability calculation.

UNIT IV: (09 Hours)

Computational learning theory – 1: Probability learning an approximately correct hypothesis, Sample complexity for infinite Hypothesis spaces, The mistake bound model of learning- Instance- Based learning- Introduction.

Learning Outcomes: Student will be able to

- Understand Probability learning and Instance- Based learning.

UNIT V: (09 Hours)

Computational learning theory – 2: K- Nearest Neighbour Learning, Locally Weighted Regression, Radial Basis Functions, Case-Based Reasoning, Remarks on Lazy and Eager Learning

Learning Outcomes: Student will be able to

- Understand the concept of classification.
- Distinguish lazy Lazy and Eager Learning.

Contemporary Problems:

Explore Modern Tools- Altair Rapid Miner Tools- Scalability Issues- Regularity Complex-Black Box Problem

Text Books

1. Tom M. Mitchell, ―Machine Learning, McGraw-Hill Education (India) Private Limited, 2013.
2. Raschka, Sebastian and Mirjalili, Vahid, Python Machine Learning, 3rd Edition, Packt Publishing., 2019
3. Stephen Marsland- Machine Learning – An Algorithmic Perspective – Second Edition – Chap Man & Hall CRC Press, 2015

References

1. Ethem Alpaydin, Introduction to machine learning, 2nd edition, PHI.
2. Kevin P. Murphy, "Machine Learning," A Probabilistic Perspective, MIT Press, 2012

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1**):**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO 2	PSO 3
CO1	3	3	1	2	2			1	2	1		2	1	2	1
CO2	3	3	1	2	2			1	2	1		2	1	2	1
CO3	3	3	3	3	3			1	2	1		2	1	2	1
CO4	3	3	1	2	2			1	2	1		2	1	2	1
CO5	3	3	1	2	2			1	2	1		2	1	2	1

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0013	**ESSENTIALS OF CYBER SECURITY**	3	0	0	3

Course Objectives:

1. Understand the fundamental concepts and principles of cyber security.
2. Understand Security architecture, risk management, attacks, incidents, and emerging IT and IS technologies.
3. To Provide the importance of Cyber Security and the integral role of Cyber Security professionals.
4. Recognize the importance of cybersecurity in protecting digital assets and information.
5. Analyze real-world cyber-attack scenarios and case studies.

Course Outcomes:

1. Understand Cyber Security architecture principles
2. Analyze the System and application security threats and vulnerabilities
3. Estimate operational cyber security strategies and policies.
4. Apply security model to handle mobile, wireless devices and related security issues.
5. Analyze the functionality of Security Technologies and Controls in Cybersecurity

UNIT - I: (8 Hours)

Introduction to Cyber Security: Need for Cyber security - History of Cyber security - Defining Cyberspace and Cyber security, scope of Cyber security, Importance of Cyber security in the modern world, Evolution of cyber threats,Importance of Cybersecurity in the digital age.

Foundations of Cyber Security: Cyber Security principles, threat models, and cyber laws. Confidentiality, integrity, and availability (CIA) Triad– Cyber security Framework, Security principles and concepts, Risk management.to better understand the dynamics of Cyber Security.

Learning Outcomes:student will be able to

- Outline the Importance of Cyber security. (L2)
- Understand the Security architecture principles and concepts. (L2)
- Understand the Design of Cyber security Framework. (L2)

UNIT-II: (10 Hours)

Common Threats and Attack Vectors: Introduction, Proxy Servers and Anonymizers, Password Cracking, Key loggers and Spywares, Virus and Worms, Trojan Horses and Backdoors, Steganography, DoS and DDoS Attacks, SQL Injection, Buffer Overflow, Attacks on Wireless Networks, Social Engineering attacks: Introduction, Phishing, spear phishing, pretexting, Identity Theft (ID Theft).

Learning Outcomes:student will be able to

- Understand about the Cyber security Threats and Attacks. (L2)
- Summarize the various types of application security vulnerabilities(L2)
- Analyze the System and application security threats and vulnerabilities(L4)

UNIT-III: (12 Hours)

Introduction to Cyber Crime, law and Investigation: Introduction to Cybercrime**,** Definition and scope of cybercrime, Categories of cybercrimes, Impact of cybercrime, Cybercrime and Information Security, classifications of cybercrimes, Cybercrime: The Legal Perspectives, cybercrime and theIndian IT Act 2000, a Global perspective on Cybercrimes.

Cyber laws: Introduction to Cyber Laws, Need for Cyber laws The Indian Context, The Indian IT Act, Challenges to Indian Law and Cybercrime Scenario in India, Consequences of Not Addressing the Weakness in Information Technology Act, Digital Signatures and the Indian IT Act, Information Security Planning and Governance, Information Security Policy Standards.

Learning Outcomes: student will be able to

- Extend The Categories of cybercrimes and Impact of cybercrime(L2)
- Understand about the Need for Cyber laws and Cybercrime Scenario in India(L2)
- Estimate operational cyber security strategies and policies(L5)
- Develop an understanding of cybercrimes and various legal perspectives involved(L3)

UNIT-IV: (10 Hours)

Cybercrime-Mobile and Wireless Devices: Introduction, Proliferation of Mobile and Wireless Devices, Trends in Mobility, Credit Card Frauds in Mobile and Wireless Computing Era, Authentication Service Security, Attacks on Mobile/Cell Phones.

Mobile Devices: Security Implications for Organizations, Organizational Measures for Handling Mobile Devices-Related Security Issues, Organizational Security Policies and Measures in Mobile Computing Era, Laptops.

Learning Outcomes: student will be able to

- Understand Various devices and related security issues (L2)
- Develop a security model to handle Policies and Measures in Computing era(L3)
- Develop a security model to handle mobile, wireless devices and related security issues of an organization (L3)

UNIT-V: (8 Hours)

Security Technologies and Controls in Cyber security: Access control mechanisms, Encryption, Firewalls, intrusion detection systems (IDS), intrusion prevention systems (IPS), Network Security, Security Information and Event Management (SIEM),functionality of cyber security tools.

Legal and Ethical Aspects of Cyber Security: Laws and regulations governing cyber security,
Ethical considerations in cyber security practices, Privacy issues.

Learning Outcomes: student will be able to

- Analyze the functionality of Security Technologies and Controls in Cyber security(L4)
- Outline the Ethical considerations in cyber security practices(L2)
- Understand the functionality of cyber security tools(L2)

Text Books:

1. Computer Security: Principles and Practice, Third Edition, William Stallings, Lawrie Brown ,Pearson Education, 2014.
2. Cyber Security Understanding Cyber Crimes, Computer Forensics and Legal Perspectives, Nina Godbole, SunitBelapure, 1st Edition Publication Wiley, 2011.
3. William Stallings, Effective Cyber security: A Guide to Using Best Practices and Standards, 1st edition, 2019.
4. Mark Rhodes, Ousley, Information Security, 1st Edition, MGH, 2013.

Reference Books:

1. Principles of Information Security, MichaelE. Whitman and Herbert J. Mattord, CengageLearning.
2. 2. Charles J. Brooks, Christopher Grow, Philip A. Craig, Donald Short, Cybersecurity Essentials, Wiley Publisher, 2018.
3. Yuri Diogenes, ErdalOzkaya, Cyber security - Attack and Defense Strategies, Packt Publishers,

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH:3; MEDIUM:2; LOW:1**):**

CNO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO3
	3	**2**	**1**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**-**	**-**	**1**
	3	**3**	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1**	**2**	**-**	**1**
	3	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**2**	**-**	**-**
	3	**2**	**1**	**1**	**2**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**-**	**-**	**1**
	3	**2**	**2**	**2**	**2**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**1**	**2**	**-**
	3	**2**	**2**	**2**	**2**	**-**	**-**	**-**	**-**	**1**	**-**	**1**	**2**	**2**	**1**

** For Entire Course, PO & PSO Mapping*

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0014	**INTRODUCTION TO REACT JS**	3	0	0	3

Course Objectives:

- To learn essential React JS skills for front-end development.
- To explore client-side JavaScript application development and the React library.
- To implement React components, hooks, and state management for building interactive UIs.
- To gain experience with React.js, JSX, HTML, CSS, and JavaScript.
- To create a functional front-end web application using React.

Course Outcomes:

1. Understand the anatomy of React Java Script. (L2)
2. Understand the life cycle methods of React JS. (L2)
3. Implement React components for building applications. (L3)
4. Apply React hooks for component reusability and monitoring. (L3)
5. Implement React rendering for interactive applications. (L3)

Unit 1 (10 Hours)

React JS: Introduction to React JS, React vs Angular, React Version History, Architecture of the React Application, Installation, Creating and Running React App, Anatomy of React Project.
Templating using JSX: Expressions, Operators, Attributes, Fragments.

Learning Outcomes: Student will be able to

- Understand react framework for building applications. (L2)
- Understand the installations of react packages. (L2)
- Implement templates in react applications. (L3)

Unit 2 (8 Hours)

React Core: Props, State, Event Handling, Lists and Keys, Styling, Pagination, React Life Cycle, Life Cycle Methods, State Management, Mounting Life Cycle.

Learning Outcomes: Student will be able to

- Understand event handling in React. (L2).
- Implement life cycle methods in react. (L3).
- Implement props and states in building react apps. (L3)

Unit 3 (10 Hours)

React Components: Pure Components, memo, Refs, Portals, Higher Order Components (HOC), Context, HTTP requests (POST & GET).

Learning Outcomes: Student will be able to

- Understand http request methods in handling end points. (L2)
- Implement components to handle react requests. (L3)
- Implement higher order components and refs in react. (L3)

Unit 4 (12 Hours)

React Hooks: Introduction to Hooks, useState, useEffect, Run Effects, Fetching Data, useContext, useReducer, useCallBack, useMemo, useRef, Custom Hooks

Learning Outcomes: Student will be able to

- Understand react hooks. (L2)
- Apply hooks and custom methods for handling components. (L3)
- Implement context and callback methods in hooks. (L3)

Unit 5 (8 Hours)

React Render: Introduction to Rendering, useState, useReducer, State Immutability, Parent & Child, Memo, Context, useCallBack.

Learning Outcomes: Student will be able to

- Understand the working react rendering. (L2)
- Implement userReducer and context for rendering react apps. (L3)

TEXT BOOKS:

1. React.js Book: Learning React JavaScript Library From Scratch by Greg Sidelnikov, Learning Curve.
2. React: Quickstart Step-By-Step Guide To Learning React Javascript Library (React.js, Reactjs, Learning React JS, React Javascript, React Programming) by Lionel Lopez

REFERENCE BOOKS:

- Full-Stack React Projects: Learn MERN stack development by building modern web apps using MongoDB, Express, React, and Node.js, 2nd Edition by Shama Hoque, Packt

Course Code	Subject Name	L	T	P	C
R23CSE-OE0015	**Deep Learning**	3	0	0	3

Course Objectives

1. Understand the fundamentals of machine learning algorithms and their challenges.
2. Learn the architecture and training of deep feedforward networks.
3. Master regularization techniques to improve deep learning model performance.
4. Explore optimization methods for training deep neural networks.
5. Gain comprehensive knowledge of convolutional neural networks and their applications.

Course Outcomes: Upon successful completion of course , students will be able to

1. Apply machine learning algorithms to solve practical problems, demonstrating understanding of overfitting and underfitting (Application).
2. Analyse and design deep feedforward networks using gradient-based learning techniques (Analysis).
3. Evaluate the effectiveness of various regularization techniques to enhance model performance and robustness (Evaluation).
4. Analyse advanced optimization strategies to efficiently train deep neural networks (Synthesis).
5. Understand the convolutional neural networks, explaining their significance in the context of deep learning history and neuroscientific principles.

Unit-I – Machine Learning Basics (8 Hours)

Learning Algorithms-Capacity,OverfittingandUnderfitting-HyperparametersandValidationSets-Estimators,BiasandVariance -SupervisedLearningAlgorithms -UnsupervisedLearningAlgorithms -ChallengesMotivatingDeepLearning.

Learning Outcomes: Student will be able to understand the fundamentals of machine learning.

Application:ML Algorithms can use in health care, NLP and computer vision applications.

Unit – II: DeepNetworks (8 Hours)

Deep Feed forward Networks: Example: Learning XOR - Gradient-Based Learning - Hidden Units - Architecture Design – BackPropagation and Other Differentiation Algorithms.

Learning Outcomes: Student will be able to analyse the fundamentals of deep learning.

Application: Deep Networks can use in NLP and finance applications for solving complex problems.

Unit – III: Regularization for Deep Learning (8 Hours)

Parameter Norm Penalties – Norm Penaltiesas Constrained Optimization- Regularization and Under Constrained Problems – DatasetAugmentation-NoiseRobustness- SemiSupervisedLearning- MultiTaskLearning- EarlyStopping - ParameterTyingandParameterSharing – SparseRepresentations -BaggingandOtherEnsembleMethods -Dropout.

Learning Outcomes: Student will be able to evaluate the regularization importance in deep neural networks.

Application: Regularization is used for improve the performance of network in various applications like computer vision and NLP etc.

Unit – IV: Optimization for Training Deep Models (8 Hours)

How Learning Differs from Pure Optimization- Challenges in Neural Network Optimization- Basic Algorithms – Parameter Initialization Strategies – Algorithms with Adaptive Learning Rates- Approximate Second Order Methods- Optimization Strategies and Meta-Algorithms.

Learning Outcomes: Student will be able to analyse the fundamentals of optimization techniques in deep learning.

Application: Optimization techniques are using in many applications like NLP,computer vision and finance sector.

Unit – V: Convolutional Networks (8 Hours)

The Convolution Operation- Motivation- Pooling – Convolution and Pooling as an Infinitely Strong Prior – Variants of the Basic Convolution Function- The Neuro scientific Basis for Convolutional Networks – Convolutional Networks and the History of Deep Learning.

Learning Outcomes: Student will be able tounderstand the purpose of CNN and its importance in deep learning.

Application:CNN used in the area of computer vision applications and many more like NLP, finance and manufacturing sectors.

Text Books: Ian Goodfellow and Yoshua Bengio and Aaron Courville," Deep Learning"MIT Press, 2017.
References Books:
1. Shai ShalevShwartz, Shai BenDavid"Understanding Machine Learning: From Theory to Algorithms" , Cambridge Press
2.Peter Harington " Machine Learning in Action", , 2012, Cengage.

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1**):**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
C01	3	2	1	1	1							1			1
C02	3	2	1	1	1							1			1
C03	3	2	1	1	1							1			1
C04	3	2	1	1	1							1			1
C05	3	2	1	1	1							1			1

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0016	**DevOps**	3	0	0	3

Course Objectives:
DevOps improves collaboration and productivity by automating infrastructure and workflows and continuously measuring applications performance.
(Need to write at least 5 objects for this course)

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

1. Enumerate the principles of continuous development and deployment, automation of configuration management, inter-team collaboration, and IT service agility
2. Understand different actions performed through Version control tools like Git.
3. Illustrate the types of version control systems, continuous integration tools, continuous monitoring tools, and cloud models
4. Ability to Perform Automated Continuous Deployment
5. Understand to leverage Cloud-based DevOps tools using Azure DevOps

Need to write what is the skill gained by student at the end of each unit and mention the blooms taxonomy levels in parenthesis for each course outcome

UNIT –I:
Introduction to Software Engineering: Phases of Software Development life cycle. Models ,Values and principles of agile software development.
Learning outcomes:

- Identify and describe the phases of the Software Development Life Cycle (SDLC) (Knowledge, Understanding). (L1 & L2)
- Compare and contrast different software development models (e.g., Waterfall, Agile) and their applications (L3)
- Apply the values and principles of agile software development in real-world scenarios (L3)

UNIT -II: Introduction To DevOps -Devops Essentials – Introduction To AWS, GCP, Azure – Version control systems: Git and Github.
Learning outcomes:

- Understand the essentials of DevOps and its importance in modern software development (L2)
- Demonstrate the use of version control systems(L3)
- Compare cloud platforms and their relevance to DevOps practices (L3)

UNIT –III:
DevOps adoption in projects: Technology aspects, Agiling capabilities, Tool stack implementation, People aspect, processes.
Learning outcomes:

- Analyze the technology aspects required for successful DevOps adoption (L4)
- Analyze the agile capabilities and tool stack implementation for DevOps in various projects (L4)
- Analyze the people and process aspects necessary for DevOps adoption and their impact on project success (L4)

UNIT -IV:

CONTINUOUS INTEGRATION USING JENKINS: Install & Configure Jenkins, Jenkins Architecture Overview, Creating a Jenkins Job, Configuring a Jenkins job, Introduction to Plugins, Adding Plugins to Jenkins, Commonly used plugins (Git Plugin, Parameter Plugin, HTML Publisher, Copy Artifact and Extended choice parameters). Configuring Jenkins to work with java, Git and Maven, Creating a Jenkins Build and Jenkins workspace.

Learning outcomes:

- Install and configure Jenkins for continuous integration (L3)
- implement Jenkins jobs and pipelines, including configuring jobs and adding plugins (L3)
- Understand Jenkins in continuous integration by creating and managing builds (L2)

UNIT–V: BUILDING DEVOPS PIPELINES USING AZURE : Create Github Account, Create Repository, Create Azure Organization, Create a new pipeline, Build a sample code, Modify azure-pipelines.yaml file

Learning outcomes:

- Create and manage repositories on GitHub and integrate them with Azure DevOps (Application). (L3)
- Implement new pipeline in Azure DevOps and build sample code using azure-pipelines.yaml file(L3)
- Analyze the Modification and optimization Azure DevOps pipelines for continuous deployment (L4)

Text Books:

- Roberto Vormittag, "A Practical Guide to Git and GitHub for Windows Users: From Beginner to Expert in Easy Step-By-Step Exercises", Second Edition, Kindle Edition, 2016.
- Jason Cannon, "Linux for Beginners: An Introduction to the Linux Operating System and Command Line", Kindle Edition, 2014

Reference Books:

- Hands-On Azure Devops: Cicd Implementation For Mobile, Hybrid, And Web Applications Using Azure Devops And Microsoft Azure: CICD Implementation for … DevOps and Microsoft Azure (English Edition) Paperback – 1 January 2020 by Mitesh Soni
- Jeff Geerling, "Ansible for DevOps: Server and configuration management for humans", First Edition, 2015.
- David Johnson, "Ansible for DevOps: Everything You Need to Know to Use Ansible for DevOps", Second Edition, 2016.
- MariotTsitoara, "Ansible 6. Beginning Git and GitHub: A Comprehensive Guide to Version Control, Project Management, and Teamwork for the New Developer", Second Edition, 2019.

Web References :

- https://www.jenkins.io/user-handbook.pdf
- https://maven.apache.org/guides/getting-started/

COURSE OUTCOMES VS POs MAPPING (DETAILED: HIGH: 3, MEDIUM: 2, LOW: 1)

Course	CNO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
DevOps		3	3	2	2					2			1	3	1	2
		3	3	2	2					2			1	3	1	2
		3	3	2		2				2			1	3	1	2
		3	3	2		2				2			1	3	1	2
		3	3	2		2				2			1	3	1	2
		3	3	2	2	2				2			1	3	1	2

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0017	**Mobile Computing**	3	0	0	3

Course Objective:

1. Understand the fundamental concepts, architecture, and paradigms of mobile computing and GSM.
2. Comprehend the motivation for specialized MAC techniques in wireless communications, addressing issues such as hidden and exposed terminals, near and far terminals and IEEE 802.11.
3. Analyze the IP and Mobile IP network layers, focusing on packet delivery, handover management, location management, registration, tunneling, encapsulation and DHCP.
4. Understand conventional TCP/IP protocols and specialized protocols like Indirect TCP, Snooping TCP, and Mobile TCP for mobile networks and database issues in mobile computing.
5. Introduce the concept, applications, and challenges of Mobile Ad hoc Networks (MANETs), and to explore various routing algorithms such as DSR, AODV, and DSDV.

Course Outcomes: Upon Successful completion of Course, the students will be able to

1. Understand t the fundamental concepts, architecture, and paradigms of mobile computing and GSM.
2. Understand the need for specialized MAC techniques in wireless communications, addressing challenges like hidden and exposed terminals, near and far terminals and IEEE 802.11.
3. Understand the concept of the IP and Mobile IP network layers, focusing on packet delivery, handover management, location management, registration, tunnelling, encapsulation, route optimization, and DHCP.
4. Understand proficient in conventional TCP/IP protocols as well as specialized protocols like Indirect TCP, Snooping TCP, and Mobile TCP.
5. Understand the concept, applications, and challenges of Mobile Ad hoc Networks (MANETs).

UNIT I

Introduction: Mobile Communications, Mobile Computing – Paradigm, Promises/Novel Applications and Impediments and Architecture; Mobile and Handheld Devices, Limitations of Mobile and Handheld Devices.

GSM – Services, System Architecture, Radio Interfaces, Protocols, Localization and Calling, Handover, Security, New Data Services, GPRS.

Learning Outcome:

1) Student able to understand the basic concepts of mobile communications and GSM.

UNIT –II

(Wireless) Medium Access Control (MAC): Motivation for a specialized MAC (Hidden and exposed Terminals, Near and far terminals), SDMA, FDMA, TDMA, CDMA.

Learning Outcome:

1) Student able to differentiate the SDMA,FDMA,TDMA and CDMA.

UNIT –III

Mobile Network Layer:IP and Mobile IP Network Layers, Packet Delivery and Handover Management, Location Management, Registration, Tunnelling and Encapsulation, Route Optimization, DHCP.

Learning Outcome:

1) Student able to explain the Mobile IP in mobile networks.

UNIT –IV

Mobile Transport Layer: Conventional TCP/IP Protocols, Indirect TCP, Snooping TCP, Mobile TCP, Other Transport Layer Protocols for Mobile Networks.

Learning Outcome:

1) Student able to understand the issues of databases and Mobile TCP/IP in mobile networks.

UNIT V

Mobile Ad hoc Networks (MANETs): Introduction, Applications & Challenges of a MANET, Routing, Classification of Routing Algorithms, Algorithms such as DSR, AODV, DSDV, etc., Mobile Agents, Service Discovery. **Protocols and Platforms for Mobile Computing:** WAP, Bluetooth, XML, J2ME, Java Card, PalmOS, Windows CE, SymbianOS, Linux for Mobile Devices, Android.

Learning Outcomes:

1) Student able to identify the best routing protocol for mobile networks for data transmission.

Text Books:

1. Jochen Schiller, “Mobile Communications”, Addison-Wesley, Second Edition, 2009.
2. Raj Kamal, “Mobile Computing”, Oxford University Press, 2007, ISBN: 0195686772

Reference Book:

1. ASOKE K TALUKDER, HASAN AHMED, ROOPA R YAVAGAL, “Mobile Computing, Technology Applications and Service Creation” Second Edition, Mc Graw Hill.
2. UWE Hansmann, Lother Merk, Martin S. Nocklous, Thomas Stober, “Principles of Mobile Computing,” Second Edition, Springer.

Course Code	Subject Name	L	T	P	C
R23CSE-OE0018	Java Full-Stack Development (Open Elective)	0	1	2	2

Course Objectives:

1. Understand the basics of full-stack web development and the software development life cycle.
2. Design simple and responsive web pages using HTML, CSS, and JavaScript.
3. Develop basic backend applications using Java Servlets, JSP, and connect to databases.
4. Learn how to use SQL for database management.
5. Build and deploy a simple full-stack project using basic tools.

Course Outcomes: After completing this course, students will be able to:

1. Understand the structure of a full-stack web application.
2. Design interactive and responsive web pages.
3. Write basic backend logic and connect to a database.
4. Apply simple SQL queries to manage data effectively.
5. Build and deploy a simple full-stack project.

Unit 1: Frontend Development

Introduction to Full-Stack Development

- What is Full-Stack Development?
- Frontend, Backend, and Databases overview

HTML & CSS Basics

- HTML5: Elements, Forms, Tables
- CSS3: Selectors, Flexbox, Grid
- Responsive design with media queries

JavaScript Basics

- Variables, Loops, Functions
- Simple DOM Manipulation and Event Handling

Unit 2: Backend Development

Java Servlets & JSP

- Servlet lifecycle
- Handling HTTP requests and responses
- Basic JSP: Scripting and Expressions

Introduction to Hibernate

- What is Hibernate?
- Basic setup and configuration
- Mapping simple Java classes to database tables

Unit 3: Database Development

SQL Basics

- SELECT, INSERT, UPDATE, DELETE
- Simple JOINs
- Basic database normalization

Hibernate Basics

- Using annotations for mapping
- Simple one-to-many relationships
- Basic queries with HQL

Unit 4: Introduction to Frameworks

Spring & Spring Boot

- What is Spring? IoC and Dependency Injection
- Introduction to Spring Boot: Starter packs, auto-configuration
- Simple Spring Boot application connecting to a database

Unit 5: REST APIs & Deployment

RESTful APIs

- Basic REST concepts: GET, POST, PUT, DELETE
- Building a simple REST API with Spring Boot

Deployment Basics

- Using Git/GitHub for version control
- Testing APIs with Postman
- Simple project deployment (local server)

Project & Capstone

Mini Projects:

- Online Book Store
- Student Portal or basic E-Commerce App

Tools:

- Git/GitHub for version control
- Maven/Gradle for builds
- Postman for testing

Project & Deployment Tools

- Git & GitHub – Version Control
- Maven/Gradle – Build Tools
- Postman – API Testing

Full-Stack Capstone Project

- Online Book Store / Student Portal
- E-Commerce App with Payment Gateway.

CONTEMPORARY TOPICS:

1. Micro services Architecture using Spring Boot and Spring Cloud
2. JWT-Based Authentication and Authorization in Web Applications
3. Containerization and Deployment using Docker and Kubernetes
4. Integration of No SQL Databases like MongoDB with Java Applications

APPLICATIONS:

1. **Online Book Store**
   - Features: User registration/login, book catalog, shopping cart, order management, admin panel
   - Tech Stack: Java Spring Boot , React/HTML-CSS-JS , MySQL
2. **Student Information Portal**
   - Features: Student profiles, course registration, grade tracking, admin dashboard
   - Tech Stack: Java Servlets + Hibernate, Bootstrap + JavaScript , PostgreSQL
3. **Job Placement Management System**
   - Features: Company registration, student applications, interview tracking, placement stats
   - Tech Stack: Spring Boot + JSP , HTML/CSS + JavaScript , MySQL

TEXT BOOKS:

1. "Learning Web Design" by Jennifer Niederst Robbins, 5th Edition, O'Reilly Media
2. "Beginning Hibernate: For Hibernate 5" by Joseph B. Ottinger, Jeff Linwood, Dave Minter, 4th Edition, Apress

REFERENCE BOOKS:

1. "Web Programming and Internet Technologies"byUttam K. Roy, Published 2010, Oxford University Press.
2. "Java: The Complete Reference" By Herbert Schildt, Published 2023, McGraw Hill Education

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1**)**

Cos	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**	**PSO1**	**PSO2**	**PSO 3**
117.1	3	2	2	1	3				1		1	1	2	3	3
117.2	3	2	2	1	3				1		1	1	2	3	3
117.3	3	3	3	2	3				1		1	2	3	3	3
117.4	3	3	3	2	3				1		1	2	3	3	3
117.5	2	2	2	2	2				1		1	1	2	2	2
117*	3	2	2	2	3				1		1	1	2	3	3

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0019	Human Computer Interface	3	0	0	3

Course Objectives:

1. Demonstrate an understanding of guidelines, principles, and theories influencing human Computer interaction.
2. Recognize how a computer system may be modified to include human diversity.
3. Select an effective style for a specific application.
4. Design mock ups and carry out user and expert evaluation of interfaces.
5. Carry out the steps of experimental design, usability and experimental testing, and evaluation of human computer interaction systems.
6. Use the information sources available, and be aware of the methodologies and technologies supporting advances in HCI.

Course Outcomes:

UNIT-I:

The User Interface: Introduction, Importance of the User Interface, Importance and benefits of Good Design History of Human Computer Interface. Characteristics of Graphical and Web User Interface: Graphical User Interface, popularity of graphics, concepts of Direct Manipulation, Graphical System advantage and disadvantage, Characteristics of GUI. Web User Interface, popularity of web, Characteristics of Web Interface, Merging of Graphical Business systems& the Web, Principles of User Interface Design.

UNIT-II:

The User Interface Design Process: Obstacles and Pitfall in the development Process, Usability, The Design Team, Human Interaction with Computers, Important Human Characteristics in Design, Human Consideration in Design, Human Interaction Speeds, Performance versus Preference, Methods for Gaining and Understanding of Users

UNIT-III:

Understanding Business Functions: Business Definitions & Requirement analysis, Determining Business Functions, Design standards or Style Guides, System Training and Documentation

UNIT-IV:

Principles of Good Screen Design: Human considerations in screen Design, interface design goals, test for a good design, screen meaning and purpose, Technological considerations in Interface Design System Menus and Navigation Schemes: Structure, Functions, Context, Formatting, Phrasing and Selecting, Navigating of Menus, Kinds of Graphical Menus Windows Interface: Windows characteristic, Components of Window, Windows Presentation Styles, Types of Windows, Window Management, Web systems.

UNIT-V:

Device and Screen-Based Control: Device based controls, Operable Controls, Text entry/read-Only Controls, Section Controls, Combining Entry/Selection Controls, Other Operable Controls and Presentation Controls, Selecting proper controls

Text Books:

1. Wilbert O. Galitz, “The Essential Guide to User Interface Design”, Wiley India Edition
2. Prece, Rogers, “Sharps Interaction Design”, Wiley India.
3. Ben Shneidermann,”Designing the user interfaces”. 3rd Edition, Pearson Education Asia.

References Books:

1. Soren Lauesen, “User Interface Design” , Pearson Education
2. Alan Cooper, Robert Riemann, David Cronin, “Essentials of Interaction Design”, Wiley
3. Alan Dix, Janet Fincay, GreGoryd, Abowd, Russell, Bealg,”HumanComputer Interaction”, Pearson Education

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0020	**Cryptography and network security**	3	0	0	3

Course Objectives:

- Understand the fundamentals of Information Security
- Acquire knowledge on Security Needs to provide confidentiality, integrity and authenticity.
- Understand the various key cryptography concepts
- Design security applications using security policies
- Understand the Security Issues in TCP/IP

Course Outcomes:

1. Analyze the vulnerabilities in any computing system and hence be able to design a security solution
2. Identify the security needs in the network
3. Explain the basic objectives of symmetric &Asymmetric key cryptography technique to secure the communication over the internet
4. Identify the security policies to provide strong authentication
5. Understand basic ecommerce security protocols.

Unit 1: Introduction.

The History of Information Security, Balancing Information Security and Access, Introduction and Security Trends, General Security Concepts and introduction to what is an "info sphere", Operational Security and People's Role in Information Security.

Learning outcomes: Student should be able to

1. Understand various types of Information Security concepts (L2)
2. Analyze the role of information security.(L4)

Unit 2: Security Needs.

The Need for Security, Business Needs, Needs to protect against Threats and Attacks, Security in Emails. Secure Software Development.

Learning outcomes: Student should be able to

1. Understand the need of security to deal with the threats and attacks.(L2)

Unit 3: Cryptography Concepts.

Concepts of Data encryption, Introduction, Plaintext & Cipher text, Substitution Techniques, Transposition Techniques, Encryption & Decryption, Symmetric& Asymmetric key Cryptography. Public Key Infrastructure (PKI), Different attacks on Cryptosystems

Network Security & Web Security.

Security Issues in TCP/IP – TCP, DNS, Routing (Topics such as basic problems of security in TCP/IP, IPsec, BGP Security, DNS Cache poisoning etc), Network Defense tools – Firewalls, Intrusion Detection, Filtering, DNSSec, NSec3, Distributed Firewalls

Learning outcomes: Student should be able to

1. Understand various Cryptography Concepts (L2)
2. Analyze the impact of Symmetric& Asymmetric key Cryptography in real time applications (L4)
3. Understand Security Issues in TCP/IP. (L2)
4. Identify the tools to provide the web and network security. (L2)

Unit 4: Security Policies and Security Handshake Pitfalls:
What is security policy, high and low level policy, user issues? Protocol problems, assumptions, Shared secret protocols, public key protocols, mutual authentication, reflection attacks, use of timestamps, nonce and sequence numbers, session keys, one-and two-way public key based authentication.
Learning Outcomes: Student should be able to

1. Understand various Security Policies for authentication (L2)
2. Identity various Security Handshake (L2)

Unit 5: Network Security:
Electronic mail security, IP security, Network management security. Security for electronic commerce: E-commerce security analysis, protocol, SSL, SET
System Security:
Intruders and Viruses, Firewalls, Intrusion Detection.
Learning outcomes: Student should be able to

1. Apply the concepts of the cryptography and security in case studies. (L4)

Text Books:
1. Michael E Whitman and Herbert J Mattord, "Principles of Information Security", Vikas Publishing House, New Delhi.
2 Micki Krause, Harold F. Tipton, " Handbook of Information Security Management", CRC Press LLC
3. AtulKahate, Cryptography and Network Security, McGraw Hill
4 Kaufman, c., Perlman, R., and Speciner, M., Network Security, Private Communication in a public world, 2nd ed., Prentice Hall PTR., 2002
5. Stallings, W.,.Cryptography and Network Security: Principles and Practice, 3rd ed., Prentice Hall PTR.,2003
6. Stallings, W. Network security Essentials: Applications and standards, Prentice Hall, 2000

COURSE OUTCOMES VS POS MAPPING (HIGH:3; MEDIUM:2;LOW:1**):**

CNO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO1	PSO2	PSO 3
	3	2						1				2		1	1
	2	2						1				2		1	1
	2	2						1				2		1	1
	2	2						1				2		1	1
	2	2						1				2		1	1
	2	2						1				2		1	1

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0021	**QUANTUM COMPUTING**	**3**	**0**	**0**	**3**

Course Objectives:

1. To understand the components of computing in a Quantum world
2. To gain knowledge on mathematical representation of quantum physics and operations.
3. To write computations in the real world (standard) in a Quantum computer and simulator.

Course Outcomes:

By the end of this course, the student is able to

1. Analyze the behavior of basic quantum algorithms
2. Implement simple quantum algorithms and information channels in the quantum circuit model
3. Simulate a simple quantum error-correcting code
4. Prove basic facts about quantum information channels
5. Know about Quantum Computing Models

UNIT –I:

Introduction: Quantum Measurements Density Matrices, Positive-Operator Valued Measure, Fragility of quantum information: Decoherence, Quantum Superposition and Entanglement, Quantum Gates and Circuits.

UNIT –II:

Quantum Basics and Principles: No cloning theorem & Quantum Teleportation, Bell's inequality and its implications, Quantum Algorithms & Circuits.

UNIT -III:

Algorithms: Deutsch and Deutsch–Jozsa algorithms, Grover's Search Algorithm, Quantum Fourier Transform, Shore's Factorization Algorithm.

UNIT –IV:

Performance, Security and Scalability: Quantum Error Correction: Fault tolerance; Quantum Cryptography, Implementing Quantum Computing: issues of fidelity; Scalability in quantum computing.

UNIT -V:

Quantum Computing Models: NMR Quantum Computing, Spintronics and QED MODEL, Linear Optical MODEL, Nonlinear Optical Approaches; Limits of all the discussed approaches, Future of Quantum computing.

Text Books:

1. Eric R. Johnston, Nic Harrigan, Mercedes and Gimeno-Segovia “Programming Quantum Computers: Essential Algorithms And Code Samples, SHROFF/O’Reilly.
2. Dr. Christine Corbett Moran, Mastering Quantum Computing with IBM QX: Explore the world of quantum computing using the Quantum Composer and Qiskit, Kindle Edition Packt

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0022	**BIG DATA ANALYTICS**	3	0	0	3

Course Objectives:

- Optimize business decisions and create a competitive advantage with Big Data analytics
- Introducing Hadoop concepts for developing solutions.
- Derive business benefits from unstructured data
- Imparting the architectural concepts of Hadoop and introducing map- reduce paradigm
- To introduce programming tools PIG & HIVE in the Hadoop ecosystem.

Course Outcomes:

1. Understands the basic concepts and challenges of handling Big Data.
2. Applying data modelling techniques of Big Data.
3. Analyze Hadoop components & its applications.
4. Analyze spark for optimized query execution and memory caching.
5. Understand the Big data frame work and its applications.

UNIT-I

Introduction: Introduction to Big data, Characteristics &Classification of Data, Challenges of conventional systems(storage), Intelligent data analysis, The Life cycle of Big Data Analytics, Typesof Big Data Analytics, Analytic processes, and tools, Big Data Industry Applications, Analysisvs. Reporting.

Learning Outcomes: Students will be able to

- Understands the Basic concept of Big Data.
- Understands their challenges in the industry

UNIT-II

Working with Big Data: Google File System, Hadoop Distributed File System (HDFS) –Building blocksof Hadoop (Name node, Datanode, Secondary Name node, Job Tracker,Task Tracker),WhatisNoSQL,WhyNoSQL, Use of No SQL in Industry, Comparison of SQL, No SQL, and New SQL ,No SQL Business Drivers ,No SQL Case Studies,

Learning Outcomes:Students will be able to

- Understand HDFS and its basic building blocks
- Understand No SQL for working with Data sets.

UNIT-III

IntroductiontoHadoop:why Hadoop, RDBMS versus Hadoop, History of Hadoop, Components of Hadoop, Hadoop Distributed File System (HDFS), Processing Data withHadoop, How Map Reduce Works, Anatomy of a Map Reduce Job run ,Map Reduce Features Hadoop environment. Interacting with Hadoop Ecosystem.

Learning Outcomes:Studentswill beableto

- UnderstandandimplementHadoopComponents.
- UnderstandtheConceptofInteractingwiththeHadoopEcosystem.

UNIT-IV

SPARK: SPARK BASICS, Using the Spark Shell, RDD Data Types and RDD Creation, RDDs (Resilient Distributed Datasets) in Spark, General RDD Operations: Transformations & Actions, RDD Lineage, RDD Persistence, Overview, Distributed Persistence

Learning Outcomes: Student will be able to

- Understand Hadoop Architecture,
- Explain about Hadoop Ecosystem components.

UNIT-V

Frameworks and Applications: HIVE : Hive Shell, Hive Services, Hive Meta store, Comparison with Traditional Databases **Learning,**Frameworks: Applications on Big Data Using Pig and Hive, Data processing operators in Pig, Hive Architecture of Hive, Hive services, HiveQL, Querying Data in Hive, fundamentals of H Base and Zoo keeper.

Outcomes: Students will be able to

- Work with PIG and Hive Tech.
- Understandprogrammingtoolsof HIVEintheHadoopechosystem.
- Appling acompletebusinessdataanalyticsolution.

Text Books :

1. BigDataAnalytics2ndEdition,SeemaAcharya,SubhashiniChellappan,WileyIndiaPvt.Ltd, SecondEdition,1Jan 2019.
2. Min Chen, Shiwen Mao, Yin Zhang,Victor C.M. Leung, "Big Data: Related Technologies, Challenges and Future Prospects", Springer; 2014.
3. BigJava4thEdition,CayHorstman,WileyJohnWiley&Sons,INC,byWileyIndiaPvt. Ltd,2008.
4. Hadoop:TheDefinitiveGuidebyTomWhite,3rdEdition,O'Reilly,12June 2012.
5. Tom White, "Hadoop- The Definitive Guide", O'reilly, 4th Edition, April 2015.

Reference Books :

1. HadoopinPracticebyAlexHolmes,MANNINGPubl,SecondEdition,5Feb2015.
2. HadoopMapReduceCookbook,SrinathPerera,ThilinaGunarathne,Ingramshorttitle, 1Jan 2013.
3. Hadoop for Dummies by Dirk deRoos, Paul C.Zikopoulos, RomanB.Melnyk,BruceBrown,Rafael Coss,byForDummies, FirstEdition,7 May2014.
4. Eric Sammer, "Hadoop Operations", O'Reilley, 2nd Edition., October 2012.

Software Links :

1. Hadoop:http://hadoop.apache.org/+
2. Hive:https://cwiki.apache.org/confluence/display/Hive/Home
3. Piglatin:http://pig.apache.org/docs/r0.7.0/tutorial.html
4. http://www.jbonneau.com/doc/2012-04-27-big_data_lecture_1.pdf
5. https: //www.ibm.com / developerworks / community / blogs / Susan Visser Editionntry/flash book understanding big data analytics for enterprise class hadoop and streaming data? Langen

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
x.1	1	2	2	3	1	2	1	1	1	-	2	1	1	2	1
x.2	2	1	3	3	3	-	-	-	1	-	-	1	2	3	1
x.3	1	2	1	3	3	3	-	-	1	-	1	1	3	3	1
x.4	2	2	3	3	3	1	1	-	-	-	1	1	3	3	3
x.5	2	2	3	3	3	1	1	-	-	-	1	1	3	3	3

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0023	**BLOCK CHAIN TECHNOLOGIES**	**3**	**0**	**0**	**3**

Course Objective:

1. To provide conceptual understanding of the function of Blockchain as a method of securing distributed ledgers.
2. To understand the structure of a Blockchain and why/when it is better than a simple distributed database
3. To make students understand the technological underpinnings of Blockchain operations as distributed data structures and decision making systems.

Course Outcomes:

Upon completion of the course, it is expected that student will be able to:

1. Define and explain the fundamentals of Blockchain.
2. Understand decentralization and the role of Blockchain in it.
3. UnderstandandanalyzeBitcioinCryptocurrencyandunderlyingBlockchainnetwork.
4. Understand Etherium currency and platform, and develop applications using Solidity.
5. Understand Hyper ledger project and its components; critically analyze the challenges and future opportunities in Block chain technology.

UNIT-I:

Introduction: History and basics, Types of Blockchain, Consensus, CAP Theorem.

Cryptographic Hash Functions: Properties of hash functions, Secure Hash Algorithm, Merkle trees, Patricia trees.

UNIT-II:

Decentralization: Decentralization using Blockchain, Methods of decentralization, decentralization framework, Blockchain and full ecosystem decentralization, Smart contracts, Decentralized Organizations, Platforms for decentralization.

UNIT-III:

Bitcoin: Introduction to Bitcoin, Digital keys and addresses, Transactions, Blockchain, The Bitcoin network, Bitcoin payments, Bitcoin Clients and APIs, Alternatives to Proof of Work, Bitcoin limitations.

UNIT-IV:

Etherium: Smart Contracts, Introduction to Ethereum, The Ethereum network, Components of the Ethereum ecosystem, Blocks and Blockchain, Fee schedule, Ethereum Development Environment, Solidity.

UNIT-V:

Hyperledger: Introduction, Hyperledger Projects, Protocol, Architecture, Hyperledger Fabric, Sawtooth Lake, Corda.

Challenges and Opportunities: Scalability, Privacy, Blockchain for IoT, Emerging trends

Text Book:

1. Mastering Block chain, Imran Bashir, Second Edition, PacktPublishing.

References:

1. Mastering Bitcoin: Unlocking Digital Cryptocurrencies, 3rd Edition Andreas Antonopoulos,O'Reilly.
2. Blockchain Blueprint for a New Economy, Melanie Swan,O'Reilly.
3. Mastering Bitcoin: Programming the Open Blockchain, Antonopoulos, Andreas M. O'Reilly.
4. Blockchain Technology: Cryptocurrency and Applications, S. Shukla, M. Dhawan, S. Sharma, S. Venkatesan, Oxford University Press

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0024	**MULTIMEDIA APPLICATION DEVELOPMENT**	3	0	0	3

COURSE OBJECTIVES: To learn

1. To understand the definition of multimedia
2. To understand and differentiate text, image, video & audio.
3. To describe the ways in which multimedia information is captured, processed, and rendered
4. Introduce multimedia quality of service (QoS) and to compare subjective and objective methods of assessing user satisfaction and multicast protocols to provide QoS guarantees
5. Discuss privacy and copyright issues in the context of multimedia

COURSE OUTCOMES: Upon successful completion of the course, the student is able to

1. Describe different realizations of multimedia tools and the way in which they are used
2. Analyze the structure of the tools in the light of low-level constraints imposed by the adoption of various QoS schemes (i.e. bottom up approach)
3. Analyze the effects of scale and use on both presentation and lower-level requirements (i.e. top down approach)
4. State the properties of different media streams;
5. Compare and contrast different network protocols and to describe mechanisms for providing QoS guarantees in the network.

UNIT – I Classes: 12

Introduction: Definitions - Brief history of Multimedia; its market; content and copyright –public Domain, establishment of Copyright, fair use, multimedia copyright issues; resources for multimedia developers – Uses of multimedia - Making multimedia : Stages of a project

UNIT – II Classes: 14

Hardware Macintosh Versus Windows Platform – Connections – SCSI – IDE – EIDE – ULTRA – IDE – ATA – ULTRA - ATA - Memory and Storage Devices - Input Devices - Output Hardware – CommunicationDevices Basic Software Tools :Text Editing - Word Processing - OCR Software - Painting and Drawing Tools - 3D Modeling and Animation Tools - Image Editing - Sound Editing – Animation – Video - Digital Movie tools - Movie Editors - Compressing Movie Files MLR Institute of Technology B.Tech-IT Academic Regulations &Syllabi – MLR18

UNIT – III Classes: 14

Text : Fonts – Designing – Choosing -Menus for Navigation - Buttons for Interaction – Fields for Readings - HTML Documents - Symbols and Icons – Animating - Fonts Foundries – Managing Fonts - Character sets and Alphabets - Mapping Text – Fontographer - Hypermedia Structures – Hypertext tools Sound : Power of sound - Multimedia System Sound - MIDI Versus Digital Audio - Preparing Digital Audio Files - Making MIDI Audio - Audio File Formats - Sound for the World Wide Web – Adding Sound to Your Multimedia Project - Toward Professional Sound - The Red Book Standard – Space Considerations - Production Tips - Audio Recording -

Keeping Track of Your Sounds - Testing and Evaluation

UNIT – IV Classes: 12

Introduction: The Bandwidth Bottleneck - Internet Services - MIME-Types - World Wide Web and HTML – Dynamic Web Pages and XML - Multimedia on the Web. Tools for the World Wide Web: Web Servers - Web Browsers - Web Page Makers and Site Builders - Plug ins and Delivery Vehicles - Text – Images –Sound - Animation, Video and Presentation - Beyond HTML - 3D Worlds, designing for the World Wide Web..

UNIT – V Classes: 08

Multimedia File Handling: Compression & De compression - Data & file formats standards - Digital voice, Audio, video – Video image and Animation - Full motion video - storage and retrieval Technologies

Text Books:

1. Multimedia making it work Tay Vaughan Tata McGrawHill, Delhi
2. Multimedia – Technology and applications David Hillman Galgotia Publications, Delhi

Subject Code	Subject Name	L	T	P	C
R23CSE-OE0025	**MOBILE AD-HOC NETWORKS**	3	0	0	3

Course Objectives:

- To understand the concepts of Ad Hoc Wireless Networks
- To understand the Data Transmission in MANETS
- To understand the MAC protocols for ad-hoc networks
- To understand and analyze the various routing protocols and model link cost
- Understanding cross layer design in Adhoc Networks

Course Outcomes:

1. Evaluate the principles and characteristics of mobile ad hoc networks (MANETs) and what distinguishes them from infrastructure-based networks
2. Discuss the challenges in designing MAC, routing, and transport protocols for wireless ad-hoc sensor networks
3.. Understand the MAC Protocols for Ad Hoc Wireless Networks
4. Illustrate the various Routing Protocols And Transport Layer In Ad Hoc Wireless
5. Demonstrate the issues and challenges in security provisioning and also familiar with the mechanisms for implementing security and trust mechanisms in MANETs and WSNs

UNIT - 1

INTRODUCTION: Introduction to ad-hoc networks – definition, characteristics features, applications. Characteristics of wireless channel, ad-hoc mobility models: indoor and outdoor models.

UNIT - 2

MEDIUM ACCESS PROTOCOLS: MAC Protocols: Design issues, goals and classification. Contention based protocols – with reservation, scheduling algorithms, protocols using directional antennas. IEEE standards: 802.11a, 802.11b, 802.11g, 802.15. HIPERLAN.

UNIT - 3

NETWORK PROTOCOLS: Routing Protocols: Design issues, goals and classification. Proactive Vs reactive routing, unicast routing algorithms, Multicast routing algorithms, hybrid routing algorithm, energy aware routing algorithm, hierarchical routing, QoS aware routing.

UNIT - 4

END – END DELIVERY AND SECURITY: Transport Layer: Issues in designing – Transport layer classification, adhoc transport protocols.
Security issues in adhoc networks: issues and challenges, network security attacks, secure routing protocols.

UNIT – 5

CROSS LAYER DESIGN:
Cross layer Design: Need for cross layer design, cross layer optimization, parameter optimization techniques, cross layer cautionary perspective. Integration of adhoc with Mobile IP networks.

TEXT BOOKS:

1. C. Siva Ram Murthy and B. S. Manoj, Ad hoc Wireless Networks Architecture and Protocols, 2nd edition, Pearson Edition, 2007.
2. Charles E. Perkins, Ad hoc Networking, Addison – Wesley, 2000.

REFERENCES:

1. Stefano Basagni, Marco Conti, Silvia Giordano and Ivan stojmenovic, Mobile ad-hoc networking, Wiley-IEEE press, 2004.
2. Mohammad Ilyas, The handbook of ad-hoc wireless networks, CRC press, 2002.
3. T. Camp, J. Boleng, and V. Davies " A Survey of Mobility Models for Ad-hoc Network"
4. Research, "Wireless Commun, and Mobile Comp.. Special Issue on Mobile Ad-hoc Networking Research, Trends and Applications, Vol. 2, no. 5, 2002, pp. 483 – 502.
5. A survey of integrating IP mobility protocols and Mobile Ad-hoc networks, Fekri M.bduljalil and Shrikant K. Bodhe, IEEE communication Survey and tutorials, no: 12007.

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1**):**

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	1	2									2	
CO2	3	3	3	1	2									2	
CO3	3	3	3	1	2									2	
CO4	3	3	3	1	2									2	
CO5	3	3	3	1	2									2	

Subject Code	Subject Name	L	T	P	C
R23CSS-OE0001	Operating Systems	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
2. Analyze process scheduling algorithms and various IPC mechanisms.
3. Understand the process synchronization, different ways for dead locks handling.
4. Analyze different page replacement methods, various File management techniques
5. Understand Linux and Android environment and behavior

Unit: 1: Operating Systems Overview: Introduction: What Operating systems Do, Types of Operating systems, Computer system Architecture, Computer system organization, Operating system functions, Operating systems operations, Protection and Security.

Virtualization: Types of Virtualizations, Benefits, and Challenges.

System structure: Operating System Services, User and Operating - System Interface, System calls, Types of System Calls, Operating system debugging, System Boot.

Learning Outcomes: Student will be able to

- Understand operating system structure and functions.
- Understand operating system services and system calls
- Comprehend the basics of virtualization

Unit: 2: Process Management: 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 will be able to

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

Unit: 3: 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, Concurrency in Distributed Systems, Consistency, and Replication.

Learning Outcomes: Student will be able to

- Analyze various solutions for process synchronization.
- Analyze the reasons for deadlocks and proposed solutions to detect, avoid, recovery from deadlocks.
- Understand concurrency issues in distributed systems

Unit: 4: Memory Management:

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

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

File system Interface and Introduction to Network Programming: - the concept of a file, Access Methods, OSI model, Unix standards, TCP and UDP & TCP connection establishment and Format, Buffer sizes and limitation, standard internet services, Protocol usage by common internet application.

Learning Outcomes: Student will be able to

- Demonstrate the ability to implement various memory management techniques
- Illustrate various demand paging techniques.
- Identify various file management and optimization techniques.

Unit: 5: Network Programming and OS Security:

Sockets: Address structures, value – result arguments, Byte ordering and manipulation function and related functions.

Elementary TCP sockets – Socket, connect, bind, listen,accept, fork and exec function, concurrent servers. Close function and related function.

Elementary UDP sockets: Introduction UDP Echo server function, lost datagram, summary of UDP example, Lack of flow control with UDP, determining outgoing interface with UDP.

OS Security - Security Policies, Intrusion Detection, and Prevention.

Learning Outcomes: Student will be able to

- Understand socket programming.
- Understand basics of UDP (L2), Comprehend OS security concepts

Text Books:

1. Silbers chatz A, Galvin PB, and Gagne G, Operating System Concepts, 9th edition, Wiley, 2013
2. Tanenbaum AS, Modern Operating Systems, 3rd edition, Pearson Education, 2008. (for Inter process Communication and File systems).

References:

1. Tanenbaum AS, Woodhull AS,Operating Systems Design and Implementation, 3rd edition, PHI, 2006.
2. Dhamdhere D M, Operating Systems A Concept Based Approach, 3rd edition, Tata Mc Graw-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
R23CSS-OE0002	Red Hat Linux	3	0	0	3

Course Objectives:

- Master essential command-line tools for file manipulation, system access, and documentation in a RHEL environment.
- Implement core system administration tasks, including booting, process control, service control (systemd), and managing user/group accounts.
- Configure and manage local storage using partitions, filesystems (XFS/Ext4), and Logical Volume Management (LVM).
- Secure the system by configuring the firewall (firewalld), managing file permissions, and enforcing SE Linux policies.
- Perform network configuration, package management, and write basic Bash shell scripts for task automation.

Course Outcomes:

1. Navigate and operate a Red Hat Enterprise Linux system entirely from the command line.
2. Manage local security policies, including users, groups, and file permissions.
3. Diagnose and troubleshoot boot process failures and service issues.
4. Apply proper file system management techniques, including creating and extending LVM.
5. Automate routine administrative tasks using shell scripting and scheduled utilities.

Unit 1: Essentials and System Access

Introduction to RHEL: Command Line Interface (CLI), Shell basics, using grep and regular expressions.
Getting Help: Utilizing man pages and system documentation.
File Management: Standard commands (ls, cp, mv), hard and soft links.
Text Editing and Remote Access: Using vim/nano for configuration; Secure Shell (ssh) usage.

Unit 2: Running Systems and Management

System Boot and Processes: Boot procedure, run levels, interrupting boot for recovery.
Process Control: Identifying, managing, and adjusting process priority (top, kill, nice).
Service Control: Managing system services and daemons using systemctl (systemd).
Package Management: Installing, updating, and removing software using dnf / yum (RPM).
User and Group Administration: Creating, modifying, and managing local users, groups, and password policies.

Unit 3: Storage Administration

Disk Partitioning: Understanding MBR/GPT and creating partitions.
Filesystems: Creating, mounting and managing XFS/Ext4 filesystems, and configuring /etc/fstab.
Logical Volume Management (LVM): PVs, VGs, LVs, creating, resizing, and extending logical volumes.
Network Storage: Basics of mounting **NFS** and **SMB/CIFS** shares.

Unit 4: Networking and Security

Basic Networking Configuration: Configuring IPv4/IPv6 addresses and network interfaces.
Firewall Management: Configuring network access restrictions using firewalld.
Security Contexts: Managing Access Control Lists (ACLs) for granular permissions.
SELinux: Introduction to SELinux modes, contexts, and troubleshooting access issues.
System Logging: Locating and interpreting system logs using journal ctl.

Unit 5: Automation and Advanced Topics

Archiving and Scheduling: Using **tar** and compression utilities; scheduling tasks with **cron** and at.
Bash Shell Scripting: Introduction, variables, conditional execution (if), loops, and processing script inputs/outputs.
Kernel and Updates: Managing kernel modules and performing system maintenance/updates.
Virtualization / Containers: Overview of enterprise virtualization and container concepts (e.g., Podman).

Text Books:

1. Red Hat RHCSA [RHEL Version] Cert Guide (Exam EX200), Sander van Vugt
2. UNIX and Linux System Administration Handbook, Evi Nemeth, Garth Snyder

Subject Code	Subject Name	L	T	P	C
R23CSS-OE0003	Cloud Computing	3	0	0	3

Course Objectives:

- To implement Virtualization
- To implement Task Scheduling algorithms
- Apply Map-Reduce concept to applications
- To build Private Cloud
- Broadly educate to know the impact of engineering on legal and societal issues involved

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

1. Interpret the key dimensions of the challenge of Cloud Computing
2. Examine the economics, financial, and technological implications for selecting cloud computing for own organization
3. Assessing the financial, technological, and organizational capacity of employers for actively initiating and installing cloud-based applications
4. Evaluate own organizations. needs for capacity building and training in cloud computing-related IT areas
5. Illustrate Virtualization for Data-Center Automation

UNIT I

Introduction: Network centric computing, Network centric content, peer-to .peer systems, cloud computing delivery models and services, Ethical issues, Vulnerabilities, Major challenges for cloud computing. Parallel and Distributed Systems: introduction, architecture, distributed systems, communication protocols, logical clocks, message delivery rules, concurrency, and model concurrency with Petri Nets.

UNIT II

Cloud Infrastructure: At Amazon, The Google Perspective, Microsoft Windows Azure, Open Source Software Platforms, Cloud storage diversity, Inter cloud, energy use and ecological impact, responsibility sharing, user experience, Software licensing, Cloud Computing : Applications and Paradigms: Challenges for cloud, existing cloud applications and new opportunities, architectural styles, workflows, The Zookeeper, HPC on cloud.

UNIT III

Cloud Resource virtualization: Virtualization, layering and virtualization, virtual machine monitors, virtual machines, virtualization- full and para, performance and security isolation, hardware support for virtualization, Case Study: Xen, vBlades, Cloud Resource Management and Scheduling: Policies and Mechanisms, Applications of control theory to task scheduling, Stability of a two-level resource allocation architecture, feedback control based on dynamic thresholds, coordination, resource bundling, scheduling algorithms, fair queuing, start time fair queuing, cloud scheduling subject to deadlines, Scheduling Map Reduce applications, Resource management and dynamic application scaling.

UNIT IV

Storage Systems: Evolution of storage technology, storage models, file systems and database, distributed file systems, general parallel file systems. Google file system. Apache Hadoop, Big Table, Megastore (text book 1), Amazon Simple Storage Service(S3) (Text book 2), Cloud Security: Cloud security risks, security . a top concern for cloud users, privacy and

privacy impact assessment, trust, OS security, Virtual machine security, Security risks.

UNIT V

Cloud Application Development: Amazon Web Services : EC2 – instances, connecting clients, security rules, launching, usage of S3 in Java, Cloud based simulation of a Distributed trust algorithm, Cloud service for adaptive data streaming (Text Book 1), Google: Google App Engine, Google Web Toolkit (Text Book 2), Microsoft: Azure Services Platform, Windows live, Exchange Online, Share Point Services, Microsoft Dynamics CRM (Text Book 2)

Text Books:

1. Cloud Computing, Theory and Practice,1st Edition, Dan C Marinescu, MK Elsevier publisher ,2013
2. Cloud Computing, A Practical Approach, 1st Edition, Anthony T Velte, Toby J Velte, Robert Elsenpeter, TMH,2017

Reference Books:

1. Mastering Cloud Computing, Foundations and Application Programming,1st Edition, Raj Kumar Buyya, Christen vecctiola, S Tammaraiselvi, TMH,2013
2. Essential of Cloud Computing, 1st Edition, K Chandrasekharan, CRC Press, 2014.
3. Cloud Computing, A Hands on Approach, ArshdeepBahga, Vijay Madisetti, Universities Press, 2014.

Subject Code	Subject Name	L	T	P	C
R23CSS-OE0004	Distributed Operating Systems	3	0	0	3

Course Objectives:

- To study the concepts and design principles of Distributed Operating Systems,
- To understand clock synchronization protocols and distributed file system implementation,
- To gain knowledge on communication, synchronization, and consistency models in distributed systems.

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

- Explain the architecture and components of distributed systems,
- Understand various synchronization and coordination mechanisms,
- Analyze consistency and fault tolerance issues,
- Describe distributed file systems and object-based distributed environments,
- Apply concepts of distributed systems in real-time applications.

Detailed Syllabus:

Unit I – Fundamentals of Distributed Systems

Introduction to distributed systems, Goals of distributed systems, Hardware and software concepts, Design issues, Network operating systems, Comparison between time-sharing, multiprocessor, and true distributed systems, System architectures for distributed systems.

Unit II – Communication in Distributed Systems

Basics of communication systems, Layered protocols, ATM models, Client–Server model, Blocking and non-blocking primitives, Buffered and unbuffered communication, Reliable and unreliable primitives, Message passing, Remote Procedure Call (RPC).

Unit III – Synchronization and Processes

Clock synchronization, Mutual exclusion in distributed systems, Election algorithms, Atomic transactions, Deadlock handling, Processes and threads in distributed systems, System models, Processor allocation, Process scheduling in distributed systems.

Unit IV – Consistency, Replication, and Fault Tolerance

Data-centric and client-centric consistency models, Replica management, Consistency protocols, Fault tolerance in distributed systems, Process resilience, Distributed commit protocols, Reliable client–server communication.

Unit V – Distributed Object-Based Systems and File Systems

Distributed object-based systems, Object-oriented architecture, Processes and communication in object-based systems, Synchronization in object environments, Consistency and replication in object-based systems, Distributed file system design and implementation.

Reference Books:

- Andrew S. Tanenbaum, *Distributed Operating Systems*, Pearson Education, Reprint, 2011,
- Andrew S. Tanenbaum and Maarten Van Steen, *Distributed Systems – Principles and Paradigms*, 2nd Edition, PHI, 2007,
- Pradeep K. Sinha, *Distributed Operating Systems – Concepts and Design*, PHI, 2007.

Subject Code	Subject Name	L	T	P	C
R23CIT-OE0001	Basics of Computer Networks	3	0	0	3

Course Objectives:

1. understand the contemporary technologies in network protocols and network architecture
2. To acquire the knowledge on design principles of network infrastructure. the basics Physical layer and their functionality.
3. Understand the functionalities of the Data Link Layer and their protocols.
4. Understand the functionalities of the Network Link Layer and routing Algorithms.
5. Analyze different protocols in Application Layer

Course Outcomes:

1. Analyze different types of network topologies, various Reference models.[L2]
2. Analyze network performance metrics and data transmission Techniques.[L4]
3. Analyze different data link layer framing techniques and Link Layer Protocols.[L4]
4. Analyze the medium access techniques and different routing algorithms.[L4]
5. Understand various Application layer protocols.[L2]

Unit 1: **10-Hours**

Introduction: Components of a Data Communication system, Dataflow **,** Network Topologies Categories of Networks: LAN, MAN,WAN. Reference models- The OSI Reference Model- the TCP/IP Reference Model, Networking and Internet working Devices.

Learning Outcomes: Student will be able to

- Understand the Basics of Computer Networks (L2).
- Understand the data flow in a Computer Network and the use of protocols.(L2)
- Analyze the importance of each layer in the reference models.(L4).

Applications:

Conceptual Framework of a Network, ATM, Online reservation systems, reservation systems.

Unit 2: **9-Hours**

Physical Layer:

Transmission Media: Guided,Unguided.Bandwidth,throughput,Latency.

Multiplexing: frequency division multiplexing, wave length division multiplexing, synchronous time division multiplexing, statistical time division multiplexing, switching techniques.

Learning Outcomes: Studentwill be able to

- Understand the Basics of physical functionality .(L2).
- Analyze different types of Multiplexing Techniques. (L4).
- Analyze the Network performance Evaluation metrics . (L4).

Applications:

Identify the use of different devices in real time computer networks and data processing tasks.

Unit 3: **10- Hours**

Data Link Layer: Design issues, Framing, flow control, error control, error detection and correction, CRC. **Data Link Layer protocols**: simplex protocol, Simplex stop and wait, Simplex protocol for Noisy Channel. Sliding window protocols. HDLC configuration and transfer modes, HDLC frame format, control field

Learning Outcomes: Student will be able to

- Understand DataLink Layer Services to the Network Layer. (L2)
- Understand Error Correction and Detection techniques. (L2)
- Apply Detecting Codes for sample data. (L3)

Applications: Error correction and detecting procedures on binary data.

Unit 4: **10- Hours**

Random Access: ALOHA protocols, Carrier sense multiple access (CSMA), CSMA with Collision Detection, CSMA with Collision Avoidance

Network Layer: Routing algorithm, shortest path routing, Flooding, distance vector routing, Link state routing Algorithms, IPv4 address, subnetting, Congestion Control Algorithms.

Learning Outcomes: Student will be able to

- Understand random access protocols in data link layer and their functions. (L2)
- Analyze the static and dynamic routing Algorithms. (L4)
- Analyze the IPv4 Addressing ,sub netting.(L4)

Applications: setting up the routes for data packets to take, checking to see if a server in another network is up and running, and addressing and receiving IP packets from other networks.

UNIT –5 : **09-Hours**

The Transport Layer: addressing, TCP establishing a connection, releasing connection, TCP Header format, End to end protocols: UDP,.

Application layer: File Transfer(FTP), WWW: architeture ,client / server ,uniform resource locator, cookies, web documents: static ,dynamic, active document, HTTP transaction: persistant, non-persistent, Proxy server, HTTP Generic Message Format, HTTP Request Message Format, HTTP Response Message Format, Domain Name System (DNS), SMTP (Simple Mail Transfer Protocol).

Learning Outcomes: Student will be able to

- Understand the functions of Transport Layer protocols.(L2)
- Analyze the various protocols in application layer .(L4)

Applications: Users can forward several emails and it also provides a storage facility, allows users to access, retrieve and manage files in a remote computer layer provides access to global information about various services.

Text Books:

1. Data Communications and Networking ,Behrouz A Forouzan,fifth Edition.
2. Tanenbaum and David J Wetherall, Computer Networks, 5th Edition, Pearson Edu, 2010

Reference Books:

1. Computer Networks, Mayank Dave, CENGAGE
2. Larry L. Peterson and Bruce S. Davie, "Computer Networks - A Systems Approach" (5th ed), Morgan Kaufmann/ Elsevier, 2011

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1**):**

SNO	PO 1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO3
Cxx.1	3	3	2	1	3				3			1		2	3
Cxx.2	3	3	2	1					3			1		2	3
Cxx.3	3	3	2	1					3					2	3
Cxx.4	3	3	2	1	3				3			1		2	3
Cxx.5	3	1	1	1	3				3			1		2	3
Cxx.*	3	3	2	1	3				3			1		2	3

** For Entire Course, PO & PSO Mapping*

Subject Code	Subject Name	L	T	P	C
R23CIT-OE0002	Cryptography & Network Security	3	0	0	3

Course Objectives:

- Classical systems, symmetric block ciphers (DES, AES, other contemporary symmetric ciphers) are Introduced.
- Introduction to Public- key cryptography (RSA, discrete logarithms) is provided.
- Algorithms for factoring and discrete logarithms, cryptographic protocols, hash functions, authentication, key management, key exchange, signature schemes are learnt.
- An overview of e-mail and web security is provided.
- An overview of viruses, firewalls and system security is provided.

Course Outcomes:

1. Understand the basics of Cryptography, the goals, services and mechanisms.
2. Analyze the Symmetric Encryption Algorithms.
3. Analyze the Asymmetric Cryptographic Algorithms.
4. Understand the Digital signature Schemes.
5. Understand the email security and system security.

UNIT- I

Basic Principles Security Goals, Cryptographic Attacks, Services and Mechanisms, Mathematics of Cryptography

Learning Outcomes: Student will be able to

- Understand what is meant by Cryptography.(L1)
- Understand the goals, mechanisms and services of Cryptography.(L1)

UNIT- II

Symmetric Encryption Mathematics of Symmetric Key Cryptography, Introduction to Modern Symmetric Key Ciphers, Data Encryption Standard, Advanced Encryption Standard.

Learning Outcomes: Student will be able to

- Understand symmetric key Cryptography (L2)
- Analyze the various algorithms of Symmetric key Cryptography (L3)

UNIT- III

Asymmetric Encryption Mathematics of Asymmetric Key Cryptography, Asymmetric Key Cryptography

Learning Outcomes: Student will be able to

- Understand symmetric key Cryptography (L1)
- Analyze the various algorithms of Asymmetric key Cryptography(L2)

UNIT- IV

Data Integrity, Digital Signature Schemes & Key Management Message Integrity and Message Authentication, Cryptographic Hash Functions, Digital Signature, KeyManagement.

Learning Outcomes: Student will be able to

- Understand about Digital Signature and the security schemes.(L1)
- Understand the Hash functions and its importance.(L2)

UNIT -V

Network Security: Security at application layer: PGP and S/MIME, Security at the Transport Layer: SSL and TLS, IPSec, System Security.

Learning Outcomes: Student will be able to

- Understand email-security.(L1)
- Understand the mechanisms of Transport Layer Security.(L1)
- Understandabout system security.(L2)

Text Books:

1. Cryptography and Network Security, Behrouz A Forouzan, Debdeep Mukhopadhyay, (3e) McGraw Hill.
2. Cryptography and Network Security, William Stallings, (6e)Pearson.
3. Everyday Cryptography, KeithM.Martin, Oxford.

Reference Books:

4. Network Security and Cryptography, Bernard Meneges, Cengage Learning

COURSE OUTCOMES VS POs MAPPING (DETAILED: HIGH: 3, MEDIUM: 2, LOW: 1)

CO \ PO/PSO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	1	3	2	1	1	1	1	1	2	3	2	2
CO2	3	3	2	2	3	1	1	1	1	1	1	2	3	3	2
CO3	3	3	3	2	3	1	1	1	2	2	2	3	3	3	3
CO4	3	3	2	3	3	1	1	1	2	2	2	3	3	3	3
CO5	3	3	2	3	3	1	1	1	2	2	2	3	3	3	3
	3	3	3	3	3	1	1	1	2	2	2	3	3	3	3

**For Entire Course, PO & PSO Mapping*

Subject Code	Subject Name	L	T	P	C
R23CIT-OE0003	Mobile Computing	3	0	0	3

Course Objectives:

- To understand the fundamentals of mobile communication
- To understand the architecture of various Wireless Communication Networks
- To understand the significance of different layers in mobile system Course Contents
- To understand the mobility supported protocols
- To apply the mobility support in real time

Course Outcomes:

1. Understand the fundamentals of mobile Networks
2. Apply knowledge in MAC, Network, and Transport Layer protocols of Wireless Network
3. Comprehend, design, and develop a lightweight network stack
4. Analyze the Mobile Network Layer system working
5. Understand WAP Model

UNIT- I

Introduction to Wireless Networks: Applications, History, Simplified Reference Model, Wireless transmission, Frequencies, Signals, Antennas, Signal propagation, Multiplexing, Modulation, Spread spectrum, Cellular Systems: Frequency Management and Channel Assignment, types of hand-off and their characteristics.

Learning Outcomes: Student will be able to

1. Understand the basic concepts of wireless networks (L2)
2. Understand the fundamentals of cellular system(L2)

UNIT-II

MAC – Motivation, SDMA, FDMA, TDMA, CDMA, Telecommunication Systems, GSM: Architecture Location tracking and call setup, Mobility management, Handover, Security, GSM, SMS, International roaming for GSM, call recording functions, subscriber and service data management, DECT, TETRA, UMTS, IMT-2000.

Learning Outcomes: Student will be able to

1. Understand the MAC layer functionalities (L2)
2. apply the strategy of subscriber and service data management(L3)

UNIT-III

Wireless LAN: Infrared vs. Radio transmission, Infrastructure, Adhoc Network, IEEE 802.11WLAN Standards, Architecture, Services, HIPERLAN, Bluetooth Architecture & protocols.

Learning Outcomes: Student will be able to

1. Understand the wireless LAN functionalities(L2)
2. Understand the the various protocols in WLAN(L2)

UNIT-IV

Mobile Network Layer: Mobile IP, Dynamic Host Configuration Protocol, Mobile Transport Layer, Traditional TCP, Indirect TCP, Snooping TCP, Mobile TCP, Fast retransmit/Fast recovery, Transmission/Time-out freezing, Selective retransmission, Transaction Oriented TCP.

Learning Outcomes: Student will be able to

1. Understand the working of mobile network layer (L2)
2. Understand the concepts of mobile transport layer(L2)

UNIT-V

Support for Mobility: Wireless Application Protocol: Architecture, Wireless Datagram Protocol, Wireless Transport Layer Security, Wireless Transaction Protocol, Wireless Session Protocol, Wireless Application Environment, Wireless Markup Language, WML Scripts, Wireless Telephone Application.

Learning Outcomes: Student will be able to

1. Understand the working functionality of wireless protocols(L2)
2. Apply the wireless markup language in real time (L3)

Text Books:

1. Jochen Schiller, "Mobile Communication", Second Edition, Pearson Education, 2008.
2. "Mobile Computing: Principles and Practices" by Asoke K. Talukder, Roopa R. Yavagal

Reference Books:

1. William Stallings, "Wireless Communications and Networks", Second Edition, Pearson Education, 2004.
2. C. Siva Ram Murthy, B. S. Manoj, "Adhoc Wireless Networks: Architectures and Protocols", Second Edition, Pearson Education, 2008.

COURSE OUTCOMES VS POs MAPPING (DETAILED: HIGH: 3, MEDIUM: 2, LOW: 1)

COs	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	3	3	2	2	2				1		1	2	3	1	2
CO2	3	3	2	2	2				1			2	3	1	2
CO3	3	3	2		2			1			1	2	3	1	2
CO4	3	3	2		2			1	1			2	3	1	2
CO5	3	3	2		2			1	1		1	2	3	1	2
CO*	3	3	2	2	2				1			2	3	1	2

**For Entire Course, PO & PSO Mapping*

Subject Code	Subject Name	L	T	P	C
R23CIT-OE0004	Wireless Sensor Networks	3	0	0	3

Course Objectives:

- Define WSN and Dynamic modulation scaling.
- Explore working of the MAC protocols
- Demonstrate Routing and Data gathering protocols
- Illustrate working of Embedded OS.
- Explore a wide range of WSN applications in different sectors

Course Outcomes:

1. Understand the basics, characteristics and challenges of Wireless Sensor Network
2. Apply the knowledge to identify appropriate physical and MAC layer protocol
3. Apply the knowledge to identify the suitable routing algorithm based on the network and user requirement
4. Analysis of OS used in Wireless Sensor Networks and build basic modules
5. Analyze specific WSN application using a case study approach

Unit-I – CHARACTERISTICS OF WSN (8 Hours)

Characteristic requirements for WSN – Challenges for WSNs – WSN vsAdhoc Networks – Sensor node architecture – Commercially available sensor nodes –Imote, IRIS, Mica Mote, EYES nodes, BTnodes, TelosB, Sunspot -Physical layer and transceiver design considerations in WSNs, Energy usage profile, Choice of modulation scheme, Dynamic modulation scaling, Antenna considerations.

Learning Outcomes:

- Identify and explain the key characteristics
- Differentiate between Wireless Sensor Networks (WSNs) and Ad-hoc Networks
- Understand the role and functionalities of each component within the sensor node.

Unit – II: MEDIUM ACCESS CONTROL PROTOCOLS (10 Hours)

Fundamentals of MAC protocols – Low duty cycle protocols and wakeup concepts – Contention based protocols – Schedule-based protocols – SMAC – BMAC – Traffic adaptive medium access protocol (TRAMA) – The IEEE 802.15.4 MAC protocol.

Learning Outcomes:

- Describe the main challenges of MAC protocols in wireless sensor networks (WSNs)
- Understand the concept of low duty cycle operation and its importance
- Evaluate the performance characteristics of contention-based protocols, including throughput, latency, and energy efficiency

Unit – III: ROUTING AND DATA GATHERING PROTOCOLS (10 Hours)

Routing Challenges and Design Issues in Wireless Sensor Networks, Flooding and gossiping – Data centric Routing – SPIN – Directed Diffusion – Energy aware routing – Gradient-based routing –Rumor Routing – COUGAR – ACQUIRE – Hierarchical Routing – LEACH, PEGASIS – Location Based Routing – GF, GAF, GEAR, GPSR – Real Time routing Protocols – TEEN, APTEEN, SPEED, RAP – Data aggregation - data aggregation operations – Aggregate Queries in Sensor Networks – Aggregation Techniques – TAG, Tiny DB.

Learning Outcomes:

- Identify the key routing challenges in WSNs compared to traditional wired networks
- Analyze popular hierarchical routing protocols
- Analyze location-based routing protocols, Real-Time Routing Protocols

Unit – IV: EMBEDDED OPERATING SYSTEMS (10 Hours)

Operating Systems for Wireless Sensor Networks – Introduction – Operating System Design Issues – Examples of Operating Systems – TinyOS – Mate – MagnetOS – MANTIS – OSPM – EYES OS – SenOS – EMERALDS – PicOS – Introduction to Tiny OS – NesC – Interfaces and Modules – Configurations and Wiring – Generic Components – Programming in Tiny OS using NesC, Emulator TOSSIM.

Learning Outcomes:

- Understand the role and importance of operating systems in managing the resources and functionalities of Wireless Sensor Networks.
- Compare and contrast prominent WSN operating systems like TinyOS, Mate, MagnetOS, MANTIS, OSPM, EYES OS, SenOS, EMERALDS, and PicOS.
- Understand the strengths and weaknesses of each operating system in terms of features, resource management, and suitability.

Unit – V: APPLICATIONS OF WSN (10 Hours)

WSN Applications – Home Control – Building Automation – Industrial Automation – Medical Applications – Reconfigurable Sensor Networks – Highway Monitoring – Military Applications – Civil and Environmental Engineering Applications – Wildfire Instrumentation – Habitat Monitoring – Nanoscopic Sensor Applications – Case Study: IEEE 802.15.4 LR-WPANs Standard – Target detection and tracking – Contour/edge detection – Field sampling

Learning Outcomes:

- Identify the key characteristics of Wireless Sensor Networks (WSNs) that make them suitable for various applications.
- Analyze a specific WSN application through a Case Study
- Develop a basic understanding of common data analysis techniques used with WSN data

Text Books:

1. Wireless Sensor Networks Technology, Protocols, and Applications, KazemSohraby, Daniel Minoli and TaiebZnati, John Wiley & Sons, 2007
2. Protocols and Architectures for Wireless Sensor Network, Holger Karl and Andreas Willig John Wiley & Sons, Ltd ,2005

References Books:

1. A survey of routing protocols in wireless sensor networks , K. Akkaya and M. Younis, Elsevier
2. Ad Hoc Network Journal, Vol. 3, no. 3, pp. 325--349
3. TinyOS Programming , Philip Levis
4. Wireless Sensor Network Designs , Anna Ha´c , John Wiley & Sons Ltd

COURSE OUTCOMES VS POs MAPPING (DETAILED; HIGH: 3; MEDIUM: 2; LOW: 1 **) :**

CO	**PO1**	**PO2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PS O1**	**PS O2**	**PS O3**
CO1	3	2	2	1	3								2		
CO2	3	2	2	1	3								2		
CO3	3	2	2	1	3								2		
CO4	3	3	2	1	3								2		
CO5	3	3	2	1	3								2		

Course Code	Subject Name	L	T	P	C
R23CSM-OE0001	An Introduction to Artificial Intelligence	3	0	0	3

Prerequisites:

- Basic knowledge of programming, linear algebra, and probability & statistics.

Course Objectives:

- To focus is made on definition, scope, foundations, historical development, applications of AI, and core concepts such as the Turing Test and intelligent agents.
- To work on uninformed and informed search techniques, including heuristic and game-based approaches, to solve AI problems effectively.
- To differentiate between various knowledge representation techniques such as logic-based, semantic networks, frames, scripts, and conceptual dependency
- To introduce students to fundamental reasoning and learning techniques in Artificial Intelligence
- To analyse the impact of AI technologies on society, identify ethical challenges, and discuss current trends in AI research, robotics, and perception.

Course Outcomes:

- Understand the Fundamentals and Scope of AI
- Develop Problem-Solving and Search Strategy Skills
- Acquire Knowledge Representation Techniques
- Apply reasoning techniques and learning methods to solve problems under uncertainty
- Explore Emerging AI Topics and Ethical Considerations

Unit-1:

Introduction to Artificial Intelligence- Definition and scope of AI- AI Applications- Foundations of AI- History and Philosophy of AI- Turing Test and Intelligent Agents.

Unit-2:

Problem Solving and Search- Problem formulation- Uninformed search: BFS, DFS- Heuristic search: Hill Climbing, Best-First, A*- Game playing: Minimax, Alpha-Beta pruning.

Unit-3:

Knowledge Representation- Declarative vs Procedural Knowledge- Logic-Based Representations- Semantic networks, Frames, Scripts- Conceptual Dependency.

Unit-4:

Reasoning and Learning- Rule-based systems and Expert Systems, Fuzzy Sets and Fuzzy Logic, Machine Learning -Types of learning – Learning by analogy- explanation based learning.

Unit-5:

Emerging Topics and AI Ethics- Robotics and Perception- AI in society: Ethics, Bias, Safety- Current trends in AI research.

Text Book:

1. *Elaine Rich, Kevin Knight, and Shivashankar B. Nair , Artificial Intelligence, Tata McGraw-Hill Education*
2. *Stuart Russell and Peter Norvig – Artificial Intelligence: A Modern Approach, 3rd Edition, Pearson*
3. George F. Luger - Artificial Intelligence Principles and Practice (2025) -Springer

Reference Text Books:

4. N.P. Padhy, Artificial Intelligence and Intelligent Systems, Oxford University Press
5. *Nick Bostrom, Superintelligence: Paths, Dangers, Strategies*
6. *Cathy O'Neil, Weapons of Math Destruction*

Course Code	Subject Name	L	T	P	C
R23CSM-OE0002	Introduction to Machine Learning Using Python	3	0	0	3

Prerequisites:

- Basic knowledge of mathematics (linear algebra, probability, and statistics) and fundamental programming concepts.

Course Objectives:

- To introduce the fundamental concepts, types, and real-world applications of machine learning, and to familiarize students with essential tools such as Python, Jupyter Notebooks, and scikit-learn.
- To enable students to understand and perform essential data pre processing techniques including data cleaning, transformation, and visualization for machine learning tasks.
- To provide a solid foundation in implementing and evaluating supervised learning algorithms such as linear regression, logistic regression, decision trees, and k-nearest neighbours.
- To familiarize students with unsupervised learning methods including clustering and dimensionality reduction techniques, and their application to engineering problems.
- To develop students' ability to validate and tune machine learning models using appropriate techniques and apply their knowledge through case studies relevant to engineering domains.

Course Outcomes:

- Describe the fundamental concepts of machine learning and its types.
- Pre process and represent data effectively using Python libraries
- Implement basic supervised learning algorithms and evaluate their performance.
- Apply unsupervised learning techniques for data grouping and dimensionality reduction
- Perform model validation, avoid over fitting, and analyze real-world ML case studies.

Unit-1:

Introduction to Machine Learning -What is Machine Learning? - Types of Machine Learning: Supervised, Unsupervised, Reinforcement- ML in real-world engineering applications, Introduction to Python, scikit-learn, and Jupyter Notebooks, ML pipeline overview.

Unit-2:

Data Representation and Pre-Processing - Data types: numerical, categorical, Feature extraction and representation, handling missing values, scaling, normalization, encoding categorical variables, splitting data: train-test split, validation set, Visualization using Matplot lib.

Unit-3:

Supervised Learning Algorithms - Linear Regression, Logistic Regression, Decision Trees, K-Nearest Neighbours, Model evaluation: accuracy, confusion matrix, Bias-variance trade-off.

Unit-4:

Unsupervised Learning Algorithm and Dimensionality Reduction- Clustering: K-Means, Hierarchical clustering, Evaluation of clustering, Principal Component Analysis (PCA).

Unit-5:

Model Validation and Applications - Cross-validation, Over fitting and under fitting. Case Studies - Predictive maintenance, Demand Forecasting, Simple Recommendation Systems.

Text Book:

1. Andreas C. Müller & Sarah Guido – Introduction to Machine Learning with Python (O'Reilly, 2016)
2. Tom M. Mitchell – Machine Learning (McGraw-Hill, 1997) – for foundational concepts
3. Zhen _Leo_ Liu - Artificial Intelligence for Engineers_ Basics and Implementations (AI) (2025)-Springer

Reference Text Books:

4. Aurélien Géron – Hands-On Machine Learning with Scikit-Learn, Keras, and Tensor Flow (O’Reilly) – for optional deeper reading/projects

Course Code	Subject Name	L	T	P	C
R23CSM-OE0003	Foundation of Deep Learning for Engineering Applications	3	0	0	3

Prerequisites:

- Basic knowledge on python programming and overview on AI and Machine Learning

Course Objectives:

- To introduce the fundamentals of artificial and deep neural networks.
- To familiarize students with the working of popular deep learning architectures.
- To train students to implement and apply deep learning models using Python-based tools.
- To expose students to practical applications of deep learning across various engineering domains.
- To highlight the ethical and responsible use of deep learning technologies.

Course Outcomes:

- Describe the basic concepts and architecture of neural networks and their relevance to engineering applications.
- Explain the training process of neural networks and optimization techniques.
- Implement and evaluate convolutional and recurrent neural networks for solving problems in image and time-series.
- Apply deep learning techniques to domain-specific case studies.
- Analyse the ethical implications, limitations, and emerging trends in deep learning.

Unit-1:

Introduction to Neural Networks- Introduction to Artificial Neural Networks (ANN)- Biological inspiration, Perceptron, Activation functions, Neural network architecture: Input, Hidden, Output layers, Applications of deep learning in various engineering fields

Unit-2:

Training Neural Networks- Forward and backward propagation, Loss functions and optimization, Gradient descent and learning rate, Overfitting and underfitting. Introduction to TensorFlow and Keras frameworks

Unit-3:

Deep Architectures – CNN and RNN- Convolutional Neural Networks (CNN): Basics, layers, and applications, CNN for image classification and object detection, Recurrent Neural Networks (RNN): Basics, vanishing gradients

Unit-4:

Applications and Case Studies- Image processing -Defect detection, Biomedical imaging- Predictive maintenance in mechanical systems- Speech and signal recognition- Forecasting in energy and climate models

Unit-5:

Ethics, Challenges & Future Trends- Interpretability and explainability in deep learning, Bias and fairness in deep learning systems, Deep fakes and misuse of AI, Green AI and energy-efficient training. Future trends: Generative AI, Edge AI, TinyML

Text Book:

1. François Chollet – *Deep Learning with Python* – Manning Publications
2. Ian Good fellow, Yoshua Bengio, Aaron Courville – *Deep Learning* – MIT Press
3. Michael Nielsen – *Neural Networks and Deep Learning* – Online book

Reference Text Books:

4. Melanie Mitchell – Artificial Intelligence: A Guide for Thinking Humans-Farrar, Straus and Giroux

Course Code	Subject Name	L	T	P	C
R23CSM-OE0004	Natural Language Processing– Frontiers Approach	3	0	0	3

Prerequisites:

- A foundational understanding of programming, basic linguistics, and probability/statistics is essential.

Course Objectives:

- To learn the fundamentals of natural language processing
- To understand the use of CFG and PCFG in NLP
- To understand the role of semantics of sentences and Pragmatics
- To gain knowledge in automated natural language generation and machine translation
- To understand language modeling

Course Outcomes:

- Understand the fundamentals of basic language features
- Analyse the words involved in NLP
- Analyse the syntactic analysis involved in NLP
- Apply semantic Analysis for NLP
- Compare different statistical approaches of NLP applications.

Unit-1:

Introduction: Origins and challenges of NLP, Language Modeling: Grammar-based LM, Statistical LM – Regular Expressions, Finite-State Automata – English Morphology, Transducers for lexicon and rules, Tokenization, Detecting and Correcting Spelling errors.

Unit-2:

Word level analysis: Unsmoothed N-grams, Evaluating N-grams, Smoothing, Interpolation and Backoff – Word Classes, Part-of-Speech Tagging, Rule-based, Stochastic and Transformation-based tagging, Issues in Po Stagging –Hidden Markov and Maximum Entropy models.

Unit-3:

Syntactic analysis: Context-Free Grammars, Grammar rules for English, Normal Forms for grammar – Dependency Grammar – Syntactic Parsing, Ambiguity, Dynamic Programming parsing – Probabilistic CFG, Probabilistic CYK, Probabilistic Lexicalized CFGs – Feature structures, Unification of feature structures.

Unit-4:

Semantics Analysis: Requirements for representation, First-Order Logic, Description Logics –Syntax- Driven Semantic analysis, Semantic attachments– Word Senses, Relations between Senses, Thematic Roles, selection restrictions – Word Sense Disambiguation

Unit-5:

Discourse Analysis and Lexical Resources: Discourse segmentation, Coherence– Reference Phenomena, Anaphora Resolution using Hobbsand Centering Algorithm– Coreference Resolution – Resources: Porter Stemmer, Lemmatizer, Penn Treebank, Brill's Tagger, Word Net, Prop Bank, Frame Net, Brown Corpus, British National Corpus (BNC).

Text Book:

1. Daniel Jurafsky, JamesH.Martin — Speechand Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech, Pearson Publication, 2014.
2. Steven Bird, Ewan Klein and Edward Loper, —Natural Language Processing with Python, First Edition, OReilly Media, 2009.

Reference Text Books:

3. BreckBaldwin,— Language Processing with Javaand Ling Pipe Cook book, Atlantic Publisher, 2015.
4. Richard M Reese,—Natural Language Processing with Java, OReilly Media, 2015.
5. Nitin Indurkhyaand Fred J.Damerau,—Handbook of Natural Language Processing, Second Edition, Chapman and Hall/CRC Press, 2010.
6. Tanveer Siddiqui, U.S. Tiwary, Natural Language Processing and Information Retrieval, Oxford University Press, 2008.