COURSE STRUCTURE
AND
DETAILED SYLLABUS
(I YEAR)

M.Tech- CAD/CAM in Mechanical Engineering

For B.Tech., Four Year Degree Course
(Applicable for the batches admitted from 2024-25)

Academic Regulation – R24

AVANTHI INSTITUTE OF ENGINEERING AND TECHNOLOGY
(Autonomous)
(Approved by A.I.C.T.E., NewDelhi,& Permanently Affiliated to J.N.T.U-GV, Vizianagaram)
NAAC"A+" Accredited Institute
Cherukupally (Village), Near Tagarapuvalasa Bridge,Vizianagaram(Dist) -531162.
www.aietta.ac.in,principal@aietta.ac.in

Institute Vision

- To develop highly skilled professionals with ethics and human values.

Institute Mission

- To impart quality education with industrial exposure and professional training.
- To produce competent and highly knowledgeable engineers with positive approach.
- To develop self confidence among students is an imperative pre requisite to face the challenges of life.

Institute Quality Policy:

Avanthi Institute of Engineering and Technology (Autonomous), emphasizes the ethical ideals to innovate advanced training by creating the best possible infrastructure through an engaging, activity-oriented teaching. It also uses the most updated information and communication technology to enhance an engineering approach among the students, aiming for an effective and ambitious administration which is responsive in all the aspects.

Program Educational Objectives (PEOs)

PEO1: To apply technical knowledge in the domain of core engineering and allied disciplines contributing to society through interdisciplinary expertise.

PEO2: Strengthen technical competence by enhancing their self-learning capacity throughout their professional career as well as to pursue higher education.

PEO3: Explore their artistry in emerging areas of engineering flourishing their leadership qualities pertaining to ethical innovation with social responsibility.

DEPARTMENT OF MECHANICAL ENGINEERING

Vision

To maintain high standards of Mechanical Engineering education through outstanding innovative curricular research training that reflects the changing needs of society.

Mission

The Mission of the Department of Mechanical Engineering is to:

M1: Prepare effective and responsible graduate engineers for global requirements by providing quality education.

M2: Constantly strike to improve pedagogical methods employed in delivering the academic programs.

M3: Respond effectively to the needs of the industry and changing world.

M4: Conduct basic and applied research and to generate intellectual property.

Program Outcomes (POs)

PO1: Demonstrate knowledge with ability to select, learn and apply appropriate techniques, skills and modern engineering tools to solve engineering problems appropriate to the relevant discipline.

PO2: Analyze engineering problems critically, conceptualize, design, implement and evaluate potential solutions to contribute to the development of scientific/technological solutions in the context of relevant discipline

PO3: Independently carry out research /investigation and development work to solve practical problems

PO4: Function effectively as an individual and in a team to possess knowledge and recognize opportunities for career progression and research.

PO5: Communicate effectively in professional practice through verbal and written formats.

PO6: Recognize the need for self-motivated pursuit of knowledge to show commitment and competence in the broadest context of technological change.

Program Specific Outcomes (PSOs)

Engineering Students will be able to:

PSO1: Create and deploy new ideas on mechanical systems with optimal design, analysis and evolution in using modern CAD Tools.

PSO2: Solve critical technical problems in core areas with the use of latest CAM Tools and Technologies.

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DEPARTMENT OF MECHANICAL ENGINEERING

Proposed Course Structure

Program– M.Tech- CAD/CAM Engineering in Mechanical Engineering

Regulation-R24

(Applicable from the academic year 2024-2025 to 2026-2027)

Program: M.Tech- CAD/CAM Engineering in Mechanical Engineering **Regulation-** R24

I Year I Semester- Course Structure

S.No.	Category	Course Code	Course Name	Hours per Week			
				L	T	P	Credits
1.	PC	R24CCPC01	**Professional Core Course-1** Geometric Modeling	3	0	0	3
2.	PC	R24CCPC02	**Professional Core Course-2** Computer Aided Manufacturing	3	0	0	3
3.	PE		**Professional Elective-I**	3	0	0	3
		R24CCPE01	Computational Methods in Engineering				
		R24CCPE02	Materials Technology				
		R24CCPE03	Mechanical Vibrations				
4.	PE		**Professional Elective-II**	3	0	0	3
		R24CCPE04	Mechatronics				
		R24CCPE05	Industrial Robotics				
		R24CCPE06	Simulation of Manufacturing systems				
5.	PC	R24CCPC03	Advanced CAD Lab	0	0	4	2
6.	PC	R24CCPC04	Advanced Manufacturing Lab	0	0	4	2
7.	MC	MTMB1105	Research Methodology & IPR	2	0	0	2
8.	AC	R24CA108	Writing Skills For Scientific Communication	2	0	0	0
			Total	**16**	**0**	**8**	**18**

Category	Courses	Credits
PC- Professional Core Courses	4	10
PE- Professional Elective	2	6
MC- Mandatory Course	1	2
AC- Audit Course	1	0
Total	8	18

DEPARTMENT OF MECHANICAL ENGINEERING

Program: M.Tech- CAD/CAM Engineering in Mechanical Engineering **Regulation-** R24

I Year II Semester- Course Structure

S.No.	Category	Course Code	Course Name	Hours per Week			
				L	T	P	Credits
1.	PC	R24CCPC05	**Professional Core Course-3** Theory of Elasticity & Plasticity	3	0	0	3
2.	PC	R24CCPC06	**Professional Core Course-4** Advanced Manufacturing Processes	3	0	0	3
3.	PE		**Professional Elective-3**	3	0	0	3
		R24CCPE07	Advanced Finite Element Methods				
		R24CCPE08	Fracture Mechanics				
		R24CCPE09	Product Design & Development				
4.	PE		**Professional Elective-4**	3	0	0	3
		R24CCPE10	Materials Characterization Techniques				
		R24CCPE11	Optimization & Reliability				
		R24CCPE12	Additive Manufacturing				
5.	PC	R24CCPC07	Material characterization lab	0	0	4	2
6.	PC	R24CCPC08	Simulation of manufacturing systems lab	0	0	4	2
7.	PR	R24CCPR01	Seminar	0	0	0	2
8.	AC	R24CA208	Personality development through life enlightenment skills	2	0	0	0
			Total	**16**	**0**	**8**	**18**

Category	Courses	Credits
PC- Professional Core Courses	4	10
PE- Professional Elective	2	6
PR- Project Work/Internship/Seminar	1	2
AC- Audit Courses	1	0
Total	8	18

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R24CCPC01 **GEOMETRIC MODELING** **3 0 0 3**

Course Objectives:

1. Understand the basic principles of geometric modeling, including points, lines, curves, surfaces, and solids.
2. To Learn the student mathematical underpinnings of geometric shapes, including algebraic and differential geometry.
3. To learn various methods for representing curves and surfaces, such as parametric, implicit, and explicit forms.
4. Explore techniques like Bézier curves, B-splines, NURBS, and subdivision surfaces.
5. Understand algorithms for geometric processing, including intersection, trimming, tessellation, and simplification.
6. To Learn methods for representing and manipulating 3D objects, including mesh representations and solid modeling techniques.
7. To Gain proficiency in using CAD software for creating and modifying geometric models.
8. Explore applications in various fields, including computer graphics, animation, virtual reality, and engineering design.

Course Code	Course Outcomes	Mapping with POs and PSOs						Dok
		PO1	PO2	PO3	PO4	PSO1	PSO2	
R24CCPC01.1	Explain the algebraic and geometric forms of cubic splines.	2	1	-	-	2	-	L2
R24CCPC01.2	Analyze the four-point form of cubic splines, reparametrization, truncating, and subdividing curves.	-	3	2	-	-	3	L3, L4
R24CCPC01.3	Apply and analyze the properties and derivatives of B-Spline curves for various modeling tasks.	3	2	-	-	3	-	L2, L3, L4
R24CCPC01.4	Construct and analyze different types of surfaces, including bicubic, Coon's surfaces, Bezier surfaces, and B-Spline surfaces.	3	2	2	-	3	-	L3, L4
R24CCPC01.5	Utilize and critically evaluate solid modeling concepts such as wire frames, boundary representation, half-space modeling, spatial cells, cell decomposition, and classification problems.	-	3	2	1	-	2	L3, L5

SYLLABUS

Unit - I **14 Hours**

Cubic splines –I Definition, Explicit and implicit equations, parametric equations, Algebraic and geometric form of cubic spline, Hermite cubic spline, tangent vectors, parametric space of a curve, blending functions. **COs: CO1**

Unit - II **14 Hours**

Cubic Splines-II: four-point form, reparameterization, truncating and subdividing of curves. Graphic construction and interpretation, composite pc curves. Bezier Curves: Bernstein basis, equations of Bezier curves, properties, derivatives. **COs: CO2**

Unit - III **12 Hours**

B-Spline Curves: B-Spline basis, equations, knot vectors, properties, and derivatives. **COs: CO3**

Unit – IV **14 Hours**

Surfaces: Bicubic surfaces, Coon's surfaces, Bezier surfaces, B-Spline surfaces, surfaces of revolutions, sweep surfaces, ruled surfaces, tabulated cylinder, bilinear surfaces, Gaussian curvature. **COs: CO4**

Unit – V **14 Hours**

Solids: Tricubic solid, Algebraic, and geometric form. Solid modeling concepts: Wire frames, Boundary representation, Half space modeling, spatial cell, cell decomposition, classification problem. **COs: CO5**

Text Books:

1. Elements of Computer Graphics by Roger & Adams Tata McGraw Hill.
2. Geometric Modeling by Micheal E. Mortenson, McGraw Hill Publishers.

References:

1. Computer Aided Design and Manufacturing, K.Lalit Narayan, K.Mallikarjuna Rao, MMM Sarcar, PHI Publishers

Board of Studies: Mechanical Engineering
Approved in BOS No: 01, 31st July, 2024
Approved in ACM No: 01

Internal Assessment Pattern

Cognitive Level	Internal Assessment #1 (%)	Internal Assessment #2 (%)
L2	50	50
L3	30	30
L4	10	10
L5	10	10
Total (%)	100	100

Sample Long Answers questions of Various Cognitive Levels

L2: Understand

1. Explain about Non – Parametric representation of curves.
2. Supply the algebraic form of a cubic spline.
3. What are the properties of parametric curves?
4. Explain about the properties of Beizer curve.
5. Explain about composite beizer curves
6. Explain about truncated and subdividing of curves

7. Explain about Quadratic and cubic B -Spline basis functions
8. Discuss the properties of composite objects.
9. Explain about Tri -cubic solid in detail.
10. Explain Half space modeling in detail and provide two examples.
11. Discuss with the help of neat sketches, the most commonly used solid entities
12. Consider the defining polygon B1 [1 1], B2 [2 3], B3 [4 3], B4 [3 1] of the open Bspline curve. Determine the first derivative of the second order curve.
13. What are the properties of parametric curves?
14. Consider four 2-D position vectors of P1[0 0], P2[1 1], P3 [2 -1] and P4[3 0] with tangent vectors P1 ι [1 1] and P4 ι [1 1]. Determine the normalized piecewise cubic spline curve through them.
15. Consider 2-D position vectors of above mentioned P1 [0 0], P2 [1 1], P3 [2 -1] and P4 [3 0] and determine the parabolically blended curve between P2 and P3 calculate intermediate points at t=1/3, 2/3.
16. Calculate the five third-order non-uniform B-spline basis functions N t i,3 (t), i=1,2,3,4,5 using the knot vectors [X] = [0 0 1 1 3 3 3] which contains an interior repeated knot value.
17. Derive the equation of a closed Bezier curve of degree 5.
18. Explain about Boundary representation
19. Explain Half space modelling in detail and provide two examples.
20. Explain about truncating and subdividing of curves.
21. Explain about coons' surface and sweep surface.

L3: Apply

1. Derive the geometric form of hermit's cubic spline.
2. Derive the equation of a closed Bezier curve of degree 5.
3. Calculate the five third -order non -uniform B -spline basis functions Ni,3 (t) i=1,2,3,4,5using the knot vectors [X]= [0011333] which contains an interior repeated knot value.
4. Fit a B -spline curve with the following control points $P_1(0,0)$, $P_2(2,2)$, $P_3(4,4)$, $P_4(6,6)$.
5. Sweep the normalized cubic spline curve segment defined by P [0 3 0 1], P [3 0 0 1] and Pi [3 0 0 0], Pi [3 0 0 0] 10 units along Z-axis
6. Determine the point on bilinear surface defined by P (0,0) = [0 0 1], P (0,1) = [1 1 1], P (1,0) = [1 0 0], P (1,1) = [0 1 0], i.e., the ends of opposite diagonals on opposite faces of unit cube in object space, corresponding to u=w=0.5 in parametric space.
7. Show by example that a planar coon bi -cubic surface results when the position, tangent and twist vectors all lie in the same plane.
8. Develop the equations of following surfaces: (i)Torus; (ii) Ruled surface; (iii) coons' bilinear patch; & (iv) Bezier.
9. Sweep the normalized cubic spline curve segment defined by P1 [0 3 0 1], P2 [3 0 0 1]and P1 ι [3 0 0 0], P2 ι [3 0 0 0] 10 units along Z-axis.
10. Determine the point on bilinear surface defined by P (0,0) = [0 0 1], P (0,1) = [1 1 1], P (1,0) = [1 0 0], P (1,1) = [0 1 0], i.e., the ends of opposite diagonals on opposite faces of unit cube in object space, corresponding to u=w=0.5 in parametric space.
11. Determine the Gaussian curvature at u=1/2, w=1 for open B-spline surface defined by the given B1,1 [-15 0 15] B2,1 [-5 5 15] B3,1 [5 5 15] B4,1 [15 0 15] , B1,2 [-15 5 5] B2,2 [-5 10 5] B3,2 [5 10 5] B4,2 [15 5 5], B1,3 [-15 5 -5] B2,3 [-5 10 -5] B3,3 [5 10 -5] B4,3 [15 5

-5], B1,4 [-15 0 -15] B2,4 [-5 5 -15] B3,4 [5 5 -15] B4,4 [15 0 -15].

12. Consider a ruled surface formed by linearly bending the curve P (0, w) and P (1, w). Determine the point on the surface Q (u,w) at u=w=0.5. P (0, w) is a third-order open B-spline curve with defining polygon vertices is given by B1 [0 0 0], B2 [1 1 0], B3 [1 1 0], B4 [2 1 0] and B5 [3 0 0]. Notice the double vertex B2 = B3 which yields a cusp in the curve. P(1, w) is also a third-order open B-spline curve its defining polygon vertices are B1 – [0 0 6], B2 – [1 1 6], B3 – [1 1 0], B4 – [3 0 4].

L4: Analyzing

1. Analyze the differences between the algebraic and geometric forms of cubic. splines. How do these differences influence the curve's behavior?
2. Given the parametric equations of a Hermite cubic spline, analyze how varying the tangent vectors at the endpoints affects the shape of the curve.
3. Analyze the impact of reparameterization on the shape and properties of a cubic spline. What changes occur in the curve's parametric space?
4. Given a composite piecewise cubic curve, analyze how truncating or subdividing a section of the curve affects its overall continuity and smoothness.
5. Analyze the role of the knot vector in B-Spline curves. How does adjusting the knot vector influence the curve's shape and continuity?
6. Given the B-Spline basis functions, analyze how changing the degree of the spline affects the curve's flexibility and smoothness.
7. Analyze how the choice of blending functions influences the shape of a bicubic surface. Compare this with a Bezier surface generated using the Bernstein basis.
8. Given a B-Spline surface, analyze the effect of changing the knot vector on the surface's curvature and smoothness.
9. Analyze the advantages and limitations of using boundary representation versus half-space modeling for solid modeling. How do these approaches handle complex geometries differently?
10. Analyze the classification problem in solid modeling. How does the choice of spatial cell decomposition affect the accuracy and efficiency of the classification process?

L5: Evaluating

1. Evaluate the effectiveness of using Hermite cubic splines versus Bezier curves for a given set of design requirements. Consider aspects such as computational efficiency, ease of implementation, and flexibility.
2. Compare the advantages and disadvantages of using algebraic versus geometric forms of cubic splines in modeling complex curves. Justify your evaluation based on specific application scenarios.
3. Assess how the choice of blending functions in cubic splines affects the smoothness and continuity of the resulting curve. Provide examples of situations where different blending functions might be preferable.
4. Evaluate the impact of reparametrization on the accuracy and computational efficiency of cubic splines. How does reparametrization influence the overall design process?
5. Critically analyze the use of the four-point form of cubic splines versus composite polynomial curves for creating complex curves in computer graphics. Discuss their respective advantages and limitations.
6. Assess the effectiveness of Bezier curves in representing complex shapes compared to B-Splines. How do their properties and derivatives influence their suitability for different

types of modeling tasks?

7. Evaluate the impact of different knot vectors on the flexibility and smoothness of B-Spline curves. Provide a detailed analysis of how knot vector choices can affect the resulting curve's properties.
8. Compare and contrast the use of B-Spline curves with other spline techniques in terms of control and precision. Justify which method would be most appropriate for a given geometric modeling task.
9. Assess how the properties and derivatives of B-Spline curves influence their application in various fields, such as animation or CAD systems. Discuss the trade-offs involved.
10. Evaluate the suitability of different surface types (bicubic, Coon's, Bezier, B-Spline) for representing complex 3D objects in a CAD system. Consider aspects such as ease of manipulation, computational efficiency, and visual quality.
11. Critically assess the impact of Gaussian curvature on the design and analysis of surfaces. How does Gaussian curvature affect the modeling and visualization of surfaces in practical applications?
12. Compare the effectiveness of different surface construction methods (e.g., sweep surfaces vs. ruled surfaces) for modeling specific geometric shapes. Discuss the advantages and limitations of each method.
13. Evaluate the use of boundary representation versus half-space modeling for creating and manipulating complex solid models. Discuss the scenarios where one method might be preferred over the other.
14. Critically analyze the role of tricubic solids in modeling complex 3D objects. How do they compare to other solid modeling techniques in terms of accuracy and computational demands?
15. Assess the impact of different solid modeling concepts (e.g., wire frames, spatial cells) on the process of solid modeling and its applications. Discuss the trade-offs involved in choosing one method over another.

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R24CCPC02 COMPUTER AIDED MANUFACTURING 3 0 0 3

Course Objectives:

1. Understand the students to the fundamentals of CAM, including the history, evolution, and basic components of CAM systems.
2. To learn students how to create detailed models and designs using computer-aided design (CAD) tools, and how these designs are integrated into CAM systems.
3. Understanding of various machining processes, such as milling, turning, drilling, and cutting, and how they are controlled and optimized using CAM.
4. To learn methods for accurate cost estimation and budgeting using CAM tools, considering factors like material costs, machine time, and labor.
5. Emphasize the importance of quality control in manufacturing and how CAM systems can be used to ensure high-quality output.
6. To learn the management of materials and resources within a CAM environment to optimize production efficiency and reduce waste

Course Code	Course Outcomes	Mapping with POs and PSOs								Dok
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	
R24CCPC02.1	Explain the APT and NC programming on CAD/CAM systems.	2	2	-	-	-	-	2	2	L2, L4
R24CCPC02.2	Organize the tooling for CNC Machines and Adaptive Control of machining processes like turning.	-	2	2	-	-	-	3	2	L2, L4
R24CCPC02.3	Explain the general structure and functions DAPP based Post Processor	2	2	-	-	-	-	2	2	L2, L4
R24CCPC02.4	Identify and describe the key hardware components of a microcontroller, including the CPU, memory, and I/O interfaces.	2	-	-	2	-	-	2	1	L1, L2
R24CCPC02.5	Develop the AI& Expect systems to the computer Aided process planning computer aided testing and inspection method	-	2	2	-	-	2	2	2	L6

SYLLABUS

UNIT - I **10 Hours**

Computer Aided Programming: General information, APT programming, Examples Apt programming problems (2D machining only). NC programming on CAD/CAM systems, the design and implementation of post processors. Introduction to CAD/CAM software, Automatic Tool Path generation. **COs: CO1**

UNIT - II **15 Hours**

Tooling for CNC Machines: Interchangeable tooling system, preset and qualified too is, coolant fed tooling system, modular fixturing, quick change tooling system, automatic head changers. DNC Systems and Adaptive Control: Introduction, type of DNC systems, advantages arid disadvantages of DNC, adaptive control with optimization, Adaptive control with constrains, Adaptive control of machining processes like turning, grinding. **COs: CO2**

UNIT – III **10 Hours**

Post Processors For Cnc: Introduction to Post Processors: The necessity of a Post Processor, the general structure of a Post Processor, the functions of a Post Processor, DAPP — based- Post Processor: Communication channels and major variables in the DAPP — based Post Processor, the creation of a DAPP — Based Post Processor. **COs: CO3**

UNIT - IV **15 Hours**

Micro Controllers: Introduction, Hardware components, I/O pins, ports, external memory: counters, timers, and serial data I/O interrupts. Selection of Micro Controllers Embedded Controllers, Applications and Programming of Micro Controllers. Programmable Logic Controllers (PLC' s): Introduction, Hardware components of PLC, System, basic structure, principle of operations, Programming mnemonics timers, Internal relays and counters, Applications of PLC's in CNC Machines. **COs: CO4**

UNIT - V **10 Hours**

Computer Aided Process Planning: Hybrid CAAP System, Computer Aided Inspection and quality control, Coordinate Measuring Machine, Limitations of CMM, Computer Aided Testing, Optical Inspection Methods, Artificial Intelligence, and expert system: Artificial Neural Networks, Artificial Intelligence in CAD, Experts systems and its structures. **COs: CO5**

Text Books:

1. Computer Control of Manufacturing Systems / Yoram Koren / Mc Graw Hill. 1983. 2. CAD/CAM Principles and Applications, P.N.Rao, TMH

References:

1. Computer Aided Design Manufacturing – K. Lalit Narayan, K. Mallikarjuna Rao and M.M.M. Sarcar, PHI, 2008.
2. CAD / CAM Theory and Practice, / Ibrahim Zeid,TMH
3. CAD / CAM / CIM, Radhakrishnan and Subramanian, New Age
4. Principles of Computer Aided Design and Manufacturing, Farid Amirouche, Pearson
5. Computer Numerical Control Concepts and programming, Warren S Seames, Thomson

Board of Studies: Mechanical Engineering
Approved in BOS No: 01, 31st July, 2024
Approved in ACM No: 01

Internal Assessment Pattern

Cognitive Level	Internal Assessment #1 (%)	Internal Assessment #2 (%)

L1	60	20
L2	40	-
L4	-	40
L5	-	20
L6	-	20
Total (%)	**100**	**100**

Sample Long Answers questions of Various Cognitive Levels

L2: Understand

1. Explain CIM
2. Explain the types of interlocks
3. Explain the drawing features of CAD.
4. Explain about the following types of transformations with example. (i) Translation (ii) scaling (iii) rotation
5. Explain the short notes on 3D scaling and 3D shearing geometric transformation
6. Compare IGES and GKS graphic standards.
7. Compare modulation and demodulation.
8. Explain the open system interconnection architecture (OSI) formulated by ISO.
9. Explain Opitz coding system.

L4: Analyzing

1. Distinguish between reflection and scaling transformations.
2. Distinguish between LAN model and MAN model
3. Analyze the impact of different types of CAD/CAM software on the efficiency of Automatic Tool Path generation.
4. Compare and contrast APT programming with other programming methods used in CAD/CAM systems
5. Analyze the benefits and drawbacks of using coolant-fed tooling systems compared to modular fixturing systems.
6. Compare different types of DNC systems and their impact on machining efficiency and control.
7. Analyze the differences between traditional post processors and DAPP-based post processors in terms of functionality and performance.
8. Compare the structure and functions of various types of post processors used in different CNC applications.
9. Analyze the interactions between CPU, memory, and I/O interfaces in a microcontroller system.
10. Compare different types of PLC hardware components and their impact on system performance.
11. Analyze the advantages and limitations of hybrid CAAP systems compared to traditional process planning methods.
12. Compare different AI techniques used in quality control and their impact on inspection accuracy.

L5: Evaluating

1. Measure the range of applications for which typical geometric modeling information is used.
2. Evaluate the advantages and disadvantages of using APT programming in modern CNC machining.
3. Assess the effectiveness of different post processor designs in reducing machining errors.
4. Evaluate the effectiveness of various adaptive control strategies in improving the performance of CNC grinding processes.
5. Assess the impact of different tooling systems on overall machining accuracy and production time.
6. Evaluate the effectiveness of a DAPP-based post processor in improving machining accuracy and reducing setup time.
7. Assess the benefits and limitations of using post processors in the context of complex CNC machining tasks.
8. Evaluate the suitability of various microcontrollers for different embedded applications, considering factors like processing power and memory.

L6: Creating

1. Develop a simple APT program for a given 2D machining task and describe the rationale behind your programming choices.
2. Design a post processor for a new type of CNC machine, considering the specific requirements and challenges.
3. Design an adaptive control system for a CNC turning machine, including considerations for optimization and constraint handling.
4. Develop a comprehensive plan for implementing a new tooling system in a CNC machining setup, addressing potential challenges and solutions.
5. Develop a PLC control program for a CNC machine, incorporating timers, internal relays, and counters to handle various machining tasks.
6. Develop a new method for optical inspection using AI techniques, addressing potential challenges and improvements.

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R24CCPE01 COMPUTATIONAL METHODS IN ENGINEERING 3 0 0 3

Course Objectives:

1. Introduce the fundamental numerical methods for solving engineering problems.
2. Develop skills to solve sets of linear and non-linear equations using iterative and relaxation methods.
3. Understand and apply least square approximation techniques and regression analysis in engineering.
4. Equip students with the knowledge to solve boundary value problems and characteristic value problems.
5. Provide an understanding of transformation techniques and their applications in engineering.
6. Teach students numerical methods for solving partial differential equations and understanding stability and convergence criteria.
7. Foster the ability to implement numerical methods using computer programs for real-world engineering problems.

Course Code	Course Outcomes	Mapping Pos and PSOs						Dok
		PO 1	PO 2	PO 3	PO 4	PSO 1	PSO 2	
R24CCPE01.1	Apply numerical methods to solve sets of linear and non-linear equations, and use regression analysis for engineering applications.	2	2		1	2	2	L2, L3, L4
R24CCPE01.2	Utilize boundary value and characteristic value methods to solve engineering problems, including the shooting method and Rayleigh-Ritz method.	2	2	2	1	2	2	L1, L2, L3, L4
R24CCPE01.3	Employ transformation techniques, such as Fourier and Laplace transforms, for analyzing and solving engineering problems in different domains.	2	2	1	1	2	2	L1, L2, L3
R24CCPE01.4	Implement numerical methods for solving partial differential equations, including Laplace's and Poisson's equations, and apply the FEM.	2	2	2	1	2	2	L2, L3, L4
R24CCPE01.5	Analyze and solve advanced partial differential equations using methods like the explicit method, Crank-Nicolson method, and method of characteristics, with a focus on stability and convergence.	2	2	2	1	2	2	L2, L3, L4

SYLLABUS

Unit – I **12 Hours**

Introduction to numerical methods applied to engineering problems: Examples, solving sets of equations – Matrix notation – Determinants and inversion – Iterative methods – Relaxation methods – System of non-linear equations. Least square approximation fitting of non-linear curves by least squares – regression analysis – multiple linear regression, non-linear regression – Introduction to computer programs for numerical methods.

Self-Learning Topic: Practical applications of regression analysis in predictive maintenance for engineering systems. **COs: CO1**

Unit – II **11 Hours**

Boundary value problems and characteristic value problems: Shooting method – Solution through a set of equations – Derivative boundary conditions – Rayleigh-Ritz method – Characteristic value problems.

Self-Learning Topic: Application of Rayleigh-Ritz method in structural analysis for buildings and bridges. **COs: CO2**

Unit – III **12 Hours**

Transformation Techniques: Continuous Fourier series, frequency and time domains, Laplace transform, Fourier integral and transform, discrete Fourier transform (DFT), Fast Fourier transform (FFT).

Self-Learning Topic: Use of Fast Fourier Transform (FFT) in signal processing for real-time data analysis in communication systems. **COs: CO3**

Unit – IV **17 Hours**

Numerical solutions of partial differential equations: Laplace's equations – Representations as a difference equation – Iterative methods for Laplace's equations – Poisson equation: Examples and applications – Derivative boundary conditions – Irregular and non-rectangular grids – Matrix patterns, sparseness – ADI method – Finite element method.

Self-Learning Topic: Implementation of finite element methods in the design and analysis of automotive components. **COs: CO4**

Unit – V **12 Hours**

Advanced Methods for Partial Differential Equations: Explicit method – Crank-Nicolson method – Derivative boundary conditions – Stability and convergence criteria – Solving wave equations by finite differences – Stability of numerical methods – Method of characteristics – Wave equations in two space dimensions – Advanced computer programs for solving partial differential equations.

Self-Learning Topic: Application of Crank-Nicolson method in the simulation of heat conduction in electronic devices. **COs: CO5**

Text Books:

1. Steven C.Chapra, Raymond P.Canale —Numerical Methods for Engineers‖ Tata Mc-Graw Hill
2. Curtis F.Gerald, Partick.O Wheatly, Applied numerical analysis‖Addison-Wesley,1989
3. Douglas J.Faires,Riched Burden‖Numerical methods‖, Brooks/Cole publishing company,1998.Second edition.

Reference Books:

1. Ward Cheney and David Kincaid —Numerical mathematics and computingl Brooks/Cole publishing company1999, Fourth edition.
2. Riley K. F, M. P. Hobson and Bence S. J, lMathematical methods for physics and engineeringl, Cambridge University press,1999.
3. Kreysis, Advanced Mathematics

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Internal Assessment Pattern

Cognitive Level	Internal Assessment #1 (%)	Internal Assessment #2 (%)
L1	25	20
L2	25	35
L3	40	35
L4	10	10
Total (%)	**100**	**100**

Sample questions of Various Cognitive Levels

L1: Remembering

1. What is the purpose of using matrix inversion in solving systems of linear equations?
2. What does the least squares method aim to achieve in regression analysis?
3. Define the shooting method and describe its role in solving boundary value problems.
4. What are characteristic values, and why are they important in differential equations?
5. What is the primary use of the Fourier series in signal processing?
6. How is the Laplace transform utilized to simplify the solving of differential equations?
7. What is Laplace's equation used for in engineering simulations?
8. Describe the fundamental concept of the finite element method.
9. What is the Crank-Nicolson method, and how does it differ from explicit methods?
10. What is the method of characteristics, and how is it applied to wave equations?

L2: Understanding

1. Explain how matrix notation simplifies solving systems of linear equations.
2. Describe the process of fitting a non-linear curve to a data set using least squares approximation.
3. How does the Rayleigh-Ritz method approximate solutions to characteristic value problems?
4. Explain the procedure for solving boundary value problems using the shooting method.
5. How does the discrete Fourier transform (DFT) help in analyzing digital signals?
6. Describe how the Fast Fourier Transform (FFT) improves computational efficiency over DFT.
7. Explain the use of iterative methods to solve Laplace's equation and their advantages.
8. Discuss how irregular grids affect the accuracy of numerical solutions in finite element analysis.
9. Compare the explicit and Crank-Nicolson methods in terms of their approach to solving PDEs.

10. Discuss the significance of stability and convergence criteria in numerical methods for PDEs.

L3: Applying

1. Apply matrix inversion to solve a given set of linear equations with numerical values.
2. Use the least squares method to fit a polynomial to a given data set and interpret the results.
3. Solve a specified boundary value problem using the shooting method, given the boundary conditions.
4. Apply the Rayleigh-Ritz method to estimate eigenvalues for a given differential equation.
5. Transform a given time-domain signal using FFT and analyze its frequency components.
6. Implement the Laplace transform to solve a given differential equation and interpret the transformed result.
7. Use the finite element method to solve a Laplace equation problem on a specified irregular grid.
8. Apply an iterative method to solve Poisson's equation with given boundary conditions and analyze the solution.
9. Solve a wave equation using the Crank-Nicolson method and discuss the stability of the solution.
10. Apply the method of characteristics to solve a wave equation problem in two dimensions and interpret the results.

L4: Analyzing

1. Analyze the convergence behavior of an iterative method for solving a set of non-linear equations and compare it to direct methods.
2. Evaluate the effectiveness of polynomial versus non-linear regression models for fitting a data set and discuss their suitability.
3. Assess the accuracy and efficiency of the shooting method in solving boundary value problems compared to the Rayleigh-Ritz method.
4. Analyze how different characteristic value problem-solving techniques impact the accuracy of solutions.
5. Evaluate the impact of irregular grid patterns on the numerical solutions of Laplace's equation and compare it to regular grids.
6. Analyze the performance of different iterative methods for solving Laplace's equation, focusing on convergence rates and computational cost.
7. Compare the stability and accuracy of explicit and Crank-Nicolson methods in solving wave equations and provide examples of their application.
8. Assess the effectiveness of various numerical methods for solving PDEs based on their stability, convergence, and computational efficiency.

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R24CCPE02 **MATERIALS TECHNOLOGY** **3 0 0 3**

Course Objectives:

1. Gain insights into the mechanisms of plastic deformation,
2. Understand various strengthening mechanisms such as work hardening, solid solution strengthening, and grain boundary strengthening.
3. Comprehend Griffith's Theory, stress intensity factor, and fracture toughness.
4. Gain knowledge of the properties, processing techniques, and applications of advanced metallic materials
5. Learn about the molecular structure, production techniques, properties, and applications of polymeric materials, fibres, foams, adhesives, and coatings.
6. Study advanced structural ceramics and analyze their properties, processing methods, and applications.

Course Code	Course Outcomes	Mapping with POs and PSOs								Dok
		PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2	
R24CCPE02.1	Analyze the mechanisms of plastic deformation, including slip and twinning, and understand the role of dislocations in yield stress and shear strength of metals.	3	3	1	1	1	3	3	1	L2, L4
R24CCPE02.2	Apply Griffith's Theory and the concepts of stress intensity factor and fracture toughness to evaluate material behavior under various loading conditions.	3	3	3	2	1	3	3	3	L3, L5
R24CCPE02.3	Conduct fatigue analysis using principles of crack initiation and propagation, and assess the impact of surface and metallurgical parameters on fatigue life.	3	3	3	2	1	3	3	3	L3, L5
R24CCPE02.4	Evaluate the properties, processing techniques, and applications of modern metallic materials, including dual steels, high-strength low-alloy steels, and shape memory alloys	3	3	2	3	2	3	3	3	L5
R24CCPE02.5	Understand the production techniques and applications of polymeric materials	3	3	2	3	1	3	3	3	L2

SYLLABUS

Unit – I **12 Hours**

Elasticity in metals, mechanism of plastic deformation, slip and twinning, role of dislocations, yield stress, shear strength of perfect and real crystals, strengthening mechanism, work hardening, solid solution, grain boundary strengthening. Poly phase mixture, precipitation, particle, fiber, and dispersion strengthening, effect of temperature, strain and strain rate on plastic behavior, super plasticity, Yield criteria: Von-mises and Tresca criteria. **COs: CO1**

Unit - II **10 Hours**

Griffth's Theory, stress intensity factor and fracture Toughness, Toughening Mechanisms, Ductile and Brittle transition in steel, High Temperature Fracture, Creep, Larson – Miller parameter, Deformation and Fracture mechanism maps. **COs: CO2**

Unit – III **15 Hours**

Fatigue, fatigue limit, features of fatigue fracture, Low and High cycle fatigue test, Crack Initiation and Propagation mechanism and Paris Law, Effect of surface and metallurgical parameters on Fatigue, Fracture of non-metallic materials, fatigue analysis, Sources of failure, procedure of failure analysis. Motivation for selection, cost basis and service requirements, Selection for Mechanical Properties, Strength, Toughness, Fatigue and Creep. **COs: CO3**

Unit – IV **8 Hours**

Modern Metallic Materials: Dual Steels, Micro alloyed, High Strength Low alloy (HSLA) Steel, Transformation induced plasticity (TRIP) Steel, Maraging Steel, Inter metallics, Ni and Ti Aluminides. Processing and applications of Smart Materials, Shape Memory alloys, Metallic Glass Quasi Crystal, and Nano Crystalline Materials. **COs: CO4**

Unit – V **12 Hours**

Nonmetallic Materials: Polymeric materials and their molecular structures, Production Techniques for Fibers, Foams, Adhesives and Coatings, structure, Properties and Applications of Engineering Polymers, Advanced Structural Ceramics WC, TiC, TaC, Al_2O_3, SiC, Si_3N_4, CBN and Diamond – properties, Processing and applications.

Materials Selection: Design process, selection factors, Materials for typical machine components, Selection case histories. **COs: CO5**

Text Books:

1. Mechanical Behavior of Materials/Thomas H. Courtney/ McGraw Hill/2 nd Edition/2000
2. Mechanical Metallurgy/George E. Dicter/McGraw Hill, 1998.

References:

1. Selection and use of Engineering Materials 3e/Charles J.A/Butterworth Heiremann.
2. Engineering Materials Technology/James A Jacob Thomas F Kilduff/Pearson
3. Material Science and Engineering/William D Callister/John Wiley and Sons
4. Plasticity and plastic deformation by Aritzur.
5. Introduction to Ceramics, 2nd Edition by W. David Kingery, H. K. Bowen, Donald R. Uhlmann

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Internal Assessment Pattern

Cognitive Level	Internal Assessment #1 (%)	Internal Assessment #2 (%)
L1	30	-

L2	30	20
L3	40	30
L4	-	30
L5	-	20
Total (%)	**100**	**100**

Sample Long Answers questions of Various Cognitive Levels

L1: Remembering:

1. Define the terms "elasticity" and "plastic deformation" in metals.
2. Define fatigue limit and explain its significance.
3. List different types of modern metallic materials such as Dual Steels and Maraging Steel.
4. Define the term "polymeric materials" and give examples.

L2: Understanding:

1. Explain the role of dislocations in plastic deformation
2. Explain the significance of the stress intensity factor in fracture mechanics.
3. Describe the Paris Law in the context of crack propagation
4. Explain the concept of Transformation Induced Plasticity (TRIP) Steel.
5. Explain the production techniques for fibers and foams.

L3: Applying:

1. Describe the process of work hardening and provide an example of a metal that undergoes this process.
2. Describe how the Larson-Miller parameter is used to predict creep behavior
3. Identify the metallurgical parameters that affect fatigue life.
4. Describe the processing and application of Shape Memory Alloys.
5. Describe the structure and properties of advanced structural ceramics such as SiC and Si3N4.

L4: Analyzing:

1. Compare and contrast the strengthening mechanisms of work hardening, solid solution strengthening, and grain boundary strengthening.
2. Differentiate between ductile and brittle fracture mechanisms
3. Analyze the differences between low-cycle and high-cycle fatigue tests and their respective applications.
4. Compare the properties and applications of Ni and Ti Aluminides with traditional metallic materials.
5. Analyze the differences in properties and applications between engineering polymers and advanced structural ceramics.

L5: Evaluating:

1. Assess the effects of temperature, strain, and strain rate on the plastic behavior of metals.
2. Evaluate the effectiveness of different toughening mechanisms in improving fracture toughness.
3. Assess the impact of surface treatments on the fatigue resistance of metals.
4. Evaluate the advantages and disadvantages of using Nano Crystalline Materials in

engineering applications.

5. Evaluate the potential of Nano Crystalline Materials in replacing traditional nonmetallic materials in engineering applications.

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R24CCPE03 **MECHANICAL VIBRATIONS** **3 0 0 3**

Course Objectives:

1. Demonstrate basic concepts and definitions of mechanical vibrations. To write equation of motion for discrete spring-mass systems with different configuration using classical and energy methods.
2. To train the students about basic concepts of forced vibrations, vibration transmissibility and isolation and seismic instruments.
3. To familiarize the students about two-degree freedom system and various types of vibration absorbers.
4. To analyze the two degree and multi degree of freedom systems.
5. To Calculate Natural Frequencies with Rayliegh and Dunkley's Methods.
6. Explain Vibration measuring devices and their applications.

Course Code	Course Outcomes	Mapping with POs and PSOs					
		PO1	PO2	PO3	PSO 1	PSO 2	Dok
R24CCPE03.1	Find natural frequency of un-damped single degree freedom systems	1	3	2	3	3	L2
R24CCPE03.2	Analyze the impulse response	2	3	2	3	3	L4
R24CCPE03.3	Analyze the two-degree freedom systems with and without damping	1	3	2	3	3	L4
R24CCPE03.4	Calculate natural frequencies of multi degree freedom system.	3	3	2	3	3	L3
R24CCPE03.5	Solve the Natural Frequencies Rayleigh and Dunkley's method and Vibration measuring devices and their applications	3	3	2	3	3	L3

SYLLABUS

Unit - I **12 Hours**

Single degree of Freedom systems: Undamped and damped free vibrations: forced vibrations; coulomb damping; Response to harmonic excitation; rotating unbalance and support excitation, Vibration isolation and transmissibility, vibrometers, velocity meters & accelerometers .**COs: CO1**

Unit - II **10 Hours**

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. **COs: CO2**

Unit - III **15 Hours**

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; Discrete-Time systems. **COs: CO3**

Unit – IV **8 Hours**

Numerical Methods: Rayliegh's, Stodola's, Matrix iteration, Rayleigh-Ritz Method and Holzer's methods **COs: CO4**

Unit – V **12 Hours**

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, damping treatment, vibration isolation, structural modification, active vibration control. **COs: CO5**

Text books

1. Elements of Vibration Analysis by Meirovitch.
2. Mechanical Vibrations by G.K. Groover.

References

1. Vibrations by W.T. Thomson
2. Mechanical Vibrations – Schaumseries.
3. Vibration problems in Engineering by S.P. Timoshenko.
4. Mechanical Vibrations – V. RamMurthy.

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Internal Assessment Pattern

Cognitive Level	Internal Assessment #1 (%)	Internal Assessment #2 (%)
L1	30	20
L2	30	20
L3	40	30
L4	-	30
Total (%)	**100**	**100**

Sample Long Answers questions of Various Cognitive Levels

L2: Understand

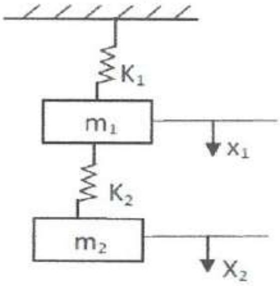
1. Describe the differences between undamped and damped free vibrations in a single-degree-of-freedom system. Provide mathematical formulations and examples for each type. Supply the algebraic form of a cubic spline.
2. Discuss in detail what main causes of vibrations.
3. Derive an expression for vibration response of a single degree of freedom system if the damping provided is over damped system.
4. Define the following terms?
   i) Periodic motion
   ii) Fundamental mode of vibration

iii) Degree of freedom
iv) Simple harmonic motion

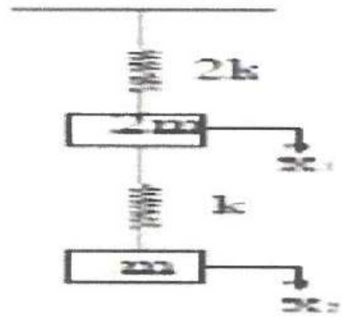
5. Derive an expression for vibration response of a single degree of freedom system if the damping provided is under damped system.
6. What are the principles on which a Vibrometer and an accelerometer are based?
7. Discuss Seismic instrument with help of a sketch?
8. Write short on the following:
   a) Damping ratio
   b) Undamped system (no damped)
   c) Under damped
   d) Critical damped
   e) Logarithmic decrement.
9. Discuss the basic principle on which vibration measuring instruments are designed. What are their practical limitations?
10. What do you know about the vibration isolation and transmissibility?
11. Differentiate between free vibrations and forced vibrations?
12. Derive an expression for vibration response of a single degree of freedom system if the damping provided is over damped system.
13. Explain the significance of unit impulse, unit step, and unit ramp functions in the analysis of non-periodic excitations. Provide examples of their applications.

L3: Apply

1. Machine is subjected to harmonic excitation due to rotating imbalance. Derive the equation of motion for this system and determine the steady-state response Derive the equation of a closed Bezier curve of degree 5
2. Derive the response of a single-degree-of-freedom system to a unit impulse using the convolution integral. Explain the physical interpretation of the result.
3. A two-degree-of-freedom system is subjected to a harmonic force. Derive the equations of motion and determine the system's response using matrix formulation.
4. Show that the time tp corresponding to the peak response of the damped spring mass system excited by astep force F_0 is $w_n t_p = \pi / (1- \zeta)^{1/2}$
5. 12. Find the normal modes of the system shown in Fig. Assume k1=k2=k and m1=m2=m



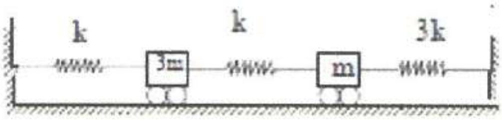
6. . Find the natural frequency and mode shapes of the system if ***m= 2 kg***, ***K= 400 N/m***, for the figure given below.



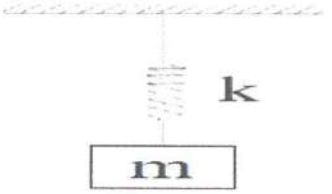
7. Derive an expression for vibration response of a single degree of freedom system if the damping provided is under damped system.
8. 1For the spring, mass, damper system the characteristic of the dash pot is such that when a constant force of 49N is applied to the piston its velocity is found to be constant at 0.12m/s. Given K=245N/m
   i) Determine the value of C
   ii) Would you expect the complete system to be periodic or aperiodic
9. Discuss in detail what are main causes of vibration.
10. Derive an expression for vibration response of a single degree of freedom system if the damping provided is over damped system.
11. Explain the classifications of vibration with examples.
12. What is the significance of convolution integral; shock spectrum in the analysis of Non periodic vibration response?
13. A uniform taut string of length 2 m fixed at both ends has a large initial tension. It is struck in such a manner as to give an initial velocity to the string which varies linearly from zero at the ends to 20 m/s at the centre. Determine the subsequent motion?
14. 42. A shaft 1.5cm diameter and 1m long is held in long bearings. The weight of the disc at the center of the shaft is 15 Kg. The eccentricity of the CG of the disc from center of rotor is 0.03 cm. E of the material of shaft is 2 x 106 Kg/cm2. The permissible stress in the shaft material is 700 Kg/cm2. (Neglecting the weight of the shaft). Find i) The critical speed of the shaft. ii) The range of speed over which it is unsafe to run the shaft.
15. 43. A mass of 50 kg suspended from spring produces a static deflection of 0.017m and when in motion, it experience a viscous damping force with a value of 250 N at a velocity of 0.3m/s. calculate the periodic time of damped vibration if the mass is then subjected to periodic disturbing force having a maximum value of 200N and making 2 Cps. Find the amplitude of the ultimate force.

L4: Analyzing (L4):

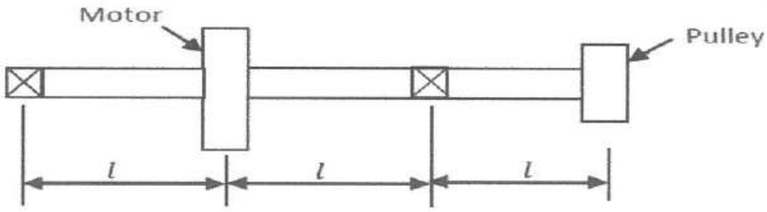
1. Analyze the effectiveness of different vibration isolation techniques for minimizing vibrations transmitted to a sensitive instrument. Compare transmissibility ratios for various isolator designs.
2. Analyze the shock spectrum of a mechanical system subjected to a sudden impact. Discuss how the shock spectrum can be used in design and failure analysis.
3. Analyze the torsional vibrations of a multi-rotor system with geared components. Discuss how the system's eigenvalues and mode shapes are affected by the gear ratios



4. Determine the differential equation of a spring mass system (shown in the figure below) and its natural frequency by using
   i. D' Alembert's principle
   ii. Rayleigh's method.



5. Figure shows a motor driving a pulley mounted overhanging on a shaft. The mass of the rotor is 55 kg and that of pulley is 15 kg. Take l = 0.4m and shaft diameter as 3 cm. Determine the natural frequencies and corresponding mode in lateral bending.



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R24CCPE04 **MECHATRONICS** **3 0 0 3**

Course Objectives:

1. Grasp the fundamentals, components, and design processes of mechatronics systems.
2. Assess the benefits and limitations of mechatronics integration.
3. Learn about solid-state devices and analog signal processing.
4. Study fluid mechanics principles and their use in hydraulic and pneumatic systems.
5. Identify and differentiate between various actuating systems and their controls.
6. Understand digital electronics, microprocessors, and PLCs.
7. Apply programming skills for control applications and compare PLCs with computers.

Course Code	Course Outcomes	Mapping with POs and PSOs						Dok
		PO1	PO2	PO3	PO4	PSO1	PSO2	
R24CCPE04.1	Understand and design mechatronics systems, evaluating their benefits and drawbacks.	1	-	-	-	1	-	L1, L2
R24CCPE04.2	Identify key electronic devices, apply signal conditioning techniques, and explain MEMS applications.	2	2	-	-	-	2	L2, L3
R24CCPE04.3	Analyze hydraulic and pneumatic systems, and understand their components and controls.	1	1	-	-	1	-	L1, L2
R24CCPE04.4	Apply digital electronics concepts, program microprocessors and PLCs, and compare PLCs with computers.	2	2	2	-	-	2	L3
R24CCPE04.5	Implement interfacing, DAQ, SCADA systems, perform A/D and D/A conversions, and apply communication protocols.	2	2	2	2	2	-	L2, L3

SYLLABUS

UNIT-I **12 HOURS**

Mechatronics systems, elements, levels of mechatronics system, Mechatronics design process, system, measurement systems, control systems, Embedded Systems, microprocessor-based controllers, advantages and disadvantages of mechatronics systems, The mechatronics design process, Advanced approaches in mechatronics, Sensors and transducers, types, displacement, position, proximity, velocity, motion, force, acceleration, torque, fluid pressure, liquid flow, liquid level, temperature and light sensors. **COs: CO1**

UNIT-II **10 HOURS**

Solid state electronic devices, PN junction diode, BJT, FET, DIA and TRIAC. Analog signal conditioning, amplifiers, Transistors, filtering. Introduction to MEMS & typical applications.

Advanced applications in mechatronics: Sensors for condition monitoring, Mechatronic control in automated manufacturing, Artificial intelligence in mechatronics. **COs: CO2**

UNIT-III **12 HOURS**

Hydraulic and pneumatic actuating systems, Basic Principles of Fluid Mechanics, Fluid systems, Hydraulic and pneumatic systems, components, control valves, electro-pneumatic, hydro-pneumatic, electro-hydraulic servo systems: Mechanical actuating systems and electrical actuating systems. **COs: CO3**

UNIT-IV **14 HOURS**

Digital electronics and systems, digital logic control, microprocessors and micro controllers, programming, Sequential Logic Circuits, process controllers, programmable logic controllers, PLCs versus computers, application of PLCs for control. **COs: CO4**

UNIT-V **12 HOURS**

System and interfacing and data acquisition, DAQS, SCADA, A to D and D to A conversions; Dynamic models and analogies, Interfacing Techniques, Communication Protocols, System response. Design of mechatronics systems & future trends. **COs: CO5**

Text Books:

1. Mechatronics Integrated Mechanical Electronics Systems/KP Ramachandran & GK Vijaya Raghavan/WILEY India Edition/2008.
2. Mechatronics Electronics Control Systems in Mechanical and Electrical Engineering by W Bolton, Pearson Education Press, 3rd edition, 2005.

References:

1. Mechatronics Source Book by Newton C Braga, Thomson Publications, Chennai.
2. Mechatronics – N. Shanmugam / Anuradha Agencies Publishers.
3. Mechatronics System Design / Devdasshetty/Richard/Thomson.
4. Mechatronics/M.D.Singh/J.G.Joshi/PHI.
5. Mechatronics – Electronic Control Systems in Mechanical and Electrical Engg. 4th Edition, Pearson, 2012 W. Bolton
6. Mechatronics – Principles and Application Godfrey C. Onwubolu, Wlsevier, 2006

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Internal Assessment Pattern

Cognitive Level	Internal Assessment #1(%)	Internal Assessment #2(%)
L1	30	10
L2	30	50
L3	40	40
Total (%)	100	100

Sample Long Answers questions of Various Cognitive Levels

L2: Understand

1. Explain the key elements of a mechatronics system and their integration.
2. Discuss the benefits and drawbacks of mechatronics systems in industry.

3. Outline the steps in designing a mechatronics system and the role of measurement and control systems.
4. Describe how a PN junction diode works and its circuit applications.
5. Explain how analog signal conditioning, including amplifiers and filtering, improves signal quality.
6. Compare the basic operations and applications of BJTs and FETs.
7. Explain fluid mechanics principles and their impact on hydraulic actuators.
8. Describe the components and control mechanisms of a pneumatic system.
9. Compare electro-hydraulic and electro-pneumatic servo systems in terms of their applications.
10. Explain the functions of digital logic gates and their use in circuits.
11. Describe how microcontrollers and microprocessors are programmed for control systems.
12. Compare PLCs and computers in process control applications, highlighting PLC advantages.
13. Discuss the importance of data acquisition systems (DAQ) in industrial processes.
14. Explain the role of communication protocols in system interfacing.
15. Describe A/D and D/A conversions and their impact on data acquisition performance

L3: Apply

1. Design a simple mechatronics system and explain how you would integrate sensors and actuators.
2. Apply the mechatronics design process to a real-world problem and outline the key steps.
3. Develop a control strategy for a mechatronics system and demonstrate how measurement systems are used.
4. Create a circuit design using a PN junction diode and explain its operation.
5. Apply analog signal conditioning techniques to improve the signal quality of a specific electronic signal.
6. Design a basic amplifier circuit using BJTs or FETs and discuss its application in signal processing.
7. Design a hydraulic or pneumatic system for a specific application and explain the choice of components.
8. Apply fluid mechanics principles to calculate the performance parameters of a hydraulic actuator.
9. Develop a control system for a pneumatic actuator and explain how you would integrate it into an automated process.
10. Create a digital logic circuit using AND, OR, and NOT gates to perform a specific function.
11. Program a microcontroller for a control application and describe the programming steps involved.
12. Design a process control system using a PLC and explain how it improves over traditional computer-based systems.
13. Create a system to convert analog signals to digital using A/D conversion and explain the impact on system performance.

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R24CCPE05 **INDUSTRIAL ROBOTICS** **3 0 0 3**

Course Objectives:

1. Learned about the different types of industrial robots and their applications.
2. Understand and implement different control strategies for precise robot operation.
3. Learned how to integrate and utilize these sensors for enhancing robotic capabilities.
4. Learned about the safety standards and regulations for operating industrial robots.
5. Understand the importance of safety in the design and operation of robotic systems.
6. Develop skills in project management and teamwork through group projects.

Course Code	Course Outcomes	Mapping with POs and PSOs								
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	Dok
R24CCPE05.1	Apply the manipulator design including actuator, drive and sensor issues.	2	2	-	-	-	-	2	-	L1
R24CCPE05.2	Analyze the forward kinematic, inverse kinematics and Jacobian for serial and parallel robots	1	2	2	-	-	-	-	2	L2, L3
R24CCPE05.3	Analyze manipulator trajectories and robot end-effectors.	2	2	-	-	-	-	2	-	L2, L4
R24CCPE05.4	Develop programming principles and language for a robot control system.	1	-	-	2	2	-	-	2	L2, L5
R24CCPE05.5	Assess various applications of industrial robot systems with cell controller.	1	-	2	-	-	2	2	-	L4, L6

SYLLABUS

UNIT - I **10 Hours**

Introduction: Automation and Robotics, Robot anatomy, robot configuration, motions joint notation scheme, work volume, robot drive systems, control systems and dynamic performance, precision of movement.

Control System and Components: basic concepts and motion controllers, control system analysis, robot actuation and feedback components, Positions sensors, velocity sensors, actuators, power transmission systems, robot joint control design. **COs: CO1**

UNIT - II **15 Hours**

Motion Analysis And Control: Manipulator kinematics, position representation, forward and inverse transformations, homogeneous transformations, manipulator path control, robot arm dynamics, configuration of a robot controller. **COs: CO2**

UNIT – III **10 Hours**

End Effectors: Grippers-types, operation, mechanism, force analysis, tools as end effectors consideration in gripper selection and design. SENSORS: Desirable features, tactile, proximity and range sensors, uses sensors in robotics.

Machine Vision: Functions, Sensing and Digitizing-imaging devices, Lighting techniques, Analog to digital single conversion, image storage: Image processing and Analysis-image data reduction, Segmentation, feature extraction, Object recognition. Training the vision system, Robotic application. **COs: CO3**

UNIT - IV **15 Hours**

Robot Programming: Lead through programming, Robot program as a path in space, Motion interpolation, WAIT, SIGNAL AND DELAY commands, Branching, capabilities and Limitations of lead through methods.

Robot Languages: Textual robot Languages, Generations of robot programming languages, Robot language structures, Elements and function. **COs: CO4**

UNIT - V **10 Hours**

Robot Cell Desgin and Control: Robot cell layouts-Robot centered cell, In-line robot cell, Considerations in work design, Work, and control, Inter locks, Error detection, Work cell controller.

Robot Application: Material transfer, Machine loading/unloading, Processing operation, Assembly and Inspection, Future Application. **COs: CO5**

Text Books:

1. Industrial Robotics / Groover M P /Pearson Edu.
2. Introduction to Robotic Mechanics and Control by JJ Craig, Pearson, 3rd edition.

References:

1. Robotics / Fu K S/ McGraw Hill.
2. Robotic Engineering / Richard D. Klafter, Prentice Hall
3. Robot Analysis and Intelligence / Asada and Slotine / Wiley Inter-Science.
4. Robot Dynamics & Control – Mark W. Spong and M. Vidyasagar / John Wiley
5. Introduction to Robotics by SK Saha, The McGrah Hill Company, 6th, 2012
6. Robotics and Control / Mittal R K & Nagrath I J / TMH

Board of Studies: Mechanical Engineering
Approved in BOS No: 01, 31st July, 2024
Approved in ACM No: 01

Internal Assessment Pattern

Cognitive Level	Internal Assessment #1 (%)	Internal Assessment #2 (%)
L1	20	
L2	40	20
L3	40	40
L4		20
L5		10
L6		10
Total (%)	**100**	**100**

Sample Long Answers questions of Various Cognitive Levels

L1: Remember

1. List the various types of position and velocity sensors used in robotics.
2. Identify the key components involved in manipulator path control.
3. List the various lighting techniques used in machine vision systems.
4. Identify the key elements and functions of a textual robot language.
5. List the various applications of robotics in material transfer and machine loading/unloading.

L2: Understand

1. Define robot anatomy and describe the different robot configurations.
2. Explain the basic concepts of automation and robotics, detailing the role of robot anatomy in different industrial applications.
3. What is manipulator kinematics, and why is it essential in robotics?
4. Explain the concept of position representation in robotic systems, providing examples of its application.
5. What are the different types of grippers used as end effectors in robotics?
6. Discuss the mechanism and force analysis of robotic grippers, providing examples of their applications.
7. Describe the concept of lead-through programming in robotics.
8. Explain the structure and elements of robot programming languages, highlighting the evolution of these languages over time.
9. What are the different types of robot cell layouts, and how do they impact robotic operations?
10. Discuss the principles of robot cell design, focusing on the key factors that influence the layout and control of robotic cells.

L3: Apply

1. How does the work volume of a robot impact its operational efficiency?
2. Describe the process of designing a robot joint control system, including the integration of actuators and power transmission systems.
3. How do forward and inverse transformations contribute to the positioning of a robot manipulator?
4. Demonstrate how to calculate forward and inverse kinematics for a simple robotic

manipulator.

5. How do tactile sensors contribute to the functioning of robotic end effectors?
6. Explain the process of training a machine vision system for a specific robotic application, detailing the steps involved.
7. How does motion interpolation enhance the programming of robotic paths?
8. Demonstrate the use of branching commands in a robot program, explaining how they influence the robot's behavi
9. How do interlocks and error detection enhance the control of a robotic work cell?
10. Explain the process of designing a robotic work cell for a specific industrial application, detailing the considerations involved.

L4: Analyzing

1. Compare different robot drive systems and their influence on dynamic performance.
2. Perform a control system analysis for a given robotic system, identifying potential issues in feedback components.
3. Discuss the significance of homogeneous transformations in robot motion analysis.
4. Analyze the impact of different robot arm dynamics on the overall performance of a robotic system.
5. Compare the use of proximity sensors versus range sensors in robotics.
6. Analyze the role of image processing and analysis in machine vision, focusing on feature extraction and object recognition.
7. Compare the capabilities and limitations of different generations of robot programming languages.
8. Analyze the advantages and disadvantages of lead-through programming compared to textual programming in robotics.
9. Compare the considerations in work design for robot-centered and in-line robot cells.
10. Analyze the role of interlocks and error detection systems in maintaining the safety and efficiency of robotic work cells.

L5: Evaluate

1. What are the key factors in selecting the precision of movement in robotic control systems?
2. Critically evaluate the performance of different robot drive systems in terms of precision, speed, and dynamic response.
3. Assess the importance of robot arm dynamics in the configuration of a robot controller.
4. Evaluate various methods of manipulator path control and their effectiveness in different scenarios.
5. What are the critical factors in the design of a robotic gripper?
6. Evaluate the effectiveness of different sensing and digitizing techniques in enhancing the performance of robotic systems.
7. Assess the effectiveness of WAIT, SIGNAL, and DELAY commands in robot programming.
8. Critically evaluate the effectiveness of different motion interpolation techniques in optimizing robotic path planning.
9. Assess the importance of work cell controllers in ensuring efficient robotic operations.
10. Evaluate the effectiveness of different robot cell layouts in optimizing material transfer, processing, and assembly operations.

L6: Creating

1. Design a control system for a robotic arm that includes sensors, actuators, and a motion controller. Justify your design choices.
2. Design a robot controller for a complex robotic arm, considering all aspects of motion analysis and control. Provide a detailed explanation of your design process.
3. Design a machine vision system for a robotics application, including considerations for image data reduction and segmentation. Explain the rationale behind your design choices.
4. Develop a robot program for a specific task, incorporating motion interpolation, branching, and signal commands. Justify the programming choices made.
5. Design a robot cell for an industrial application involving assembly and inspection. Include considerations for work design, control, and future scalability. Provide a detailed explanation of your design choices.

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R24CCPE06 SIMULATION OF MANUFACTURING SYSTEMS 3 0 0 3

Course Objectives:

1. Understand the basics of simulation, including model types, parameter estimation, and hypothesis testing.
2. Build, validate, and verify simulation models using various techniques, including handling stochastic input elements with advanced modeling techniques.
3. Generate random variates using various methods and evaluate simulation languages and software tools for effective simulation.
4. Analyze output data from simulations using advanced techniques, including statistical analysis, data visualization, and real-time data analysis.
5. Apply simulation methods to practical problems in manufacturing, supply chain management, and healthcare, including complex queueing and inventory systems.
6. Develop advanced skills in simulation modeling, analysis, and application

Course Code	Course Outcomes	Mapping with POs and PSOs					DoK
		PO1	PO2	PO5	PO6	PSO2	
R24CCPE06.1	Analyze and apply various simulation models and methodologies, including emerging trends and advanced parameter estimation techniques.	2	2	1	-	-	L1
R24CCPE06.2	Develop and validate simulation models for complex systems, and apply stochastic modeling and big data validation techniques.	2	2	-	-	2	L2
R24CCPE06.3	Generate random variates using advanced methods and compare simulation languages and software tools, including modern platforms.	1	2	-	-	2	L2, L3
R24CCPE06.4	Perform output data analysis using advanced techniques, including real-time data analysis and machine learning methods, and determine warm-up periods and steady-state analysis.	2	2	1	-	-	L3, L5
R24CCPE06.5	Apply simulation techniques to real-world problems in manufacturing, supply chain management, and healthcare, including complex systems and queueing models	2	2	2	2	1	L4, L6

SYLLABUS

UNIT - I: Introduction to Simulation **16 Hours**

System – ways to analyze the system, Model – types of models, Simulation – Definition, Types of simulation models, Steps involved in simulation, Advantages & Disadvantages. Emerging Trends in Simulation Systems (e.g., digital twins, cyber-physical systems), Advanced Parameter Estimation Techniques (e.g., machine learning methods), Bayesian Methods in Hypothesis Testing

COs: CO1

UNIT - II: Simulation Model Development. 16 Hours

Building of Simulation Model, Validation, Verification, and Credibility – Principles and Timing Techniques for Verification, Statistical Procedures for Developing Credible Models, Modeling of Complex Systems (e.g., multi-agent systems, adaptive behaviors), Validation and Verification in Big Data Simulations. Advanced Stochastic Modeling Techniques (e.g., Markov Chains, Queuing Theory Enhancements) **COs: CO2**

UNIT - III: Random Variate Generation and Simulation Languages 16 Hours

Generation of Random Variates – Methods and Techniques, Inverse Transform, Composition, Convolution, Acceptance-Rejection, Generation of Random Variables (e.g., exponential, uniform, Weibull, normal, Bernoulli, Binomial, Poisson), Advanced Random Variate Generation Methods (e.g., Low-Discrepancy Sequences, Quasi-Monte Carlo Methods), Simulation Languages, Comparison with General Purpose Languages, Simulation Languages vs. Modern Software Platforms (e.g., cloud-based tools), Software Features and Statistical Capabilities-Examples: GPSS, SIMAN, SIMSCRIPT, Python-based Simulation Libraries (e.g., SimPy), R-based Simulation Packages, Simulation of M/M/1 Queue and Comparison of Simulation Languages **COs: CO3**

UNIT - IV: Output Data Analysis 16 Hours

Output Data Analysis – Types and Techniques, Advanced Techniques for Output Data Analysis (e.g., Machine Learning for Anomaly Detection), Real-Time Data Analysis Techniques, Warm-Up Period and Algorithms (e.g., Geometric Method, alternative methods), Approaches for Steady-State Analysis , application and Batch Means Methods, Comparisons **COs: CO4**

UNIT - V: Applications of Simulation 14 Hours

Applications in Industry 4.0 and Smart Manufacturing, Flow Shop System, Job Shop System, Complex Queueing Systems (e.g., M/G/1 queues, Networks of Queues), Simulation in Supply Chain Management and Healthcare Systems, Simple Fixed Period Inventory System, New Boy Paper Problem. **COs: CO5**

Text Books

1. J.Banks, J.S. Carson, B. L. Nelson and D.M. Nicol, "Discrete Event System Simulation", PHI, New Delhi, 2009.
2. A.M. Law and W.D.Kelton, "Simulation Modeling and Analysis", Tata McGraw Hill Ltd, New Delhi, 2008.
3. N. Viswanadham and Y. Narahari, "Performance Modeling of Automated Manufacturing Systems", PHI, New Delhi, 2007

Reference Books

1. "Discrete-Event System Simulation" by Jerry Banks, John S. Carson II, Barry L. Nelson, and David M. Nicol Mechanical Vibrations – Schaumseries.
2. "Simulation Modeling and Analysis" by Averill M. Law.
3. "Manufacturing Systems Modeling and Analysis" by Guy L. Curry and Richard M. Feldman.
4. "Modeling and Analysis of Manufacturing Systems" by Ronald G. Askin and Charles R. Standridge.

5. "Introduction to Simulation and Risk Analysis" by James R. Evans and David L. Olson

Board of Studies: Mechanical Engineering
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Internal Assessment Pattern

Cognitive Level	Internal Assessment #1 (%)	Internal Assessment #2 (%)
L2	40	10
L3	40	30
L4	20	30
L5	-	20
L6		10
Total (%)	**100**	**100**

Sample questions of Various Cognitive Levels

L1: Remembering:

1. What are the types of models used in simulation?
2. Define simulation and list its types.
3. What is model validation in simulation?
4. List the techniques for verification of simulation models.
5. What is the inverse transform method in random variate generation?
6. List examples of simulation languages.
7. What is the warm-up period in simulation output data analysis?
8. Define batch means methods.
9. What are some applications of simulation in Industry 4.0?
10. How is simulation used in healthcare systems?

L2: Understand:

1. What are the advantages and disadvantages of simulation?
2. Explain the concept of emerging trends in simulation systems.
3. Explain the principles of verification, validation, and credibility in simulation.
4. Discuss advanced stochastic modeling techniques used in simulation.
5. Describe the methods for generating random variates.
6. Explain the differences between simulation languages and general-purpose programming languages.
7. Explain the role of simulation in smart manufacturing.
8. Discuss the application of simulation in complex queuing systems.

L3: Apply:

1. Describe the steps involved in simulation.
2. How can digital twins be applied in manufacturing systems?
3. How do you validate a complex simulation model?
4. Apply Markov Chains in a simulation scenario.
5. How can the acceptance-rejection method be used in random variate generation?
6. Apply the use of Simply in creating a simple simulation model.

7. Explain the types and techniques of output data analysis in simulation.
8. Discuss real-time data analysis techniques.
9. How can you use machine learning for anomaly detection in simulation output?
10. Apply steady-state analysis methods in a given simulation scenario.
11. Apply simulation techniques to a flow shop system.
12. How can simulation improve supply chain management?

L4: Analyzing:

1. Compare different types of simulation models.
2. Analyze the role of Bayesian methods in hypothesis testing within simulation.
3. Analyze the importance of verification in simulation model development.
4. Compare different stochastic modeling techniques.
5. Compare the features of GPSS, SIMAN, and SIMSCRIPT.
6. Analyze the effectiveness of low-discrepancy sequences in random variate generation.
7. Analyze the effectiveness of the geometric method in determining the warm-up period.
8. Compare different approaches for steady-state analysis.
9. Analyze the benefits of simulation in a job shop system.
10. Compare different simulation applications in manufacturing systems.

L5: Evaluating:

1. Evaluate the effectiveness of machine learning methods in advanced parameter estimation techniques.
2. Evaluate the credibility of a given simulation model.
3. Evaluate the pros and cons of using cloud-based simulation tools.
4. Evaluate the use of batch means methods for output data analysis.
5. Evaluate the effectiveness of simulation in a simple fixed period inventory system.

L6: Creating:

1. Design a simple simulation model for a given manufacturing process.
2. Develop a simulation model using advanced stochastic techniques.
3. Design a simulation model using a Python-based simulation library.
4. Develop a real-time data analysis method for a specific simulation scenario.
5. Design a simulation model for the New Boy Paper Problem.

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R24CCPC03 **ADVANCED CAD LAB** **0 0 4 2**

Course Objectives:

1. Gain proficiency in using advanced features of CAD software such as AutoCAD, SolidWorks, CATIA, or Fusion 360.
2. Undertake and complete complex design projects that involve creating detailed and accurate 3D models.
3. Understand and apply finite element analysis (FEA) and
4. Understand and apply Computational fluid dynamics (CFD) principles.
5. Utilize version control and collaborative tools within CAD software to manage shared projects.
6. Design for manufacturability and understand the constraints and capabilities of different manufacturing techniques.

Course Code	Course Outcomes	Mapping with POs and PSOs						Dok
		PO1	PO2	PO3	PO4	PSO1	PSO2	
R24CCPC03.1	Apply principles of static equilibrium and material mechanics to evaluate the performance of trusses under various loads.	3	3	2	-	2	1	L2, L3
R24CCPC03.2	Develop detailed models of beams and perform structural analysis to determine stress, strain, and deflection.	3	2	2	-	-	2	L4
R24CCPC03.3	Utilize FEA tools within CAD software to perform detailed structural analysis of various components.	3	2		2	-	2	L4,L5

List of Experiments

1. Trusses - 2D **COs: CO1**
2. Trusses - 3D **COs: CO1**
3. Beams **COs: CO2**
4. Plate with Plane stress condition **COs: CO3**
5. Plate with Plane strain condition **COs: CO3**
6. Cylinders – Axi-symmetric condition **COs: CO3**
7. Natural frequencies of Beam **COs: CO3**
8. Develop a mini project on above experimental knowledge. **COs: CO3**

Board of Studies: Mechanical Engineering
Approved in BOS No: 01, 31st July, 2024
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R24CCPC04 **ADVANCED MANUFACTURING LAB** **0 0 4 2**

Course Objectives:

1. Study the solidification process in different casting methods.
2. Analyze temperature gradients and their impact on metallurgical phases and microstructure.
3. Identify and understand the causes of defects in cast products and learn mitigation techniques.
4. Study the effects of temperature, strain rate, and material properties on the forging process.
5. Gain knowledge of sheet metal forming processes such as blanking, bending, and deep drawing.
6. Understand the metallurgical changes that occur during welding and their effects on weld integrity.

Course Code	Course Outcomes	Mapping with POs and PSOs				Dok
		PO1	PO2	PO3	PSO2	
R24CCPC04.1	Study the principles of powder metallurgy, including powder compaction and sintering.	2	2	2	2	L2
R24CCPC04.2	Estimate the chip reduction coefficient and shear angle in orthogonal turning.	2	3	2	2	L3
R24CCPC04.3	Identify common defects in forming processes and implement strategies to minimize them.	2	2	2	3	L4

EXPERIMENTS

1. Casting processes - Study of Solidification, temperatures, metallurgical phases. **COs: CO3**
2. Forging processes - Study of hot working processes and extrusion. **COs: CO3**
3. Forming Processes – Study of blanking, bending and deep drawing. **COs: CO3**
4. Welding Processes – Study of arc, and spot-welding processes. **COs: CO3**
5. Powder metallurgy- Study of Green Density and sintering density. **COs: CO1**
6. Additive Manufacturing – Study of simple parts in 3D printing. **COs: CO3**
7. Machining- Estimation of chip reduction coefficient and shear angle in orthogonal turning, Measurement of cutting forces and average cutting temperature, and Estimation of tool life of a single point turning tool. **COs: CO2**
8. Develop a mini project on above experimental knowledge. **COs: CO3**

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Approved in BOS No: 01, 31st July, 2024
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MTMB1105 **Research Methodology and IPR** **3 0 0 3**

Course Objectives:

1. To give an overview of the research methodology and explain the technique of defining a research problem.
2. To explain the functions of the literature review in research and guide the process of conducting a literature search, reviewing it, and writing a review.
3. To explain various research designs, their characteristics, and the details of sampling designs, measurement and scaling techniques, along with different methods of data collection.
4. To explain several parametric tests of hypotheses, including the Chi-square test, and their application in research.
5. To explain various forms of intellectual property, its relevance, business impact, and leading international instruments concerning Intellectual Property Rights in the global business environment.

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

CourseCode	Course Outcomes	Mappingwith POs			Dok
		PO1	PO5	PO6	
MTMB1105.1	Understanding Research Fundamentals	2	1	2	L1,L4
MTMB1105.2	Conducting Literature Reviews	2	2	2	L1,L4
MTMB1105.3	Designing Research and Sampling Methods	3	1	2	L1,L3
MTMB1105.4	Data Collection and Analysis	3	1	2	L1,L3
MTMB1105.5	Interpreting Results and Reporting	3	3	2	L1,L4

SYLLABUS

UNIT-I: Research Methodology **10Hours**

Introduction, Meaning of Research, Objectives of Research, Types of Research, Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Research Process, Criteria of Good Research,. Problems Encountered by Researchers in India.

Technique Involved in Defining a Problem, an Illustration. **CO'S-CO1**

UNIT-II: Reviewing the literature **8Hours**

Place of the literature review in research, Bringing clarity and focus to research problem, Improving research methodology, Broadening knowledge base in research area, Enabling contextual findings, Review of the literature, searching the existing literature, reviewing the selected Literature, Developing a theoretical framework, Developing a conceptual framework, Writing about the literature reviewed.

Research Design: Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs, Important Experimental Designs. **CO'S-CO2**

UNIT-III: Design of Sample Surveys **12Hours**

Design of Sampling: Introduction, Sample Design, Sampling and Non-sampling Errors, Sample

Survey versus Census Survey, Types of Sampling Designs.

Measurement and Scaling: Qualitative and Quantitative Data, Classifications of Measurement Scales, Goodness of Measurement Scales, Sources of Error in Measurement, Techniques of Developing Measurement Tools, Scaling, Scale Classification Bases, Scaling Technics, Multidimensional Scaling, Deciding the Scale.

Data, Selection of Appropriate Method for Data Collection, Case Study Method.**CO's-CO3 UNIT-IV: Testing of Hypotheses** **12Hours**

Hypothesis, Basic Concepts Concerning Testing of Hypotheses, Testing of Hypothesis, Test Statistics and Critical Region, Critical Value and Decision Rule, Procedure for Hypothesis Testing, Hypothesis Testing for Mean, Proportion, Variance, for Difference of Two Mean, for Difference of Two Proportions, for Difference of Two Variances, P-Value approach, Power of Test, Limitations of the Tests of Hypothesis. Goodness of Fit, Cautions in Using Chi Square Tests. Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports.

CO's-CO4

UNIT-V: Interpretation and Report Writing: **12Hours**

Intellectual Property: The Concept, Intellectual Property System in India, Development of TRIPS Complied Regime in India, Patents Act, 1970, Trade Mark Act, 1999, The Designs Act, 2000, The Geographical Indications of Goods(Registration and Protection) Act1999,CopyrightAct,1957, The Protection of Plant Varieties and Farmers'RightsAct,2001,TheSemi-Conductor Integrated Circuits Layout Design Act, 2000, Trade Secrets, Utility Models, IPR and Biodiversity, The Convention on Biological Diversity (CBD) 1992, Competing Rationales for Protection of IPRs, Leading International Instruments Concerning IPR, World Intellectual Property Organisation (WIPO),WIPO and WTO, Paris Convention for the Protection of Industrial Property, National Treatment, Right of Priority, Common Rules, Patents, Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition, Patent Cooperation Treaty (PCT), Advantages of PCT Filing, Berne Convention for the Protection of Literary and Artistic Works, Basic Principles, Duration of Protection, Trade Related Aspects of Intellectual Property Rights (TRIPS) Agreement, Covered under TRIPS Agreement, Features n of the Agreement, Protection of Intellectual Property under TRIPS, Copyright and Related Rights, Trademarks, Geographical indications, Industrial Designs, Patents, Patentable Subject Matter, Rights Conferred, Exceptions, Term of protection, Conditions on Patent Applicants, Process Patents, Other Use without Authorization of the Right Holder, Layout-Designs of Integrated Circuits, Protection of Undisclosed Information, Enforcement of Intellectual Property Rights, UNSECO. **CO's-CO5**

Board of Studies : Management Science

Approved in BOS No: 05, August, 2024

Approved in ACM No: 01

Textbooks:

1. Research Methodology: Methods and Techniques - C.R. Kothari, Gaurav Garg, New Age International, 4th Edition, 2018.
2. Research Methodology a step-by-step guide for beginners. (For the topic Reviewing the literature under module2)- Ranjit Kumar SAGE Publications Ltd, 3rdEdition, 2011
3. Study Material (For the topic Intellectual Property under module5), Professional

Programme Intellectual Property Rights, Law and Practice, The Institute of Company Secretaries of India, Statutory Body under an Act of Parliament, September 2013.

Reference Books:

1. Research Methods: The concise knowledge base-Trochim, Atomic Dog Publishing,2005
2. Conducting Research Literature Reviews: From the Internet to Paper–Fink, Sage Publications, 2009.

Web References:

1. https://www.ebooksdirectory.com/
2. http://www.sciencedirect.com/Science
3. https://onlinecourses.nptel.ac.in/
4. https://www.link.springer.com/physics/
5. https://www.loc.gov/rr/scitech/selected-internet/physics.html

Internal Assessment Pattern

Cognitive Level	InternalAssessment#1(%)	InternalAssessment#2(%)
L1	30	30
L2	30	30
L3	20	20
L4	20	20
Total(%)	**100**	**100**

Sample Short and Long Answers questions of Various Cognitive

Levels Module-1: Research Methodology

1. What is the primary objective of research?
2. Describe the difference between basic and applied research.
3. Explain the significance of using the scientific method in research.
4. Differentiate between research methods and research methodology.
5. Outline the steps in the research process.
6. What are the criteria for good research?
7. Identify common problems encountered by researchers in India.
8. What are the main research approaches, and how do they differ from one another?
9. Discuss the significance of defining are search problem clearly.
10. Provide an example of how to define a research problem, including the steps involved.

Module-2: Reviewing the Literature & Research Design

1. What is the role of a literature view in a research study?
2. How does reviewing literature help in clarifying the research problem?
3. What is the difference between a theoretical frame work and a conceptual frame work?
4. List and describe the key features of a good research design.
5. Why is research design crucial for the validity of a study
6. Explain the different types of research designs and their applications?
7. What are basic principles of experimental designs?
8. How can a literature review improve research methodology?
9. Describe the process of searching and reviewing existing literature?
10. Illustrate how a well-developed theoretical framework can guide a research study?

Module-3: Design of Sample Surveys, Measurement, and Scaling

1. What is the difference between sampling errors and non-sampling errors?
2. Discuss the advantages and disadvantages of sample surveys compared to census surveys.
3. Explain the concept of sample design and its importance in research.
4. What are the classifications of measurement scales, and how are they used?
5. Describe the sources of error in measurement and techniques to minimize them.
6. Differentiate between qualitative and quantitative data.
7. What is multi dimensional scaling, and how is it applied in research?
8. Explain the process of developing a measurement tool.
9. How does scaling affect data collection and analysis?
10. Discuss the role of the case study method in data collection.

Module-4: Testing of Hypotheses

1. Define hypothesis and its role in research.
2. What is the procedure for hypothesis testing?
3. Differentiate between Type I and Type II errors in hypothesis testing.
4. Explain the concept of the critical value and its role in decision-making.
5. How do you test hypotheses for differences between two means or proportions?
6. Describe the P-value approach and its significance in hypothesis testing.
7. What is the power of a test, and why is it important?
8. Discuss the limitations of hypothesis testing.
9. Explain how the chi-square test is used for goodness of fit and its cautions.
10. Describe the different test statistics used in hypothesis testing for variances.

Module-5: Interpretation, Report Writing, and Intellectual Property

1. What is the meaning of interpretation in research, and why is it important?
2. Discuss the techniques used for interpreting research data.
3. What are the key steps in writing a research report?
4. How should a research report be structured?
5. What precautions should be taken while writing a research report?
6. Explain the concept of intellectual property and its types.
7. Discuss the TRIPS Agreement and its impact on intellectual property laws.
8. What is the role of the World Intellectual Property Organization (WIPO)?
9. How do national and international IP laws intersect?
10. Describe the protection mechanisms for patents and copyrights under Indian law.

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Cherukupally(V), Near Tagarapuvalasa Bridge,
Bhogapuram(M), Vizianagaram(Dist)-531162

R24CA108 **Writing Skills for Scientific Communication** **2 0 0 0**

Course Objectives:

1. It aims to provide the students with theoretical knowledge about various elements of scientific writing.
2. To provide the students with tools and to improve their scientific texts.
3. To communicate orally research results in a good way.

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

Course Code	Course Outcomes	Mapping with POs			Dok
		PO9	PO10	PO12	
R24CA108.1	To evaluate scientific texts and improvements with respect to clear writing, and precision of the text content.	1	3	2	L5
R24CA108.2	To learn how scientific data is communicated and to know about the tools of own presentations.	1	3	2	L2
R24CA108.3	To define the main concepts of academic writing.	2	3	1	L1
R24CA108.4	To identify and locate the thesis statement and the topic sentence in an essay and a paragraph respectively.	2	3	1	L1
R24CA108.5	To identify and locate the supporting ideas in essays and paragraphs	1	2	3	L5

SYLLABUS

UNIT-I: **4 Hours**

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness, Highlighting Your Findings, Hedging and Criticising. **COs-C01**

UNIT-II: **3 Hours**

Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Review of the Literature, Methods, Results, Discussion, Conclusions, The Final written draft. **COs-C02**

UNIT-III: **5 Hours**

Key skills are needed when writing a Title, key skills are needed when writing an Abstract/synopsis, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature. **COs-C03**

UNIT-IV: **4 Hours**

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions to justify the topic. **COs-C04**

UNIT-V: **3 Hours**

Useful phrases, how to ensure paper is as good as it could possibly be the first- time submission. **COs-C05**

Board of Studies : ENGLISH
Approved in BOS No: 6th August, 2024
Approved in ACM No:

Textbooks:

1. C.R. Kothari: Research Methodology, methods and Techniques New Age
2. International Publisher.
3. Ranjit Kumar: Research Methodology and its applications, pearson education

Reference Books:

1. Research Methodology Concepts And Cases, Deepak Chawla
2. NeenaSandhi, Vikas Publishing House

A. Bhujangarao, Research Methodology, Excel Books, 2008

Web References:

1. http://www.naceweb.org/Press/Frequently_Asked_Questions.aspx?referal
2. http://www.writingcommission.org/pr/writing_for_employ.html
3. https://www.uky.edu/ hr/ sites/ www.uky.edu.hr/ files/ wellness/ images/ Conf14_FourCommStyles.pdf

Internal Assessment Pattern

Cognitive Level	Internal Assessment #1(%)	Internal Assessment #2(%)
L1	30	40
L2	30	30
L5	40	30
Total (%)	**100**	**100**

Sample Short and Long Answers questions of Various Cognitive Levels

L1: Remember

1. What is considered scientific writing?
2. How do you say for example in scientific writing?
3. What are scientific and technical writing examples?
4. How to write a scientific essay example?
5. What is scientific writing example?
6. What is the basic concept of scientific writing?
7. What are the 6 major characteristics of scientific writing?
8. What are the rules of scientific writing?
9. What is respectively in scientific writing?
10. What is the difference between academic writing and scientific writing?

L2: Understand

1. To what extent are you able to disagree with others without starting an argument?
2. How confident are you that you can do the hardest work that is assigned to you?
3. What is a benefit of self-employment?
4. When you get stuck while learning something new, how likely are you to try a different strategy?
5. Before you start on a challenging project, how often do you think about the best way to approach the project?

L5: Evaluating

1. What type of questions/topics are included in the in-person written exam (Phase II)?
2. Do I get course credits upon completion of certification?
3. If I could not clear the certification, will it be reflected on my academic transcripts?
4. I am in my first year of PhD and did not complete the "Writing Course" yet in the institute. Can I attempt the certification process?

5. I am a PhD student from Physical Research Laboratories, registered at IITGN. Am I eligible to attempt the certification?
6. If I am unable to clear the certification in the first attempt, can I retake/appear for the next round of certification?
7. What is the timeline for the exam?
8. How do I prepare for the certification? Can you suggest resources that I can go through for better performance in the certification process?
9. How is the exam tailored to suit the HSS discipline students?
10. Is there any option to take the written exam online?

L6: Creating

1. Is certification anything to do with the student's monthly stipend?
2. If I pass Phase I, but will not be able to attempt Phase II during the designated date and time, can I appear for the Phase II exam in the next semester?
3. What is the acceptable similarity index required for the manuscript/proposal submissions to scientific writing phase I ?
4. Explain why scientific writing is important ¬Identify resources that students can use to learn to write in a scientific style
5. Introduce steps that students can take to learn to write in APA style and become a proficient scientific writer
6. Describe characteristics of high quality scientific writing
7. Introduce you to my area of research expertise
8. What are the three aspects of scientific writing?
9. What does the scientific writing course cover?
10. Where do educational psychologists look for guidance related to content, style and form in writing

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R24CCPC05 THEORY OF ELASTICITY AND PLASTICITY 3 0 0 3

Course Objectives:

1. Understand the Fundamental Concepts: Acquire a deep understanding of the fundamental concepts of elasticity.
2. Analyze Stress and Strain: Develop the ability to analyze and solve problems related to stress and strain in both rectangular and polar coordinates.
3. Apply General Theorem's elasticity, such as the differential equations of equilibrium and compatibility, to solve practical problems in structural analysis.
4. Study Beam Bending: Analyze the bending behavior of prismatic bars and beams.
5. Explore Plasticity Theory: Understand and apply the principles of plasticity.
6. Solve Practical Problems: Employ methods for solving practical problems in plasticity and deformation.

Course Code	Course Outcomes	Mapping Pos and PSOs						Dok
		PO1	PO2	PO3	PO5	PSO1	PSO2	
R24CCPC05.1	Describe the fundamental concepts and equations of elasticity.	1	2	-	-	2	3	L1, L2
R24CCPC05.2	Analyze stress and strain problems in polar coordinates and solve two-dimensional problems in rectangular and polar coordinates.	1	1	-	-	2	2	L1, L2, L3
R24CCPC05.3	Apply general theorems and analyze the bending of beams.	1	2	2	2	2	3	L2, L3, L4
R24CCPC05.4	Explain the theories of plasticity.	2	1	1	2	2	1	L2, L3
R24CCPC05.5	Utilize methods for solving practical problems in plasticity and deformation.	2	1	2	2	3	1	L3, L4

SYLLABUS

Unit - I: **12 Hours**

Elasticity: Introduction to elasticity - Basic concepts and definitions. Two-dimensional stress analysis - Plane stress - Plane strain - Equations of compatibility - Stress function - Boundary conditions. Problems in rectangular coordinates - Solution by polynomials - Detailed discussion on Saint-Venant's principles - Determination of displacement - Simple beam problems. **COs: CO1**

Unit - II: **16 Hours**

Problems in polar coordinates: General equations in polar coordinates - Stress distribution symmetrical about axis - Strain components in polar coordinates - Simple and symmetric problems with practical examples. Analysis of stress and strain in three dimensions - Principal stresses - Homogeneous deformations - Strain spherical and deviatoric stress - Hydrostatic strain. **COs: CO2**

Unit - III: **10 Hours**

General theorems and bending: Differential equations of equilibrium and compatibility - Displacement - Significance of uniqueness of solution - Reciprocal theorem. Bending of prismatic bars - Stress function - Bending of cantilever beam - Beam of rectangular cross-section - Beams of circular cross-section. **COs: CO3**

Unit - IV: **14 Hours**

Plasticity and deformation: Plastic deformation of metals - Structure of metals - Deformation - Creep stress relaxation of deformation - Strain rate condition of constant maximum shear stress - Condition of constant strain energy - Approximate equation of plasticity. Practical applications of plasticity theory in engineering. **COs: CO4**

UNIT - V: **10 Hours**

Practical problem-solving methods: The characteristic method - Engineering method (steps and description) - Compression of metal under press - Theoretical and experimental data drawing.

COs: CO5

Text Books:

1. Timoshenko, S., Theory of Elasticity and Plasticity, MC Graw Hill Book company.
2. Sadhu Singh, Theory of Elasticity and Plasticity, Khanna Publishers.
3. Elasticity: Theory, Applications, and Numerics by Martin H. Sadd, Academic Press

Reference Books:

1. An Engineering Theory of Plasticity by E.P. Unksov.
2. Applied Elasticity by W.T. Wang.
3. Theory of Plasticity by Hoffman and Sacks.
4. Advanced Mechanics of Materials and Applied Elasticity by Ansel C. Ugural and Saul K. Fenster, Pearson Education
5. Plasticity: Fundamentals and Applications by Jagabandhu Chakrabarty, Springer

Board of Studies: Mechanical Engineering
Approved in BOS No: 01, 31st July, 2024
Approved in ACM No: 01

Internal Assessment Pattern

Cognitive Level	Internal Assessment #1 (%)	Internal Assessment #2 (%)
L1	25	20
L2	25	35
L3	40	35
L4	10	10
Total (%)	**100**	**100**

Sample questions of Various Cognitive Levels

L1: Remembering

1. Define plane stress and plane strain.
2. What is Saint-Venant's Principles?
3. State the equations of compatibility in elasticity.
4. List the boundary conditions used in elasticity problems.

5. What is the purpose of the stress function in two-dimensional stress analysis?
6. Define the general equations of stress in polar coordinates.
7. What is meant by symmetrical stress distribution about an axis?
8. Describe strain components in polar coordinates.
9. What is the difference between plane stress and plane strain?
10. State the definition of homogeneous deformations.
11. What are the differential equations of equilibrium in elasticity?
12. Define the uniqueness theorem in elasticity.
13. State the reciprocal theorem in the context of elasticity.
14. Describe the concept of displacement in the general theorems of elasticity.
15. What are the main assumptions in the differential equations of compatibility?
16. What is plastic deformation in metals?
17. Describe the basic structure of metals related to plasticity.
18. What is creep in the context of materials science?
19. Define the constant maximum shear stress condition in plasticity.
20. Explain the condition of constant strain energy in plastic deformation.
21. What is the characteristic method in solving practical problems?
22. Define the engineering method in the context of plasticity.
23. What factors are considered in the compression of metal under a press?
24. How is theoretical data compared to experimental data in plasticity?
25. What is the importance of drawing data in engineering methods?

L2: Understanding

1. Explain the significance of the stress function in solving two-dimensional problems.
2. How does the solution to stress problems in rectangular coordinates apply to real-world beam problems?
3. Describe the approach to solving simple beam problems using elasticity principles.
4. How are the equations of compatibility derived for plane stress conditions?
5. Explain the role of boundary conditions in determining the displacement in elasticity problems.
6. Explain how to solve stress problems using polar coordinates.
7. How do symmetrical stress distributions affect strain calculations?
8. Describe the process of analyzing stress and strain in polar coordinates.
9. How does the analysis of plane stress differ from plane strain in practical applications?
10. Discuss the implications of homogeneous deformations in three-dimensional stress analysis.
11. Explain the concept of the uniqueness of solutions in elasticity problems.
12. How do the differential equations of equilibrium relate to stress analysis in beams?
13. Describe the reciprocal theorem and its application in solving complex elasticity problems.
14. How can the general theorems of elasticity be used to analyze practical engineering problems?
15. Explain the role of compatibility conditions in ensuring the accuracy of displacement solutions.
16. Describe the process of plastic deformation in metals under varying loading conditions.
17. Explain how the structure of metals influences their plastic deformation behavior.
18. How does strain rate affect the deformation of metals?

19. Discuss the significance of different plasticity conditions, such as constant maximum shear stress.
20. Analyze the effects of creep on the long-term performance of materials.
21. Explain the characteristic method for solving metal compression problems.
22. How does the engineering method apply to real-world plasticity problems?
23. Describe how theoretical data is used to predict experimental outcomes in plasticity.
24. Discuss the importance of accurate data drawing in practical engineering applications.
25. How can the compression of metal under a press be analyzed using theoretical and experimental approaches?

L3: Applying

1. Apply the general equations in polar coordinates to solve a problem involving radial stress distribution.
2. Calculate the strain components in a circular plate subjected to uniform pressure.
3. Solve a plane stress problem involving a circular hole in a sheet subjected to tensile loading.
4. Determine the stress distribution in a cylindrical pressure vessel using polar coordinates.
5. Analyze the stress and strain in a disk with a hole under radial loading.
6. Apply the differential equations of equilibrium to solve a complex beam bending problem.
7. Use the reciprocal theorem to analyze a beam with varying cross-section.
8. Solve a practical problem involving the application of the uniqueness theorem in elasticity.
9. Analyze a composite beam using the general theorems of elasticity.
10. Apply the displacement theory to determine the deformation in a beam under dynamic loading.
11. Analyze the plastic deformation of a metal subjected to creep and relaxation conditions.
12. Evaluate the effect of different strain rate conditions on the plastic deformation of a material.
13. Compare the plastic deformation behavior of different metals under similar loading conditions.
14. Analyze the stress distribution in a metal subjected to cyclic loading and plastic deformation.
15. Evaluate the approximate equations of plasticity in predicting material behavior under extreme conditions.
16. Apply the characteristic method to solve a problem involving the compression of metal under a press.
17. Analyze theoretical and experimental data for a plastic deformation problem in metals.
18. Evaluate different engineering methods for solving practical problems in plasticity.
19. Compare the results of theoretical analysis and experimental data in a plasticity problem.
20. Analyze the impact of strain hardening on the deformation behavior of materials.

L4: Analyzing

1. Analyze a beam subjected to various load conditions using the differential equations of equilibrium.
2. Evaluate the stress distribution in a beam using the general theorems of elasticity.
3. Compare the displacement predictions from different elasticity theories for a cantilever beam.
4. Analyze the impact of boundary conditions on the accuracy of displacement solutions.

5. Investigate the effects of load variations on the deformation of composite beams.
6. Analyze the effects of different plasticity models on metal deformation under a press.
7. Evaluate the accuracy of the characteristic method for predicting real-world compression scenarios.
8. Compare theoretical predictions with experimental data for plastic deformation problems.
9. Analyze the effectiveness of various plasticity theories in engineering applications.
10. Investigate the impact of strain hardening on the performance of materials under different conditions.

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R24CCPC06 ADVANCED MANUFACTURING PROCESSES 3 0 0 3

Course Objectives:

1. Understand and apply advanced surface treatment methods and coatings, including electroforming, chemical vapor deposition, and thermal spraying.
2. Learn about ceramic materials, their properties, and processing methods such as powder preparation, sintering, and finishing.
3. Gain knowledge in various composites, including particulate, fiber-reinforced, and polymer matrix composites, and their manufacturing techniques.
4. Understand microelectronic device production, covering crystal growth, wafer preparation, and film deposition.
5. Explore advanced machining methods like EDM, Wire EDM, ECM, and laser beam machining, including their principles and applications.
6. Study rapid prototyping technologies, including stereolithography and laser sintering, and their applications in rapid tooling and manufacturing.
7. Develop skills to optimize manufacturing processes and assess the economic implications of advanced manufacturing techniques.

Course Code	Course Outcomes	Mapping with POs and PSOs						Dok
		PO 1	PO 2	PO 3	PO 4	PSO 1	PSO 2	
R24CCPC06.1	Understand and apply advanced surface treatment methods and coatings.	3	2	1	2	2	1	L2
R24CCPC06.2	Learn about ceramic materials, their properties, and processing methods.	2	3	2	2	3	2	L3
R24CCPC06.3	Gain knowledge in various composites and their manufacturing techniques.	2	2	2	3	1	3	L4
R24CCPC06.4	Understand microelectronic device production processes.	2	2	3	2	1	2	L3
R24CCPC06.5	Explore advanced machining methods and their applications.	2	2	2	3	1	3	L5

SYLLABUS

UNIT-I **10 Hours**

Surface Treatment: Scope, Cleaners, Methods of cleaning, Surface coating types, and ceramic and organic methods of coating, economics of coating. Electro forming, Chemical vapor deposition, thermal spraying, Ion implantation, diffusion coating, Diamond coating and cladding.

COs: CO1

UNIT- II **15 Hours**

Processing of Ceramics: Applications, characteristics, classification. Processing of particulate ceramics, Powder preparations, consolidation, Drying, sintering, Hot compaction, Area of application, finishing of ceramics. Processing of Composites: Composite Layers, Particulate and fiber reinforced composites, Elastomers, Reinforced plastics, MMC, CMC, Polymer matrix composites.

COs: CO2

UNIT- III **12 Hours**

Fabrication of Microelectronic Devices: Crystal growth and wafer preparation, Film Deposition oxidation, Etching, lithography, bonding and packaging, Testing and reliability and yield, Printed Circuit boards, computer aided design in microelectronics, surface mount technology, Integrated circuit economics. **COs: CO3**

UNIT - IV **12Hours**

Advanced Machining Processes: EDM, WireEDM, ECM, LBM, EBM, AJM, WJM, Plasma Arc Machining – Principle, working, limitations and applications, Surface finish. **COs: CO4**

UNIT -V RAPID PROTOTYPING: **11 Hours**

Working Principles, Methods, Stereo Lithography, Laser Sintering, Fused Deposition Method, Applications and Limitations, Rapid tooling, Techniques of rapid manufacturing, Materials for Rapid Prototyping. **COs: CO5**

Text Books:

1. Manufacturing Engineering and Technology I Kalpakijian / Adisson Wesley, 1995.
2. Process and Materials of Manufacturing / R. A. Lindburg / 1th edition, PHI 1990.

References:

1. Microelectronic packaging handbook / Rao. R. Thummala and Eugene, J. Rymaszewski / Van Nostrand Renlhold,
2. MEMS & Micro Systems Design and manufacture / Tai — Run Hsu / TMGH
3. Advanced Machining Processes / V.K.Jain / Allied Publications.

Board of Studies: Mechanical Engineering
Approved in BOS No: 01, 31st July, 2024
Approved in ACM No: 01

Internal Assessment Pattern

Cognitive Level	Internal Assessment #1(%)	Internal Assessment #2(%)
L2	60	20
L3	40	40
L4		20
L5		20
Total (%)	100	100

Sample Long Answers questions of Various Cognitive Levels

L2: Understand

1. Explain Chemical Vapor Deposition (CVD) and compare its effectiveness with other surface coating methods.
2. Describe different surface cleaning methods and their impact on subsequent treatments.
3. Explain the sintering process in ceramics and its effect on the material's properties.
4. Compare particulate and fiber-reinforced composites in terms of processing and applications.
5. Describe photolithography and its role in microelectronics fabrication.
6. Explain bonding techniques in microelectronics, such as wire bonding and flip-chip bonding, and their impact on device reliability.
7. Describe how Electrical Discharge Machining (EDM) works and its advantages over

traditional machining.

8. Explain Laser Beam Machining (LBM) and its benefits compared to other advanced machining processes.
9. Explain the principle of Stereo Lithography (SLA) and its advantages for rapid prototyping.
10. Describe the Fused Deposition Modeling (FDM) process and its role in prototyping complex geometries.
11. Describe Rapid Tooling and its role in enhancing manufacturing efficiency alongside rapid prototyping.
12. Discuss the types of materials used in rapid prototyping and their effects on the process.

L3: Apply

1. Design a surface treatment plan for a metal exposed to harsh conditions, including cleaning and coating methods.
2. Apply thermal spraying to enhance a high-wear component's durability. Outline the process steps.
3. Propose a fabrication process for a new integrated circuit, including wafer preparation, deposition, and lithography.
4. Develop strategies to enhance the yield and reliability of a microelectronic device, focusing on bonding and testing.
5. Choose an advanced machining process (e.g., Wire EDM) for aerospace components and explain its suitability.
6. Design a Water Jet Machining (WJM) setup for cutting high-strength composites, detailing setup and advantages
7. Address the limitations of Abrasive Jet Machining (AJM) for a specific application and suggest improvements.
8. Design a prototype for a consumer product using Fused Deposition Modeling (FDM), detailing design considerations.
9. Develop a combined rapid prototyping process using Stereo Lithography (SLA) and Laser Sintering (LS) to optimize quality and speed.
10. Develop an EDM process plan for creating a complex mold, including key parameters.
11. Apply rapid prototyping to create a functional prototype for a new electronic gadget, outlining process steps and material choices.
12. Develop a workflow combining Fused Deposition Modeling (FDM) and Selective Laser Sintering (SLS) for a multi-material prototype.

L4: Analyze

1. Describe the process of crystal growth and wafer preparation for microelectronic device fabrication. Explain the importance of crystal orientation and wafer cleaning.
2. Compare and contrast different film deposition techniques used in microelectronic device fabrication.
3. Explain the oxidation process in microelectronic device fabrication. Discuss the importance of oxidation in device fabrication.
4. Describe the testing and reliability procedures used in microelectronic device fabrication.
5. Explain the role of computer-aided design (CAD) in microelectronic device fabrication.

L5: Evaluating

1. Evaluate the working principles of Stereo Lithography (SLA) and Laser Sintering (LS) rapid prototyping techniques.
2. Evaluate the rapid tooling techniques, including soft tooling, bridge tooling, and hard tooling.
3. Critically evaluate the selection criteria for materials used in rapid prototyping.
4. Evaluate the role of computer-aided design (CAD) in rapid prototyping and manufacturing.
5. Evaluate the sustainability and environmental impact of rapid prototyping and manufacturing techniques.

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R24CCPE07 ADVANCED FINITE ELEMENT METHODS 3 0 0 3

Course Objectives:

1. To learn basic principles and skills of finite element modeling and analysis.
2. To learn the theory and characteristics of finite elements that represent engineering structures.
3. To learn and apply finite element solutions to problems in mechanical engineering.
4. To Learn advanced techniques for formulating finite element models for complex engineering problems.
5. To Learn techniques for solving Multiphysics problems involving the interaction of different physical fields (e.g., thermal, structural, fluid-structure interaction)
6. Develop skills for implementing FEM algorithms and custom solutions using programming languages and software libraries.
7. Develop the knowledge and skills needed to effectively evaluate finite element analyses performed by others

Course Code	Course Outcomes	Mapping with POs and PSOs				Dok
		PO1	PO2	PS01	PS02	
R24CCPE07.1	Analyze the structures by using the various methods to calculate stiffness	2	2	2	3	L1, L2
R24CCPE07.2	Apply suitable boundary conditions to a global equation for bars, trusses and beams.	2	2	2	2	L1, L2 L3
R24CCPE07.3	Evaluate the stiffness matrix of 2-D structures by using CST, LST, Isoperimetric, quadrilateral element.	2	2	3	2	L2, L3, L4
R24CCPE07.4	Evaluate the stiffness matrix of 3-D structures and 1-D,2-D, heat conduction slabs.	2	2	3	2	L4, L5, L6
R24CCPE07.5	Evaluate the mass matrix and natural frequencies of dynamic systems.	2	2	2	3	L4, L5 L6

SYLLABUS

UNIT - I **12 Hours**

Formulation Techniques: Methodology, Engineering problems and governing differential equations, finite elements., Variational methods-potential energy method, Raleigh Ritz method, strong and weak forms, Galerkin and weighted residual methods, calculus of variations, Essential and natural boundary conditions. **COs: CO1**

UNIT – II **16 Hours**

Basic Elements Truss and Beam: Basic Elements Truss and Beam Interpolation and shape functions, Element matrices, Linear triangular elements (CST), Quadratic triangular elements, Bilinear rectangular elements, Quadratic rectangular elements, Solid elements, Higher order elements, Development of Truss equations, Development of beam equations, Nodal loads-stress calculations. **COs: CO2**

UNIT – III **12 Hours**

Two dimensional problems: CST, LST, four noded and eight nodded rectangular elements, Lagrange basis for triangles and rectangles, serendipity interpolation functions. Axisymmetric Problems: Axisymmetric formulations, Element matrices, boundary conditions. Heat Transfer problems: Conduction and convection, examples: - two-dimensional fin. **COs: CO3**

UNIT – IV **12 Hours**

Isoperimetric formulation: Concepts, sub parametric, super parametric elements, numerical integration, Requirements for convergence, h-refinement and p-refinement, complete and incomplete interpolation functions, Pascal's triangle, Patch test. **COs: CO4**

UNIT – V **8 Hours**

Finite elements in Structural Analysis: Static and dynamic analysis, eigen value problems, and their solution methods, case studies using commercial finite element packages. **COs: CO5**

Text Book:

1. Finite element methods by Chandrupatla & Belagundu.

References:

1. J.N. Reddy, Finite element method in Heat transfer and fluid dynamics, CRC press,1994
2. Zienckiwicz O.C. & R. L. Taylor, Finite Element Method, McGraw-Hill,1983.
3. K. J. Bathe, Finite element procedures, Prentice-Hall, 1996

Board of Studies: Mechanical Engineering
Approved in BOS No: 01, 31st July, 2024
Approved in ACM No: 01

Internal Assessment Pattern

Cognitive Level	Internal Assessment #1 (%)	Internal Assessment #2 (%)
L1	20	
L2	30	
L3	30	30
L4	20	30
L5		30
L6		10
Total (%)	**100**	**100**

Sample Long Answers questions of Various Cognitive Levels

L1: Remember

1. List the various method of solving boundary value problems.
2. Differentiate between primary and secondary variables with suitable examples.
3. How will you identify types of Eigen Value Problems?
4. List out the advantages of finite element method over other numerical analysis method.
5. List the various weighted residual methods
6. Explain the various methods of engineering analysis with suitable illustrations.
7. Describe the principle of stationary total potential energy.
8. A tapered bar made of steel is suspended vertically with the larger end rigidly clamped and the smaller end acted on by a pull of 10°N. The areas at the larger and smaller ends are 80

cm² and 20 cm² respectively. The length of the bar is 3m. The bar weighs 0.075 N/cc. Young's modulus of the bar material is E=2 x 107 N/cm². Obtain an approximate expression for the deformation of the rod using Ritz technique. Determine the maximum displacement at the tip of the bar.

9. Write the conduction, convection, and thermal load matrices for 1D heat transfer through a fin.
10. A tapered bar made of steel is suspended vertically with the larger end rigidly clamped and the smaller end acted on by a pull of 10^5N. The areas at the larger and smaller ends are 80 cm^2 and 20 cm^2 respectively. The length of the bar is 3m. The bar weighs 0.075 N/cc. Young'smodulus of the bar material is E=2 x 10^7 N/cm^2. Obtain an approximate expression for the deformation of the rod using Ritz technique. Determine the maximum displacement at the tip of the bar.
11. Show the displacement function equation for CST element.
12. List out the application of two-dimensional problems.
13. Define two-dimensional scalar variable problem.
14. How do you define two dimensional elements?
15. Define 2D vector variable problems.
16. List out the various elasticity equations.
17. Define plane stress and plane strain.

L2: Understand

1. Illustrate the methods generally associated with the finite element analysis.
2. Why polynomial type interpolation functions are mostly used in FEM.
3. Distinguish between Error and Residual
4. Differentiate between initial value problem and boundary value problem.
5. What do you mean by constitutive law?
6. Using collocation method, find the solution of given governing equation.
7. We know that, linearly varying pressure JIT - JEPPIAAR acting on the side J, K, N =0 Determine the expression for the deflection and bending moment in a simply supported beam subjected to uniformly distributed load over the entire span. Find the deflection and moment at midspan and compare with exact solution using Rayleigh Ritz method Use y = a1sin (πx/l) + a2 sin(3πx/l).
8. Discuss 'Principal stresses.
9. Mention the difference between the use of linear triangular elements and bilinear rectangular elements for a 2D domain.
10. Consider the triangular element shown in figure. The element is extracted from a thin plate of thickness 0.5 cm. The material is hot rolled low carbon steel. The nodal coordinates are x1 = 0, y1 = 0; xj 0; yj – 1, xk =2, yk = -2. Determine the elemental stiffness matrix. Assuming plane stress analysis, take μ = 0.3 and E = 2.1 x 10^7 N/cm^2.
11. Explain briefly General steps of the finite element analysis
12. Solve the differential equation for a physical problem expressed as$d^2y/dx^2 + 100 = 0$, $0 \le x \le 10$with boundary conditions as y (0) =0 and y (10) =0 using (i) Point collocation method (ii) Sub domain collocation method (iii) Least square method and (iv) Galerkin method.
13. What is meant by steady state heat transfer? Write down its governing differential equation.

14. Distinguish between plane stress, plane strain and axisymmetric analysis in solid mechanics.
15. Define axisymmetric formulation.

L3: Apply

1. Write the stiffness matrix for a one dimensional 2 nodded linear element.
2. Point out any four advantages of finite element method.
3. Calculate nodal displacement and elemental stresses for the truss shown in fig. E= 70 Gpa.Cross sectional area A= 2 cm^2 for all truss members.
4. The following differential equation is available for a physical phenomenon AE d^2y/dx^2 +q0 =0 with the boundary condition y(0)=0, x=L, dy/dx=0, find the value of f(x) using theweighted residual method.
5. Solve the ordinary differential equation $d^2y/dx^2 + 10\ x^2 = 0$, $0 \leq x \leq 1$ with boundary conditions as y (0) = 0 and y (1) = 0 using the Galerkin's method with the trial function No(x) = 0; N1(x) = x $(1-x^2)$.
6. For the constant strain triangular element shown in figure. Assemble strain-displacement matrix. Take t = 20 mm, E = 2 X 10^5 N / mm^2
7. For the axisymmetric elements shown in fig. Determine the element stresses. Let E = 210 Gpa and v = 0.25. The coordinates are in millimeters. The nodal displacements are u1= 0.05 mm, u2= 0.02 mm, u3= 0 mm, w1 = 0.03 mm, w2 = 0.02 mm, w3 = 0 mm.
8. Calculate the value of central deflection in the figure below by assuming Y = a sin πx/L the beam is uniform throughout and carries and central point load P.
9. Relate path line with streamline.
10. Illustrate the Stress-Strain relationship matrix for an axisymmetric triangular element.
11. Distinguish between plate and shell elements.
12. Show the Stress-Strain displacement matrix for axisymmetric solid

L4: Analyzing

1. State the advantages of Rayleigh Ritz method.
2. Compare the Ritz technique with the nodal approximation method.
3. Mention the weak formulation of FEA.
4. State the principle of minimum potential energy.
5. Describe the step-by-step procedure of solving FEA.
6. Determine the element mass matrix for one-dimensional dynamic structural analysis problems. Assume the two-node, linear element.
7. Define the transverse vibration.
8. Determine the first two natural frequencies of longitudinal vibration of the stepped steel bar shown in fig. and plot the mode shapes. all the dimensions are in mm E=200GPa. and ρ= 0.78 kg/cc. A=4 cm^2, length l=500mm.
9. Define QST (Quadratic strain Triangle) element.

L5: Evaluating

1. Discuss Ritz method.
2. Determine the expression for deflection and bending moment in a simply supported beam subjected to uniformly distributed load over entire span. Find the deflection and moment at mid span and compare with exact solution Rayleigh-Ritz method. Use

$$y = a_1 \sin\left(\frac{\pi x}{l}\right) + a_2 \sin\left(\frac{3\pi x}{l}\right)$$

3. Deduce the stiffness matrix for a 1D two nodded linear element.
   A metallic fin 20 mm wide and 4 mm thick is attached to a furnace whose wall temperature is 180 °C. The length of the fin is 120 mm. if the thermal conductivity of the material of the fin is 350 W/m °C and convection coefficient is 9 W/m^2 °C, determine the temperature distribution assuming that the tip of the fin is open to the atmosphere and that the ambient temperature is 25 °C.
4. Define geometric Isotropy.
5. Write the Lagrange shape functions for a 1D, 2noded elements.
6. Determine the shape functions for a constant strain triangular (CST) Element.
7. Compute the element matrices and vectors for the element shown infig. when the edges 2-3 and 1-3 experience convection heat loss.

L6: Creating

1. How to develop the equilibrium equation for a finite element?
2. Formulate the boundary conditions of a cantilever beam AB of span L fixed at A and free at B subjected to a uniformly distributed load of P throughout the span
3. How will you develop total potential energy of a structural system?
4. Find the eigen value and eigen function of $y'' - 4\lambda y' + 4\lambda^2 y = 0$; with the boundary conditions are $y'(1) = 0$, $y(2) + 2y'(2) = 0$.
5. Formulate the shape function for One-Dimensional Quadratic bar element.
6. Develop the Shape function, Stiffness matrix and force vector for one dimensional linear element
7. How will you modify a three-dimensional problem to a Two-dimensional problem?
8. Formulate the (B) matrix for CST element

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R24CCPE08 **FRACTURE MECHANICS** **3 0 0 3**

Course Objectives:

1. Understand and describe the macroscopic failure modes in materials, including brittle and ductile behaviors, and identify the characteristics of fracture surfaces.
2. Explain the fundamentals of Linear Elastic Fracture Mechanics (LEFM), including the three loading modes, state of stress ahead of the crack tip, stress concentration factors, and stress intensity factors.
3. Define and differentiate alternative failure prediction parameters, including Crack Tip Opening Displacement (CTOD) and the J integral.
4. Define key terms related to fatigue, including High Cycle Fatigue, Low Cycle Fatigue, mean stress R ratio, and understand the concepts of strain and load control.
5. Understand the stages of creep deformation—primary, secondary, and tertiary creep—and describe the evolution of creep damage.
6. Analyze the micro-mechanisms of creep, including the role of diffusion, and use Ashby creep deformation maps to predict creep behavior.

Course Code	Course Outcomes	Mapping with Pos and PSOs								DoK
		PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PSO 1	PSO 2	
R24CCPE08.1	Accurately identify and classify macroscopic failure modes in materials, distinguishing between brittle and ductile behaviors.	3	2	1				1	1	L1, L2
R24CCPE08.2	Apply Griffiths analysis to calculate and interpret the energy release rate (G) and fracture energy (R)	2			3	2		2	1	L1, L2
R24CCPE08.3	Apply EPFM principles to measure and predict fracture behavior		1				2	1		L2, L3
R24CCPE08.4	Analyze micro mechanisms of fatigue damage, including initiation and propagation processes.		3	1		2		3	1	L1, L2, L3
R24CCPE08.5	Apply Larson-Miller parameters for creep extrapolation and assess creep-fatigue interactions	1			3		2	2	1	L2, L3

SYLLABUS

Unit-I **10 Hours**

Energy Relase Rate: Kinds of Failure; Historical Aspects; Brittle And Fracture Failure; Modes of Fracture Failure; How Potent Is A Crack; Damage Tolerance; characteristics of fracture surfaces; intergranular and intra-granular failure, cleavage and micro-ductility, growth of fatigue cracks, The ductile/brittle fracture transition temperature for notched and unnotched components. Fracture at elevated temperature. **COs: CO1**

Unit-II **15 Hours**

Griffiths analysis: Concept of energy release rate, G, and fracture energy, R. Modification for ductile materials, loading conditions. Concept of R curves.

Linear Elastic Fracture Mechanics, (LEFM). Three loading modes and the state of stress ahead of the crack tip, stress concentration factor, stress intensity factor and the material parameter the critical stress intensity factor, crack tip plasticity, effect of thickness on fracture toughness.

COs: CO2

Unit-III **15 Hours**

Elastic-Plastic Fracture Mechanics; (EPFM). The definition of alternative failure prediction parameters, Crack Tip Opening Displacement, and the J integral. Measurement of parameters and examples of use. **COs: CO3**

Unit-IV **10 Hours**

Fatigue: definition of terms used to describe fatigue cycles, High Cycle Fatigue, Low Cycle Fatigue, mean stress R ratio, strain and load control. S-N curves. Goodmans rule and Miners rule. Micromechanisms of fatigue damage, fatigue limits and initiation and propagation control, leading to a consideration of factors enhancing fatigue resistance. Total life and damage tolerant approaches to life prediction. **COs: CO4**

Unit-V **15 Hours**

Creep deformation: the evolution of creep damage, primary, secondary and tertiary creep. Micro-mechanisms of creep in materials and the role of diffusion. Ashby creep deformation maps. Stress dependence of creep – power law dependence. Comparison of creep performance under different conditions – extrapolation and the use of Larson-Miller parameters. Creep-fatigue interactions. Examples. **COs: CO5**

Text Books:

1. T.L. Anderson, Fracture Mechanics Fundamentals and Applications, 2nd Ed. CRC press (1995)
2. J.F. Knott, Fundamentals of Fracture Mechanics, Butterworths (1973)
3. G. E. Dieter, Mechanical Metallurgy, McGraw Hill, (1988)
4. S. Suresh, Fatigue of Materials, Cambridge University Press, (1998)

References:

1. B. Lawn, Fracture of Brittle Solids, Cambridge Solid State Science Series 2nd ed1993.
2. J.F. Knott, P Withey, Worked examples in Fracture Mechanics, Institute of Materials.
3. H.L.Ewald and R.J.H. Wanhill Fracture Mechanics, Edward Arnold, (1984).
4. L.B. Freund and S. Suresh, Thin Film Materials Cambridge University Press,(2003).
5. D.C. Stouffer and L.T. Dame, Inelastic Deformation of Metals, Wiley (1996)

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Internal Assessment Pattern

Cognitive Level	Internal Assessment #1 (%)	Internal Assessment #2 (%)
L1	30	30
L2	20	30
L3	30	20
L4	20	20
Total (%)	**100**	**100**

Sample questions of Various Cognitive Levels:

L1: REMEMBER

1. What is a singularity? What kind of singularity describes a stress field near the vicinity of a crack tip in LEFM? Is it expected to be different for elastic-plastic fracture mechanics?
2. Stress field is the same for plane stress and plane strain problems. Why is it not so for displacement fields?
3. In problems of plates, stress components are expressed in the Cartesian coordinate system whereas the location at which stress is considered is defined in polar coordinates.
4. For many problems of practical applications, solutions of infinite plates are applicable. Justify the statement.
5. Displacement near the crack tip is determined by integrating strain components. Why do we equate integration constants to zero?
6. Mode I case has been solved for a biaxial case and its stress and displacement fields are taken to be approximately the same as of an uniaxial case. Justify.
7. Why do we not use biharmonic equation to solve Mode III problems for a centre crack in an infinite plate?
8. How does the rate of change of strain energy give G for constant load case or constant deflection case? Is this approach valid for non-linear elastic materials?
9. Why is failure.catastrophic once a crack starts growing in a DCB specimen?
10. What are different mechanisms of anelastic deformation in a polymer?
11. If the load is increased gradually on a component made of a ductile material, why do we obtain stable crack growth before the catastrophic failure
12. Why does a brittle material not have stable crack growth?
13. Why are thin plates tougher in comparison to thick plates?
14. Why is critical energy release rate not given in handbooks for thin plates?

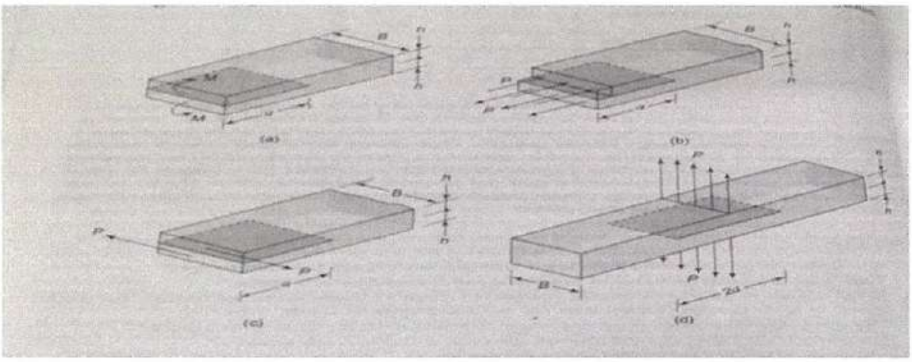
L2: UNDERSTAND

1. Why is the solution of collinear cracks in an infinitely long strip important?
2. Why is an edge crack more dangerous than a centre crack of the same length?
3. In the case of a shallow elliptical edge crack, the SIP at the tip of the minor axis is higher than the SIF at the tip of the major axis. This may sound contrary to our intuition. Can you explain the results on physical grounds?
4. In a short fiber composite material, an embedded fiber does not act like a dangerous crack. Explain it by assuming the fiber has a shape of an ellipse.
5. Why does material property E appear in the expression that relate.s G1 with Kr?

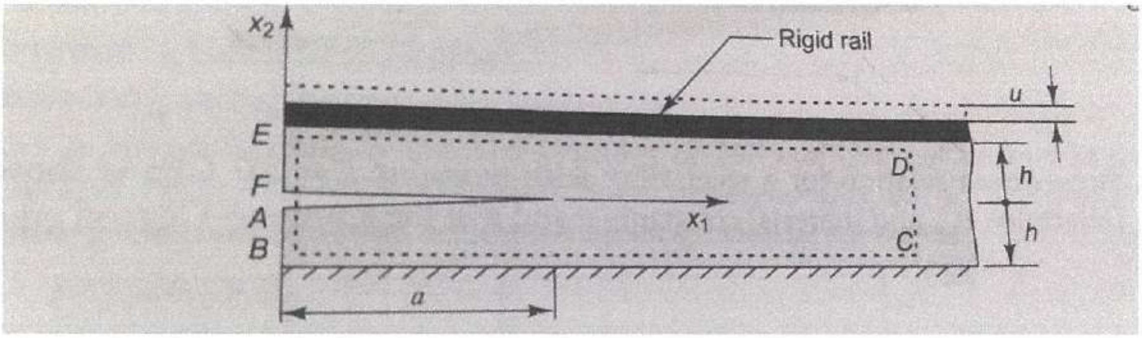
6. Energy release rate of various modes can be summed, whereas the SIF cannot be. Why?
7. If a designer finds that a crack (e.g., slot) in a component gives K1 > K1c, discuss the different options available to avoid such a situation.
8. Why does K1c depend on the direction i.n a rolled plate?
9. Why do rolled or forged components have better toughness?
10. Name an application of bending and twisting a plate with a crack.
11. If we use a specimen with a large lateral dimension to find Krc, the accuracy of the experimental results is high. But, in experiments to determine the SIF, specimens with large lateral dimensions are not employed. Why not?
12. Determine value of K1 for some cases listed in Appendix 4B for the following values:(a) Centre-cracked plate under uniform tension; 2a = 60 mm, 2W = 140 mm, <1= 150 MPa.(b) Single-edge-notch three point bend (SENB) plate; a = 20 mm, S = 150 mm, W = 50 mm, B = 25 mm, P = 20 kN.(c) Single-edge-cracked plate under uniform tension; a= 30, W = 70 mm, cr = 140 MPa.(d) Strip with edge crack under bending;a = 25 mm, W = 60 mm, B = 20 mm,M = 2000 Nm.

L3: APPLY

1. Why is the numerical evaluation of J_1 usually simpler than the evaluation of G_1 or K_1 in the case of the LEFM?
2. Path independence of the J-Integral is not valid for elastic-plastic materials. Why?
3. If path independence is not valid for elastic-plastic materials, how can we apply it to real life cases dealing with large plastic zone in the vicinity of the crack tip?
4. Although a variation is found to be large in an experimentally determined Je, it is acceptable for design purposes. Justify.
5. Why is the Ramberg-Osgood relation convenient for determining the J-Integral for elastic-plastic materials?
6. Why are the specimens very thick to determine the value of K_1 of ductile materials? 7. Unlike the case of K_1e-test, the specimen recommended for finding the critical J-Integral need not be thick for ductile materials. Why?
7. Approach for constant load. 2. Determine the energy release rate, using elementary beam analysis, for the configuran given in Fig. (h<<a).



8. Consider an infinitely long strip with an edge-crack of length a. The lower surface of the strip is bonded to a rigid surface and the upper surface to a rigid rail as shown in Fig.



9. The shape of the plastic zone, as determined in this chapter, is approximate. Why?
10. In comparison to a plane strain case, a plane stress loading gives much larger plastic zone for the same SIF? Why?
11. Looking at a fractured surface, stress, plane strain or transitional? can you distinguish whether the loading
12. Show the yield planes of plane stress cases through a clear diagram.
13. Why is the fracture plane of plane strain case normal to the free surface and in the plane of the original crack surface for Mode I loading?
14. Why is burr developed during machining?
15. Does fracture mechanics recommend the enhancement of the yield stress of an alloy through a heat treatment? Justify your answer.

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R24CCPE09 PRODUCT DESIGN & DEVELOPMENT 3 0 0 3

Course Objectives:

1. Gain insights into the foundational principles of product design and the modern product development process.
2. Utilize the principles of morphology of design and conceptual design generation, selection, and embodiment.
3. Understand product architecture and the industrial design process.
4. Apply robust design techniques such as Taguchi Designs and Design of Experiments (DOE) for optimizing product design.
5. Perform qualitative and quantitative economic analyses of product designs.
6. Employ creativity techniques such as brainstorming, conceptualization, and simulation in the design process.
7. Apply concurrent engineering and rapid prototyping tools, use drafting and modeling software, and integrate CAM interfaces.

Course Code	Course Outcomes	Mapping Pos and PSOs						Dok
		PO1	PO2	PO3	PO6	PSO1	PSO2	
R24CCPE09.01	Understand the classification and specifications of products, product life cycle, and product mix.	1	2		1	1		L2
R24CCPE09.2	Apply the principles of morphology of design, conceptual design generation, selection, and embodiment.	2	2	3	2	2	2	L2, L3
R24CCPE09.3	Understand legal and social issues, and apply engineering ethics in product design. Utilize value engineering and value analysis methodologies	2	2	3	2	2	2	L2, L3, L4
R24CCPE09.4	Conduct economic analysis using qualitative and quantitative methods.	2	2		2	2		L3, L4
R24CCPE09.5	Employ creativity techniques such as creative thinking, brainstorming, conceptualization, primary design, drawing, and simulation in the product design process.	3	2		2	2	3	L2, L3, L6

SYLLABUS

Unit-I **10 Hours**

Introduction: Classification/Specifications of Products, Product life cycle. Product mix, Introduction to product design, Modern product development process, Innovative thinking.

COs: CO1

Unit-II **12 Hours**

Morphology of design. Conceptual Design: Generation, selection & embodiment of concept. Product architecture, Industrial design: process, need, Robust Design: Taguchi Designs & DOE, Design Optimization. **COs: CO2**

Unit- III **12 Hours**

Design for Manufacturing & Assembly: Methods of designing for Manufacturing and assembly, Designs for Maintainability, Designs for Environment, Product costing, Legal factors and social issues, Engineeringethics and issues of society related to design of products. Value Engineering / Value Analysis.: Definition. Methodology, Case studies. **COs: CO3**

Unit- IV **12 Hours**

Economic analysis: Qualitative & Quantitative. Ergonomics / Aesthetics: Gross human autonomy, Anthropometry, Man-Machine interaction, Concepts of size and texture, colour. Comfort criteria,Psychological & Physiological considerations. **COs: CO4**

Unit- V **14 Hours**

Creativity Techniques: Creative thinking, conceptualization, brain storming, primary design, drawing, simulation, detail design. Concurrent Engineering, Rapid prototyping, Tools for product design –Drafting / Modeling software, CAM Interface, Patents & IP Acts.

Decision Making: Decision theory, utility theory, decision trees, concept evaluation methods, Pugh concept selection method, weighted decision matrix, analytic hierarchy process, introduction to embodiment design, product architecture, types of modular architecture, steps in developing product architecture. **COs: CO5**

Text Books:

1. Karl T Ulrich, Steven D Eppinger, — Product Design & Development. ‖ Tata McGrawhillNew Delhi 2003.
2. David G Ullman, -The Mechanical Design Process. ‖ McGrawhill Inc Singapore1992 N J M Roozenberg , J Ekels , N F M Roozenberg — Product Design Fundamentals and Methods . JohnWilley & Sons 1995.
3. Kevin Otto & Kristin Wood Product Design: -Techniques in Reverse Engineering and New Product Development. 1 / e 2004, Pearson Education New Delhi.

References:

1. L D Miles -Value Engineering.
2. Hollins B & Pugh S -Successful Product Design. Butter worths London.
3. Baldwin E N &Neibel B W -Designing for Production. Edwin Homewood Illinois
4. Jones J C -Design Methods. ‖ Seeds of Human Futures. John Willey New York.

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Internal Assessment Pattern

Cognitive Level	Internal Assessment #1 (%)	Internal Assessment #2 (%)
L1	40	-
L2	30	-
LE	30	30

L4		40
L5		30
Total (%)	100	100

Sample Long Answers questions of Various Cognitive Levels

L1: Remembering:

1. Define the product life cycle and explain its significance in product design.
2. Identify the different classifications and specifications of products.
3. Describe the stages involved in the modern product development process.
4. What is the morphology of design? Explain its importance in the conceptual design process.
5. Define product architecture and discuss its role in industrial design.
6. Explain the concept of value engineering and describe its methodology
7. Identify the legal factors and social issues that influence product design.
8. Describe the role of anthropometry in ergonomic design.
9. Identify the psychological and physiological considerations in product design
10. Define concurrent engineering and explain its benefits in product development
11. Identify the key elements of patent preparation and intellectual property acts

L2: Understand:

1. Describe the process of generating and selecting a concept in product design.
2. Explain the difference between qualitative and quantitative economic analysis
3. Explain the importance of understanding product classification and specifications for effective product design, providing examples from industry.
4. Discuss the application of Taguchi Designs and Design of Experiments (DOE) in achieving robust design, Provide examples of how these techniques can optimize design.
5. Discuss the ethical considerations in engineering design and **analyze** how these considerations
6. Discuss how economic analysis can influence product design decisions. **Provide** examples of both qualitative and quantitative methods.
7. Discuss the role of creativity techniques such as brainstorming and conceptualization in the product design process. **Provide** examples of how these techniques can lead to innovative designs

L4: Analyzing:

1. List the methods of designing for manufacturing and assembly.
2. Analyze the relationship between product mix and product life cycle, and discuss how innovative thinking can impact these aspects.
3. Analyze the need for industrial design in product development and evaluate the benefits of a robust design process in manufacturing.
4. Analyze the impact of ergonomics and aesthetics on user comfort and interaction, and evaluate the importance of these factors in the design process.

L5: Evaluate:

1. Evaluate the importance of designing for maintainability and the environment in product development. Provide case studies to support your argument.
2. Evaluate the significance of rapid prototyping and drafting/modeling software in

modern product development. Analyze how these tools enhance the design process

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R24CCPE10 MATERIALS CHARACTERIZATION TECHNIQUES 3 0 0 3

Course Objectives:.

1. Familiarize with various diffraction techniques and their applications in material science.
2. Develop understanding of tools and methods used for structure analysis.
3. Understanding of different microscopy techniques used in materials science.
4. Introduce thermal analysis techniques and their applications in material characterization.
5. Familiarize with different techniques for measuring magnetization and magnetic properties.
6. Understanding of principles and applications of various spectroscopic methods.

Course Code	Course Outcomes	Mapping with POs and PSOs						Dok
		PO 1	PO 2	PO 3	PO 4	PSO 1	PSO 2	
R24CCPE10.1	Analyze and apply various structure analysis tools to determine phase identification, lattice parameters, and material characteristics.	3	3	2	-	3	-	L2
R24CCPE10.2	Evaluate and interpret microscopy techniques to characterize material surfaces and interfaces, and assess their structural and compositional properties.	3	3	-	2	-	3	L3,L4,
R24CCPE10.3	Apply thermal and electrical characterization techniques to investigate material properties and performance under varying conditions.	3	2	-	2	2		L3, L4
R24CCPE10.4	Employ magnetic characterization methods to study magnetic properties and behaviors of materials.	3	3	2	-	-	3	L4
R24CCPE10.5	Utilize optical and electronic characterization techniques to analyze material properties and assess their electronic and optical behavior.	3	3	-	2	2	-	L4

SYLLABUS

Unit – I **10 Hours**

Introduction to materials and Techniques, Structure analysis tools: X-ray diffraction: phase identification, indexing and lattice parameter determination, Analytical line profile fitting using various models, Neutron diffraction, Reflection High Energy Electron Diffraction, and Low Energy Electron Diffraction. **COs: CO1**

Unit – II **10 Hours**

Microscopy techniques: Optical microscopy, transmission electron microscopy (TEM), energy dispersive X-ray microanalysis (EDS), scanning electron microscopy (SEM), Rutherford backscattering spectrometry (RBS), atomic force microscopy (AFM) and scanning probe microscopy (SPM). **COs: CO2**

Unit – III **10 Hours**

Thermal analysis technique: Differential thermal analysis (DTA), Differential Scanning Calorimetry (DSC), Thermogravimetric analysis (TGA); Electrical characterization techniques: Electrical resistivity, Hall effect, Magnetoresistance. **COs: CO3**

Unit – IV **10 Hours**

Magnetic characterization techniques: Introduction to Magnetism, Measurement Methods, Measuring Magnetization by Force, Measuring Magnetization by Induction method, Types of measurements using magnetometers: M-H loop, temperature dependent magnetization, time dependent magnetization, Measurements using AC susceptibility, Magneto-optical Kerr effect, Nuclear Magnetic Resonance, Electron Spin Resonance. **COs: CO4**

Unit – V **10 Hours**

Optical and electronic characterization techniques: UV-VIS spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy, X-ray photoelectron spectroscopy. **COs: CO5**

Text Books:

1. Characterization of Materials (Materials Science and Technology: AcomprehensiveTreatment, Vol 2A & 2B,VCH (1992).
2. Semiconductor Material and Device Characterization, 3rdEdition, D.K. Schroder, Wiley-IEEE Press (2006).
3. Materials Characterization Techniques, S Zhang, L.Li andshok Kumar, CRC Press (2008).

References:

1. Physical methods for Materials Characterization, P. E. J. Flewitt and R K Wild, IOP Publishing (2003).
2. Characterization of Nano – phase materials, Ed. Z L Wang, Willet-VCH (2000).

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Internal Assessment Pattern

Cognitive Level	Internal Assessment #1 (%)	Internal Assessment #2 (%)
L2	60	40
L3	40	40
L4		20
Total (%)	**100**	**100**

Sample Long Answers questions of Various Cognitive Levels

L2: Understand

1. How does X-ray diffraction help in phase identification?
2. How can AFM be used to measure surface topography?
3. How is Thermogravimetric Analysis (TGA) performed?
4. How can AC susceptibility be used to study magnetic materials?
5. How can FTIR spectroscopy identify functional groups?
6. Explain the process of phase identification using X-ray diffraction, including how indexing and lattice parameter determination are performed.
7. Explain how Atomic Force Microscopy (AFM) works and how it can be used to measure the surface topography of a material.

8. Explain the procedure and applications of Thermogravimetric Analysis (TGA) for studying the thermal stability of materials.
9. Explain how AC susceptibility measurements can provide insights into the magnetic properties and dynamics of a material.
10. Explain how Fourier Transform Infrared (FTIR) spectroscopy can be used to identify functional groups in a material and describe the types of information it provides.

L3: Apply

1. How would you use XRD to find the lattice parameters of a material?
2. How would you use EDS to determine a material's composition?
3. How would you interpret DSC curves for polymers?
4. How would you use MOKE to analyze magnetic thin films?
5. How would you interpret Raman spectra of a material?
6. Given a set of X-ray diffraction data, outline the steps you would take to determine the lattice parameters and phase composition of a material.
7. Describe the procedure for using Energy Dispersive X-ray Spectroscopy (EDS) to analyze the elemental composition of a sample, including data interpretation.
8. Given a set of Differential Scanning Calorimetry (DSC) curves for a polymer, describe how you would analyze them to identify thermal transitions and their implications for material performance.

L4: Analyze

1. Compare and contrast X-ray diffraction with neutron diffraction in terms of their applications and limitations.
2. Analyze the advantages and limitations of using Scanning Probe Microscopy (SPM) compared to Optical Microscopy.
3. Analyze the impact of electrical resistivity measurements on understanding the conductivity of a semiconductor material.
4. Analyze the differences in information obtained from M-H loops and temperature-dependent magnetization measurements.
5. Analyze the differences between X-ray Photoelectron Spectroscopy (XPS) and UV-VIS spectroscopy in terms of the information they provide.
6. Analyze the advantages and disadvantages of X-ray diffraction versus neutron diffraction for characterizing different types of materials.
7. Analyze the strengths and limitations of Scanning Probe Microscopy (SPM) versus Optical Microscopy in studying material surfaces.
8. Analyze the relationship between electrical resistivity measurements and the conductivity of semiconductor materials, including factors that may influence the results.
9. Analyze the differences between M-H loops and temperature-dependent magnetization measurements in terms of the information they provide about magnetic materials.
10. Analyze the differences between X-ray Photoelectron Spectroscopy (XPS) and UV-VIS spectroscopy in terms of the type of information each provides about a material's electronic structure.

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R24CCPE11 OPTIMIZATION AND RELIABILITY 3 0 0 3

Course Objectives:

1. Gain a comprehensive understanding of classical and numerical optimization techniques, including single-variable and multi-variable optimization with and without constraints.
2. Learn to apply advanced optimization methods, such as genetic algorithms (GA) and genetic programming (GP),
3. To solve complex engineering problems, including multi-objective and constrained scenarios.
4. Develop the skills to optimize engineering designs and manufacturing processes by applying various optimization strategies to improve performance, efficiency, and quality.
5. To Understand and implement key reliability principles, including the use of engineering statistics, risk assessment, and probabilistic approaches to ensure system reliability and safety.
6. Learn to create and evaluate robust optimization and reliability models to address real-world engineering challenges, ensuring system resilience and optimal performance.

Course Code	Course Outcomes	Mapping with Pos						DoK
		PO 1	PO 2	PO 4	PO 6	PSO 1	PSO 2	
R24CCPE11.1	Use various optimization methods to solve engineering problems and improve system performance.	3	1	1	2	2	2	L2,L3
R24CCPE11.2	Apply genetic algorithms and genetic programming to solve complex optimization problems.	3	2	1	2	2	2	L2,L3
R24CCPE11.3	Optimize engineering designs and manufacturing processes to enhance efficiency and performance.	3	1	1	1	2	2	L3,L4
R24CCPE11.4	Analyze reliability data and apply reliability concepts to evaluate and improve engineering systems.	3	1	1	1	2	2	L2,L3
R24CCPE11.5	Develop models and strategies to address optimization and reliability challenges in engineering.	3	2	1	2	2	2	L3,L4

SYLLABUS

Unit – I **10 Hours**

Classical Optimization Techniques: Single variable optimization with and without constraints, multi – variable optimization without constraints, multi – variable optimization with constraints – method of Lagrange multipliers, Kuhn-Tucker conditions, merits and demerits of classical optimization techniques.

Unit – II **10 Hours**

Numerical Methods For Optimization: Nelder Mead's Simplex search method, Gradient of a function, Steepest descent method, Newton's method, Pattern search methods, conjugate method, types of penalty methods for handling constraints, advantages of numerical methods.

UNIT - III **10 Hours**

Genetic Algorithm (GA): Differences and similarities between conventional and evolutionary algorithms, working principle, reproduction, crossover, mutation, termination criteria, different reproduction and crossover operators, GA for constrained optimization, draw backs of GA.

Genetic Programming (GP): Principles of genetic programming, terminal sets, functional sets, differences between GA & GP, random population generation, solving differential equations using GP.

Multi-Objective GA: Pareto's analysis, non-dominated front, multi – objective GA, Non-dominated sorted GA, convergence criterion, applications of multi-objective problems.

UNIT – IV **10 Hours**

Applications of Optimization in Design and Manufacturing Systems: Examples of common applications include the following: general machining process optimization, arc welding parameter optimization, weight minimization for cantilever beams, spring and gear optimization, general machining process optimization model, and general procedure for machining operations sequence optimization.

UNIT V **10 Hours**

Reliability: Concepts of Engineering Statistics, risk and reliability, probabilistic approach to design, reliability theory, design for reliability, numerical problems, hazard analysis.

Text Books:

1. Optimization for Engineering Design – Kalyanmoy Deb, PHI Publishers
2. Engineering Optimization – S.S.Rao, New Age Publishers
3. Reliability Engineering by L.S.Srinath
4. Multi objective genetic algorithm by Kalyanmoy Deb, PHI Publishers.

References:

1. Genetic algorithms in Search, Optimization, and Machine learning – D.E.Goldberg, AddisonWesley Publishers
2. Multi objective Genetic algorithms - Kalyanmoy Deb, PHI Publishers
3. Optimal design – Jasbir Arora, Mc Graw Hill (International) Publishers
4. An Introduction to Reliability and Maintainability Engineering by CE Ebeling, Waveland Printers Inc., 2009
5. Reliability Theory and Practice by I Bazovsky, Dover Publications, 2013

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Internal Assessment Pattern

Cognitive Level	Internal Assessment #1 (%)	Internal Assessment #2 (%)
L1	30	30
L2	20	30

L3	30	20
L4	20	20
Total (%)	**100**	**100**

Sample Questions of Various Cognitive Levels:

L2. Understanding

1. Explain the difference between single-variable optimization with and without constraints.
2. Describe how the method of Lagrange multipliers is used to handle constraints in optimization problems.
3. How do the Kuhn-Tucker conditions extend the method of Lagrange multipliers?
4. Explain how the Nelder Mead's Simplex search method works.
5. Describe the significance of the gradient in the steepest descent method.
6. How does Newton's method differ from the steepest descent method?
7. What is the purpose of using penalty methods in constrained optimization?
8. Explain the basic concept of the conjugate gradient method.
9. Explain how optimization is used in the design of a four-bar mechanism.
10. Why is it important to minimize the weight of a cantilever beam, and how is it achieved?
11. How does optimizing spring design impact the performance of mechanical systems?
12. Describe the process of optimizing machining operations sequence.
13. How do optimization techniques improve the quality and efficiency of arc welding?

L3. Applying

1. Solve a simple single-variable optimization problem: Find the maximum of f(x)=−x2+4xf(x) = -x^2 + 4xf(x)=−x2+4x.
2. Apply the method of Lagrange multipliers to the following problem: Maximize f(x,y)=xyf(x, y) = xyf(x,y)=xy subject to x+y=10x + y = 10x+y=10.
3. Use the Kuhn-Tucker conditions to find the minimum of f(x,y)=x2+y2f(x, y) = x^2 + y^2f(x,y)=x2+y2 subject to x+y≥1x + y \geq 1x+y≥1.
4. Given the function f(x)=x4−3x3+2f(x) = x^4 - 3x^3 + 2f(x)=x4−3x3+2, use the steepest descent method to find a local minimum starting from x=1x = 1x=1.
5. Apply Newton's method to find a root of the function f(x)=x2−2f(x) = x^2 - 2f(x)=x2−2 starting from x=1x = 1x=1.
6. Use Nelder Mead's Simplex method to optimize the function f(x,y)=(x−2)2+(y−3)2f(x, y) = (x-2)^2 + (y-3)^2f(x,y)=(x−2)2+(y−3)2.
7. Given the function f(x)=−x2+4xf(x) = -x^2 + 4xf(x)=−x2+4x, use a genetic algorithm to find the maximum value within the range [0, 5].
8. Apply a single-point crossover to the following parent solutions: Parent1 = [10101], Parent2 = [11001].
9. Implement a genetic algorithm to solve the knapsack problem where items have weights [2, 3, 4, 5] and values [3, 4, 5, 6], and the maximum capacity is 7.
10. Create a genetic programming approach to find a symbolic regression model for the data set {(x,y)|y=x2+2x+1}\{(x, y) | y = x^2 + 2x + 1 \}{(x,y)|y=x2+2x+1}.
11. Use genetic programming to evolve a solution for the differential equation dydx=x2−3x+2\frac{dy}{dx} = x^2 - 3x + 2dxdy=x2−3x+2.

12. Implement a genetic programming technique to design a decision tree for a classification problem.
13. Use a multi-objective genetic algorithm to optimize the functions f1(x)=x2f_1(x) = x^2f1 (x)=x2 and f2(x)=(x−2)2f_2(x) = (x-2)^2f2(x)=(x−2)2 simultaneously.
14. Apply Pareto's analysis to a given set of solutions for a multi-objective optimization problem.
15. Implement a non-dominated sorted genetic algorithm for optimizing multiple conflicting objectives in a supply chain problem.
16. Apply optimization techniques to design a four-bar mechanism that achieves a specific path synthesis requirement.
17. Use optimization methods to minimize the weight of a cantilever beam while maintaining structural integrity under given loads.
18. Develop an optimization model for selecting spring parameters (e.g., material, dimensions) to achieve desired performance characteristics.
19. Implement an optimization strategy to determine the best gear parameters for a gear train in a mechanical transmission system.
20. Optimize arc welding parameters such as voltage, current, and feed rate to achieve the best weld quality and efficiency.
21. Use engineering statistics to calculate the mean time to failure (MTTF) for a given system.
22. Apply a probabilistic approach to design a component with a specified reliability requirement.
23. Solve a numerical problem involving the reliability function for a series system with two components, each with a reliability of 0.9.
24. Perform a hazard analysis for a given engineering system and identify potential failure modes.
25. Design a reliability test plan for a new product to ensure it meets reliability standards.

L4. Analyzing

1. Compare and contrast different crossover operators used in genetic algorithms.
2. Analyse the impact of mutation rate on the convergence speed of a genetic algorithm.
3. How do genetic algorithms handle constraints differently compared to traditional optimization methods?
4. Compare the terminal and functional sets in genetic programming.
5. Analyse the differences in population generation between genetic algorithms and genetic programming.
6. How does genetic programming solve differential equations differently than traditional numerical methods?
7. Compare the effectiveness of single-objective genetic algorithms and multi-objective genetic algorithms.
8. Analyse the impact of non-dominated sorting on the diversity of solutions in multi-objective optimization.
9. How does the choice of convergence criteria affect the performance of a multi-objective genetic algorithm?
10. Apply optimization techniques to design a four-bar mechanism that achieves a specific path synthesis requirement.

11. Use optimization methods to minimize the weight of a cantilever beam while maintaining structural integrity under given loads.
12. Develop an optimization model for selecting spring parameters (e.g., material, dimensions) to achieve desired performance characteristics.
13. Implement an optimization strategy to determine the best gear parameters for a gear train in a mechanical transmission system.
14. Optimize arc welding parameters such as voltage, current, and feed rate to achieve the best weld quality and efficiency.
15. Use engineering statistics to calculate the mean time to failure (MTTF) for a given system.
16. Apply a probabilistic approach to design a component with a specified reliability requirement.
17. Solve a numerical problem involving the reliability function for a series system with two components, each with a reliability of 0.9.
18. Perform a hazard analysis for a given engineering system and identify potential failure modes.
19. Design a reliability test plan for a new product to ensure it meets reliability standards.
20. Compare the effectiveness of different statistical methods used in reliability analysis.
21. Analyse the impact of risk factors on the reliability of a system.
22. How do different reliability models affect the design of engineering systems?
23. Examine the consequences of inadequate hazard analysis on product safety and performance.
24. Evaluate the trade-offs between reliability and cost in the design of an engineering system.

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R24CCPE12 **ADDITIVE MANUFACTURING** **3 0 0 3**

Course Objectives:

1. Understand the basic principles of additive manufacturing.
2. Evaluate the theoretical potentials of rapid prototyping processes, including their applications and limitations.
3. Design and develop rapid prototyping models using various techniques
4. Apply rapid tooling concepts, including direct and indirect methods, to manufacture tools for plastic and metal components.
5. Analyze the applications of rapid prototyping in industrial product development
6. Develop expertise in additive manufacturing technologies

Course Code	Course Outcomes	Mapping with POs and PSOs					Dok
		PO1	P02	P03	PSO1	PSO2	
R24CCPE12.1	Understand the principles of prototyping, classification of RP processes	2	2	-	1	-	L1, L2
R24CCPE12.2	Explain the working principles and applications of various rapid prototyping machines	2	2	-	2	-	L2, L3
R24CCPE12.3	Apply the strategic aspects of rapid prototyping in industrial product development.	2	2	-	2	-	L1, L3
R24CCPE12.4	Design and evaluate indirect rapid tooling process includes molding, follow-up processes, and indirect methods for manufacturing tools for plastic and metal components, to optimize tooling production.	2	2	-	2	2	L4, L5
R24CCPE12.5	Develop direct rapid tooling processes, prototype tooling, metal tools based on multilevel AM processes, and direct tooling, to create functional tools and components.	2	2	2	2	2	L5, L6

SYLLABUS

Unit - I **10 Hours**

Additive Manufacturing Process: Basic Principles of the Additive Manufacturing Process, Generation of Layer Information, Physical Principles for Layer Generation. Elements for Generating the Physical Layer, Classification of Additive Manufacturing Processes, Evaluation of the Theoretical Potentials of Rapid Prototyping Processes. **COs: CO1**

Unit - II **10 Hours**

Machines for Rapid Prototyping: Overview of Polymerization: Stereolithography(SL), Sintering/ Selective Sintering: Melting in the Powder Bed, Layer Laminate Manufacturing (LLM) and Three-Dimensional Printing(3DP). **COs: CO2**

Unit - III **10 Hours**

Rapid Prototyping: Classification and Definition, Strategic Aspects for the Use of Prototypes, Applications of Rapid Prototyping in Industrial Product Development. Rapid Tooling: Classification and Definition of Terms, Properties of Additive Manufactured Tools, Indirect Rapid.

COs: CO3

Unit – IV **10 Hours**

Tooling Processes: Molding Processes and Follow-up Processes, Indirect Methods for the Manufacture of Tools for Plastic Components, Indirect Methods for the Manufacture of Metal Components. **COs: CO4**

Unit – V **10 Hours**

Direct Rapid Tooling Processes: Prototype Tooling: Tools Based on Plastic Rapid Prototyping Models and Methods, Metal Tools Based on Multilevel AM Processes, Direct Tooling: Tools Based on Metal Rapid Prototype Processes. **COs: CO5**

Text Books:

1. Andreas Gebhardt Jan-Steffen Hötter, Additive Manufacturing: 3D Printing for Prototyping and Manufacturing, Hanser Publications, 6915 Valley Avenue, Cincinnati, Ohio.
2. Ian Gibson, David Rosen, Brent Stucker, Additive Manufacturing Technologies: 3DPrinting, Rapid Prototyping, and Direct Digital Manufacturing, Second Edition, Springer New York Heidelberg Dordrecht London.

References:

1. Liou L.W. and Liou F.W., ―Rapid Prototyping and Engineering application tool box for prototype development‖, CRC Press, 2007.
2. Kamrani A.K. and Nasr E.A., ―Rapid Prototyping: Theory and practice‖, Springer, 2006.
3. Hilton P.D. and Jacobs P.F., ―Rapid Tooling: Technologies and Industrial Applications‖, CRC press, 2000.

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Internal Assessment Pattern

Cognitive Level	Internal Assessment #1 (%)	Internal Assessment #2 (%)
L1	20	-
L2	40	20
L3	40	30
L4	-	30
L5	-	10
	-	10
Total (%)	**100**	**100**

Sample Long Answers questions of Various Cognitive Levels

Level 1: Remembering

1. What are the basic principles of additive manufacturing?
2. What are the fundamental principles underlying additive manufacturing (AM) processes?
3. Discuss the theoretical potential of rapid prototyping processes in terms of efficiency and accuracy.

4. Describe the basic principles of additive manufacturing and explain the concept of layer generation.
5. Define Stereolithography (SL) and describe its basic operational principles.
6. List and describe the different classifications of rapid prototyping techniques
7. List and describe the main molding processes used in tooling.

Level 2: Understanding

1. How do different additive manufacturing processes compare in terms of their classification?
2. What is polymerization, and how is it relevant to stereolithography (SL)?
3. Describe the role of light and resin in the stereolithography process.
4. Explain the stereolithography process and its applications.
5. What are the advantages and limitations of using stereolithography in rapid prototyping?
6. What are the key factors affecting the quality of sintered parts?
7. Explain the various classifications of additive manufacturing processes and how they are used in different applications.
8. Explain the strategic aspects of utilizing prototypes in the industrial product development process.
9. Explain the key differences between molding processes and follow-up processes in the context of tooling.

Level 3: Applying

1. Which additive manufacturing process would you choose for creating a complex geometric part? Why?
2. Describe the process of melting in the powder bed for additive manufacturing.
3. What are the strategic considerations when using prototypes in product development?
4. Provide examples of how rapid prototyping is applied in industrial product development.
5. What are the indirect methods used for manufacturing tools for plastic components?
6. Apply your understanding of different additive manufacturing processes to select the most appropriate process for producing a complex component. Justify your choice based on the component's requirements.
7. Apply your knowledge of different rapid prototyping machines to select the most appropriate technology for a specific project. Justify your choice based on factors like material, accuracy, and production speed.
8. Apply your knowledge of rapid prototyping techniques to address a specific problem in product development. Describe the approach and techniques you would use.
9. Apply your knowledge of molding processes to design a tool for manufacturing plastic components. Describe the process and considerations involved.

Level 4: Analyzing

1. Compare the theoretical potentials of different rapid prototyping processes.
2. Explain the significance of thermal dynamics and material properties in layer generation.
3. Analyze and compare the theoretical advantages and limitations of various rapid prototyping processes, considering factors such as material compatibility, precision, and cost.
4. Analyze and compare the advantages and limitations of rapid prototyping machines such as Stereolithography (SL) and Three-Dimensional Printing (3DP). Discuss their suitability for different types of projects.

5. Analyze how rapid prototyping contributes to the product development lifecycle. Discuss its impact on design, testing, and manufacturing.
6. Analyze and compare the effectiveness of various tooling processes in producing high-quality components. Discuss factors such as cost, efficiency, and quality

Level 5: Evaluating

1. Assess the effectiveness of additive manufacturing processes for industrial applications.
2. What are the challenges associated with RP methods?
3. Evaluate the effectiveness of various additive manufacturing processes in meeting the demands of different industrial applications. Provide examples and discuss factors influencing their suitability.
4. Evaluate the effectiveness of various rapid prototyping machines in industrial settings. Discuss their performance based on criteria such as cost, efficiency, and material properties.
5. Evaluate how rapid tooling techniques affect the efficiency and effectiveness of product development. Provide examples and discuss benefits and challenges.
6. Evaluate the performance and efficiency of indirect methods for manufacturing tools. Discuss their advantages and limitations in terms of cost and output quality.
7. Explain the process of using plastic rapid prototyping models to create prototype tooling. Discuss the steps involved and their significance.

Level 6: Creating

1. Design a new additive manufacturing process incorporating advanced layer generation techniques.

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R24CCPC07 MATERIAL CHARACTERIZATION LAB 0 0 4 0

Course Objectives:

1. Study the solidification process in different casting methods.
2. Analyze temperature gradients and their impact on metallurgical phases and microstructure.
3. Identify and understand the causes of defects in cast products and learn mitigation techniques.
4. Study the effects of temperature, strain rate, and material properties on the forging process.
5. Gain knowledge of sheet metal forming processes such as blanking, bending, and deep drawing.
6. Understand the metallurgical changes that occur during welding and their effects on weld integrity.

Course Code	Course Outcomes	Mapping with POs and PSOs				Dok
		PO1	PO2	PO3	PSO2	
R24CCPC07.1	Study the principles of powder metallurgy, including powder compaction and sintering.	2	2	2	2	L2
R24CCPC07.2	Estimate the chip reduction coefficient and shear angle in orthogonal turning.	2	3	2	2	L3
R24CCPC07.3	Identify common defects in forming processes and implement strategies to minimize them.	2	2	2	3	L4

List of Experiments

1. Microscopy: Different microscopy techniques, Resolution, Magnification, Depth of field Imaging – theory and concepts. **COs: CO1**
2. Optical Microscopy: Grain size estimation, Phase Percentage Estimation. **COs: CO1**
3. Micro hardness evaluation of Ferrous and Nonferrous metals. **COs: CO3**
4. Testing of Tensile Properties of mild steel material. **COs: CO2**
5. Testing of Compression Properties. **COs: CO3**
6. Testing of Flexural Strength on Ferrous metals. **COs: CO3**
7. Evaluation of Tribological properties of Ferrous and Nonferrous metals through Pin on Disc Tester. **COs: CO3**
8. Develop a mini project on above experimental knowledge. **COs: CO1-CO3**

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R24CCPC08 SIMULATION OF MANUFACTURING SYSTEMS LAB 0 0 4 2

Course Objectives:

1. To comprehend the basic concepts and principles of simulation, particularly in the context of manufacturing systems.
2. To develop skills in modeling various manufacturing processes and systems using simulation software.
3. To analyze the performance of manufacturing systems through simulation, identifying bottlenecks, inefficiencies, and areas for improvement.
4. To gain practical experience by implementing simulation projects that mimic real-world manufacturing scenarios.
5. To learn methods for collecting and analyzing data needed for accurate simulation modeling.

Course Code	Course Outcomes	Mapping with POs and PSOs					Dok
		PO 1	PO 2	PO 3	PSO 1	PSO 2	
R24CCPC08.1	Simulate solidification in casting, analyzing temperature distributions and residual stresses.	3	3	2	2	2	L4
R24CCPC08.2	Analyze material flow, stress-strain behavior, and temperature variations in these processes.	3	3	2	2	2	L4
R24CCPC08.3	Perform simulations of various welding techniques including arc welding, spot welding, and laser welding.	3	3	2	2	3	L4

List of Experiments

1. Casting processes - Simulation of Solidification, temperatures, Residual stresses, metallurgical phases etc. **COs: CO1**
2. Bulk Forming processes - Simulation of cold working and hot working processes for extrusion, drawing, rolling, etc. **COs: CO2**
3. Sheet Metal Forming Processes – Simulation of blanking, bending, deep drawing, etc. **COs: CO2**
4. Welding Processes – Simulation of arc, spot, laser welding, etc. **COs: CO3**
5. Machining Processes- Simulation of Turning, Milling and Shaping operations. **COs: CO3**
6. Develop a mini project on above experimental knowledge. **COs: CO1-CO3**

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R24CA208 **Personality Development through Life Enlightenment Skills** **2 0 0 2**

Course Objectives:

1. To know themselves better
2. Identify their own potentials and accept their own limitations
3. Consciously overcome the limitations and move towards self esteem
4. Maximise the own potential in enabling a holistic development

Course Code	Course Outcomes	Mapping with POs			Dok
		PO9	PO10	PO12	
R24CA208.1	This programme provides a space for the students to know themselves better and shape their personality with positive traits and multiple intelligence.	1	3	2	L1
R24CA208.2	The central focus of this programme is intra-personal development	1	3	2	L2
R24CA208.3	To apply ethical and moral principles in personal and professional forefronts;	2	3	1	L3
R24CA208.4	To develop a positive outlook towards humanity.	2	3	1	L2
R24CA208.5	To identify and locate the supporting ideas in essays and paragraphs	1	2	3	L5

SYLLABUS

UNIT I: Self – knowledge **9 Hours**

1. Exploring habits, attitudes, preferences and experience.
2. Becoming aware of strengths and weaknesses, talents and problems, emotions and ideas.
3. Identifying the optimum means of improving personal performance
4. Identifying areas of expertise and use these to solve problems in new contexts.
5. Knowing your ambitions, goals, and values.
6. Understanding feelings and emotions: primary feelings and secondary feelings, Self regulating emotions. **COs-C01**

UNIT II: Self management **8 Hours**

1. Focusing on Internal narratives.
2. Managing change, confusion and uncertainty.
3. Sharpening the Intellect.
4. Schooling the mind.
5. Socializing the individual **COs-C02**

UNIT III: Academic coping strategies **9 Hours**

Memory, Art of listening, Note making, Seminar presentation, Art of learning and writing guidelines. **COs-C03**

UNIT IV: Personal Competence and Maturity **9 Hours**

Motivation, developing rapport, Giving and receiving constructive criticism, Assertiveness and negotiation skills, Leadership. **COs-C04**

UNIT V: Integrated Personality Development **8 Hours**

1. Recognizing the gradual growth in different dimension of one's personality such as:

(a) Physical (b) Intellectual (c) Emotional (d) Moral (e) Social and (f) Spiritual
2. Learning the Development process- Tools and Skills.
3. Helping to maximize one's potentials.
4. Enhancing one's self image, self-esteem and self- confidence **COs-C05**

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Textbooks:

1. Personality Development and Soft Skills, Barun K. Mitra, Oxford University Press
2. Practical personality and development, Janardhana Krishna Pillamarri, Scitech Publications

Reference Books:

1. Placement & Personality Development, Dr.K.V.S.G.Murali Krishna et.al, Reem pub
2. The Great Indian Scientists, New Delhi, Cengage Learning Publications

Internal Assessment Pattern

Cognitive Level	Internal Assessment #1(%)	Internal Assessment #2(%)
L1,L2	40	40
L3, L4	40	40
L5	20	20
Total (%)	**100**	**100**

Sample Short and Long Answers questions of Various Cognitive Levels

UNIT I: Self – knowledge

1. What are my strengths?
2. What do I think about myself?
3. How would you describe yourself?
4. What did i struggle with today
5. How do I define success?

UNIT II: Self management

1. What are self-management questions?
2. What is the self-management question answer?
3. What are the factors affecting self-management?
4. What self-management prevents?
5. What skills do you think are necessary for someone to manage themselves effectively?

UNIT III: Academic coping strategies

1. What are some questions to ask about coping?
2. What are some questions about academic stress?
3. What is the coping strategies questionnaire?
4. What are coping strategies for academic performance?
5. What is coping style questionnaire?

UNIT IV: Personal Competence and Maturity

1. Describe a time when you worked under pressure.
2. Describe a time when you had to persuade a colleague or manager.

3. What is your biggest career achievement so far? ...
4. Describe a time when you faced a conflict while working with a team.

UNIT V: Integrated Personality Development

1. What does a fully integrated personality mean?
2. How is integration of personality achieved?
3. What is integrative personality theory?
4. Who said that personality is integrated form of traits?
5. Why is integrated personality development important?

Swaroopa Rani

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