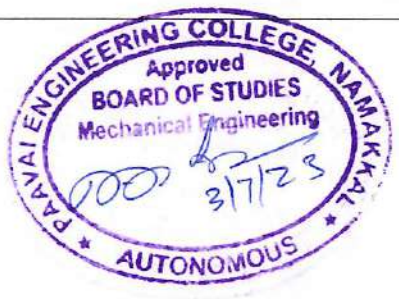
PAAVAI ENGINEERNG COLLEGE (Autonomous)
M.E. - ENGINEERING DESIGN
REGULATIONS 2023
(CHOICE BASED CREDIT SYSTEM)
CURRICULUM
(For the candidates admitted during the Academic Year 2023-24)
SEMESTER - I

S.No.	Category	Course Code	Course Title	L	T	P	C
Theory							
1	PC	PED23101	Advanced Engineering Materials	3	0	0	3
2	PC	PED23102	Concepts of Engineering Design	3	0	0	3
3	PC	PED23103	Computer Applications in Design	3	0	0	3
4	PC	PED23104	Vibration Analysis and Control	3	1	0	4
5	MC	PEN23101	Research Methodology and IPR	3	0	0	3
6	PE	PED23***	Professional Elective I	3	0	0	3
7	AC	PAC23101	English for Research Paper Writing (Audit Course I)	2	0	0	0
Practical							
1	PC	PED23105	Computer Aided Design Laboratory	0	0	4	2
TOTAL				**20**	**1**	**4**	**21**

SEMESTER – II

S.No.	Category	Course Code	Course Title	L	T	P	C
Theory							
1	PC	PED23201	Finite Element Methods in Mechanical Design	3	1	0	4
2	PC	PED23202	Integrated Product Development	3	0	0	3
3	PC	PED23203	Mechanical Behavior of Materials	3	0	0	3
4	PC	PED23204	Advanced Mechanics of Materials	3	1	0	4
5	PE	PED23***	Professional Elective II	3	0	0	3
6	PE	PED23***	Professional Elective III	3	0	0	3
7	AC	PAC23201	Pedagogy Studies (Audit Course II)	2	0	0	0
Practical							
1	PC	PED23205	Simulation and Analysis Laboratory	0	0	4	2
TOTAL				**20**	**2**	**4**	**22**



SEMESTER - III

S.No.	Category	Course Code	Course Title	L	T	P	C
Theory							
1	PC	PED23301	Engineering Fracture Mechanics	3	0	0	3
2	PE	PED23***	Professional Elective IV	3	0	0	3
3	PE	PED23***	Professional Elective V	3	0	0	3
4	OE	PED23***	Open Elective	3	0	0	3
Practical							
1	EE	PED23302	Project Work (Phase I)	0	0	12	6
			TOTAL	**12**	**0**	**12**	**18**

SEMESTER – IV

S.No.	Category	Course Code	Course Title	L	T	P	C
Practical							
1	EE	PED23401	Project Work (Phase II)	0	0	24	12
			TOTAL	**0**	**0**	**24**	**12**

TOTAL CREDITS: 21+22+18+12=73

PROFESSIONAL ELECTIVE COURSES

S.No.	Category	Course Code	Course Title	L	T	P	C
1.	PE	PED23151	Design for Sustainability	3	0	0	3
2.	PE	PED23152	Mechanics of Composite Materials	3	0	0	3
3.	PE	PED23153	Design of Hydraulic and Pneumatic Systems	3	0	0	3
4.	PE	PED23154	Tribology in Design	3	0	0	3
5.	PE	PED23155	Advanced Mechanisms in Design	3	0	0	3
6.	PE	PED23156	Product Lifecycle Management	3	0	0	3
7.	PE	PED23157	Surface Engineering	3	0	0	3
8.	PE	PED23158	Optimization Techniques in Design	3	0	0	3
9.	PE	PED23159	Mechanical Measurements and Analysis	3	0	0	3
10.	PE	PED23160	Design for X	3	0	0	3
11.	PE	PED23161	Vehicle Dynamics	3	0	0	3

S.No	Category	Course Code	Course Title	L	T	P	C
12.	PE	PED23162	Wearable Technologies	3	0	0	3
13.	PE	PED23163	Solid Freeform Manufacturing	3	0	0	3
14.	PE	PED23164	Bio Materials	3	0	0	3
15.	PE	PED23165	Advanced Finite Element Analysis	3	0	0	3
16.	PE	PED23166	Design of Hybrid and Electric Vehicles	3	0	0	3
17.	PE	PED23167	Bearing Design and Rotor Dynamics	3	0	0	3
18.	PE	PED23168	Material Handling Systems and Design	3	0	0	3
19.	PE	PED23169	Artificial Intelligence and Machine Learning	3	0	0	3
20.	PE	PED23170	Industrial Internet of Things	3	0	0	3

OPEN ELECTIVE COURSES

S. No	Category	Course Code	Course Title	L	T	P	C
1	OE	PED23901	Industrial Safety	3	0	0	3
2	OE	PSE23901	Climate change and Adaptation	3	0	0	3
3	OE	PPS23901	Alternate Energy Sources	3	0	0	3
4	OE	PCS23901	Design of Digital Elements	3	0	0	3
5	OE	PCE23901	Big Data Analytics	3	0	0	3

SPECIAL ELECTIVE COURSES

S. No	Category	Course Code	Course Title	L	T	P	C
1	SPE	PMR23001	Materials Characterization Techniques	3	0	0	3
2	SPE	PMR23002	Composite Materials and Testing	3	0	0	3
3	SPE	PMR23003	Soft Computing	3	0	0	3

PED23101	ADVANCED ENGINEERING MATERIALS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1.	understand the structure of various materials and its behaviors in the engineering field.
2.	learn imperfection, deformation, diffusion, dislocation and strengthening mechanisms.
3.	create phase diagram in iron carbon system to improve and enhance their research activities.
4.	acquire the knowledge of various failures of metals.
5.	familiarize the processing of metals like ceramics, polymers and composites.

UNIT I	STRUCTURE OF MATERIALS	9

Properties of materials - Classification of materials. Advanced Materials, Future materials and modern materials, Atomic structure. Atomic bonding in solids, Crystal structures, Crystalline and non-crystalline materials. Miller indices. Anisotropic elasticity. Elastic behavior of composites. Structure and properties of polymers. Structure and properties of ceramics.

UNIT II	IMPERFECTIONS IN SOLIDS, DIFFUSION, DISLOCATIONS AND STRENGTHENING MECHANISMS	9

Point defects. Theoretical yield point. Line defects and dislocations. Interfacial defects. Bulk or volume defects. Atomic vibrations; Elastic deformation. Plastic deformation. Diffusion mechanisms. Non-equilibrium transformation and microstructure, Dislocation and plastic deformation. Mechanisms of strengthening in metals. Recovery, re-crystallization and grain growth. Strengthening by second phase particles. Optimum distribution of particles. Lattice resistance to dislocation motion.

UNIT III	PHASE DIAGRAMS	9

Equilibrium phase diagrams. Particle strengthening by precipitation. Precipitation reactions. Kinetics of nucleation and growth. The iron-carbon system. Phase transformations. Transformation rate effects and TTT diagrams. Microstructure and property changes in iron carbon system.

UNIT IV	FAILURES OF MATERIALS	9

Fracture. Ductile and brittle fracture. Fracture mechanics. Impact fracture. Ductile brittle transition. Fatigue. Crack initiation and propagation. Crack propagation rate. Creep - Generalized creep behavior. Stress and temperature effects.

UNIT V	PROCESSING OF MATERIALS	9

Thermal processing of metals. Heat treatment. Precipitation hardening. Types and applications of ceramics. Mechanical behavior of polymers. Mechanisms of deformation and strengthening of polymers. Polymer types. Polymer synthesis and processing, Particle reinforced composites. Fiber reinforced composites. Structural composites, Economic, Environmental and Social Issues of Material Usage. Recycling issues. Life cycle analysis and its use in design.

	TOTAL PERIODS:	45

COURSE OUTCOMES At the end of the course, the students will be able to		BT MAPPED (Highest Level)
CO1	demonstrate an understanding of physical properties of materials including metals, ceramics and polymers	Understanding (K2)
CO2	understand existence of imperfections and their cause of failure	Understanding (K2)
CO3	demonstrate understanding of phase diagrams and their use in predicting phase transformation and microstructure	Understanding (K2)
CO4	understand and predict various types of failures using concept of fracture mechanics, creep and effect of impact	Understanding (K2)
CO5	know the processing of metals, ceramics, polymers and composites	Applying (K3)

REFERENCES

1. Materials Science and Engineering, William D. Callister, Jr, John Wiley & sons, 2007
2. Advanced Engineering Materials and Modeling, Ashutosh Tiwari, N. Arul Murugan , Rajeev Ahujar, Hardcover, 2016.
3. Advanced Engineering Materials, M N Avadhanulu, Dr. Shilpa A. Pande, Dr. Arti R. Golhar, Dr. Mohan Giriya, S Chand And Company Ltd. 2019.
4. Introduction to Materials Science for Engineers, James F Shackelford, Pearson; 7th edition, 2008.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	-	2	2	3
CO2	3	3	2	2	2	3
CO3	3	3	2	-	2	3
CO4	3	2	2	-	2	3
CO5	3	2	-	-	2	3

PED23102	CONCEPTS OF ENGINEERING DESIGN	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1. impart the fundamentals designing cost effective, preservation and productive.
2. familiarize with the customer-oriented design and societal considerations.
3. understand reinforces the knowledge being learned and shortens the overall learning of design methods.
4. know the concepts of materials for the design process.
5. acquire the knowledge in the design of reliability of failure mode effect analysis and probability concepts.

UNIT I DESIGN FUNDAMENTALS — 9

Importance of design- The design process-Considerations of Good Design – Morphology of Design – Organization for design– Computer Aided Engineering –Designing to codes and standards – Concurrent Engineering – Product and process cycles – Technological Forecasting – Market Identification – Competition Bench marking.

UNIT II CUSTOMER ORIENTED DESIGN AND SOCIETAL CONSIDERATIONS — 9

Identification of customer needs- customer requirements- Quality Function Deployment- Product Design Specifications- Human Factors in Design – Ergonomics and Aesthetics. Societal consideration – Contracts – Product liability – Protecting intellectual property – Legal and ethical domains – Codes of ethics – Ethical conflicts – Environment responsible design-future trends in interaction of engineering with society.

UNIT III DESIGN METHODS — 9

Creativity and Problem Solving –Creativity Methods-Theory of Inventive Problem Solving (TRIZ) – Conceptual decomposition-Generating design concepts-Axiomatic Design – Evaluation methods- Embodiment Design-Product Architecture- Configuration Design- Parametric Design. Role of models in design-Mathematical Modeling – Simulation – Geometric Modeling –Rapid prototyping.

UNIT IV MATERIAL SELECTION PROCESSING AND DESIGN — 9

Material Selection Process – Economics – Cost Vs Performance – Weighted property Index – Value Analysis – Role of Processing in Design – Classification of Manufacturing Process – Design for Manufacture – Design for Assembly –Designing for castings, Forging, Metal Forming, Machining and Welding – Residual Stresses – Fatigue, Fracture and Failure.

UNIT V PROBABILITY CONCEPTS IN DESIGN FOR RELIABILITY — 9

Probability – Distributions – Test of Hypothesis – Design of Experiments – Reliability Theory – Design for Reliability – Reliability centered Maintenance-Robust Design- Failure mode Effect Analysis.

TOTAL PERIODS: 45

COURSE OUTCOMES At the end of the course, the students will be able to		**BT MAPPED** (Highest Level)
CO1	understand the fundamentals of design process and designing codes and standards.	Understanding (K2)

CO2	familiarize the product design specifications, ergonomics and aesthetics.	Applying (K3)
CO3	identify the suitable design methods for problem solving.	Understanding (K2)
CO4	understand the proper material selection processing	Understanding (K2)
CO5	apply the probability concepts in design foe reliability	Applying (K3)

REFERENCES

1. George E.Dieter and Linda C.Schmidt, Engineering Design,McGraw Hill, 5th International Editions, 2012.
2. Pahl, G, and Beitz. W, Engineering Design, Springer – Verlag, London, 2007.
3. Suh, N.P., —The principles of Design, Oxford University Press, NY.1990.
4. Karl T. Ulrich and Steven D. Eppinger, Product Design and Development,McGraw Hill, 5th Edition 2011.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	-	3	1
CO2	3	3	3	-	3	1
CO3	3	3	3	-	3	1
CO4	3	3	3	-	3	1
CO5	3	3	3	-	3	1

PED23103	COMPUTER APPLICATIONS IN DESIGN	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1.	understand fundamental concepts of computer graphics and its tools in a generic framework.
2.	impart the parametric fundamentals to create and manipulate geometric models using curves, surfaces and solids.
3.	impart the parametric fundamentals to create and manipulate geometric models using NURBS and solids.
4.	provide clear understanding of CAD systems for 3D modeling and viewing.
5.	create strong skills of assembly modeling and prepare the student to be an effective user of a standards in CAD system.

UNIT I	INTRODUCTION TO COMPUTER GRAPHICS FUNDAMENTAL	9

Overview of Graphics systems: Video Display Devices, Raster-Scan System, Random-Scan Systems, Graphics Monitors and Workstations, Input Devices, Hard-Copy Devices, Graphics Software. Output primitives: Line Drawing Algorithm - DDA, Bresenham's and Parallel Line Algorithm. Circle generating algorithm – Midpoint Circle Algorithm. Geometric Transformations: Coordinate Transformations, Windowing and Clipping, 2D Geometric transformations -Translation, Scaling, Shearing, Rotation and Reflection, Composite transformation, 3D transformations.

UNIT II	CURVES AND SURFACES MODELLING	9

Introduction to curves - Analytical curves: line, circle and conics – synthetic curves: Hermite cubic spline- Bezier curve and B-Spline curve – curve manipulations. Introduction to surfaces - Analytical surfaces: Plane surface, ruled surface, surface of revolution and tabulated cylinder – synthetic surfaces: Hermite bi cubic surface- Bezier surface and B-Spline surface- surface manipulations.

UNIT III	NURBS AND SOLID MODELING	9

NURBS- Basics- curves, lines, arcs, circle and bi linear surface. Regularized Boolean set operations - primitive instancing - sweep representations - boundary representations - constructive solid Geometry- comparison of representations - user interface for solid modeling.

UNIT IV	VISUAL REALISM	9

Hidden Line removal, Hidden Surface removal – Hidden Solid Removal algorithms – Shading - Rendering – Coloring. Animation - Conventional, Computer animation, Engineering animation - types and techniques.

UNIT V	ASSEMBLY OF PARTS AND PRODUCT LIFE CYCLE MANAGEMENT	9

Assembly modeling – Design for manufacture – Design for assembly – computer aided DFMA - inferences of positions and orientation - tolerances analysis –Center of Gravity and mass property calculations - mechanism simulation. Graphics and computing standards – Data Exchange standards. Product development and management – new product development –models utilized in various phases of new product development – managing product life cycle.

	TOTAL PERIODS:	45

COURSE OUTCOMES At the end of the course, the students will be able to		BT MAPPED (Highest Level)
CO1	solve 2D and 3D transformations for the basic entities like line and circle.	Understanding (K2)
CO2	formulate the basic mathematics fundamental to CAD system.	Applying (K3)
CO3	use the different geometric modeling techniques like feature based modeling, surface modeling and solid modeling.	Understanding (K2)
CO4	create geometric models through animation and transform them into real world systems	Applying (K3)
CO5	simulate assembly of parts using Computer-Aided Design software.	Applying (K3)

REFERENCES

1. Ibrahim Zeid, "Mastering CAD/CAM", McGraw Hill, 2nd Edition, 2006.
2. Boothroyd, G, "Assembly Automation and Product Design" Marcel Dekker, New York, 1997.
3. Chitale A.K and Gupta R.C "Product design and manufacturing " PHI learning private limited, 6th Edition, 2015.
4. David Rogers, James Alan Adams "Mathematical Elements for Computer Graphics" 2nd Edition, Tata McGraw-Hill edition.2003

CO - PO MAPPING

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(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	3	1
CO2	3	2	3	2	3	1
CO3	3	2	3	2	3	1
CO4	3	2	3	-	3	1
CO5	3	3	3	-	3	1

PED23104	VIBRATION ANALYSIS AND CONTROL	3	1	0	4

COURSE OBJECTIVES

To enable the students to

1.	appreciate the basic concepts of vibration in damped and undamped systems
2.	calculate the natural frequencies and mode shapes of the two degree freedom systems
3.	determine the natural frequencies and mode shapes of the multi degree freedom and continuous systems
4.	learn the fundamentals of control techniques of vibration and noise levels
5.	use the instruments for the measuring and analyzing the vibration levels in a body

UNIT I	FUNDAMENTALS OF VIBRATION	12

Introduction -Sources of Vibration-Mathematical Models- Displacement, velocity and Acceleration Review of Single Degree Freedom Systems -Vibration isolation Vibrometers and accelerometers - Response to Arbitrary and non- harmonic Excitations – Transient Vibration –Impulse loads, Critical Speed of Shaft-Rotor systems.

UNIT II	TWO DEGREE FREEDOM SYSTEM	12

Introduction-Free Vibration of Undamped and Damped - Forced Vibration with Harmonic Excitation System – Coordinate Couplings and Principal Coordinates.

UNIT III	MULTI-DEGREE FREEDOM SYSTEM AND CONTINUOUS SYSTEM	12

Multi Degree Freedom System –Influence Coefficients and stiffness coefficients- Flexibility Matrix and Stiffness Matrix – Eigen Values and Eigen Vectors-Matrix Iteration Method –Approximate Methods: Dunkerley, Rayleigh's, and Holzer Method -Geared Systems-Eigen Values & Eigenvectors for large system of equations using sub space, Lanczos method – Continuous System: Vibration of String, Shafts and Beams.

UNIT IV	VIBRATION AND NOISE CONTROL	12

Specification of Vibration Limits – Vibration severity standards- Vibration as condition Monitoring Tool-Vibration Isolation methods - Dynamic Vibration Absorber - Static and Dynamic Balancing machines – Field balancing - Major sources of noise – Noise survey techniques – Measurement technique for vehicular noise – Road vehicle noise standards – Industrial noise sources – Control Strategies – Noise control at the source and along the path – use of acoustic barriers – Noise control at the receiver.

UNIT V	EXPERIMENTAL METHODS IN VIBRATION ANALYSIS	12

Vibration Analysis Overview - Experimental Methods in Vibration Analysis.-Vibration Measuring Instruments - Selection of Sensors- Accelerometer Mountings. -Vibration Exciters-Mechanical, Hydraulic, Electromagnetic And Electrodynamics –Frequency Measuring Instruments-. System Identification from Frequency Response -Testing for resonance and mode shapes.

	TOTAL PERIODS:	60

COURSE OUTCOMES At the end of the course, the students will be able to		BT MAPPED (Highest Level)
CO1	apply the basic concepts of vibration in damped and undamped systems	Understanding (K2)

CO2	determine the natural frequencies and mode shapes of the two degree freedom systems.	Applying (K3)
CO3	calculate the natural frequencies and mode shapes of the multi degree freedom and continuous systems	Understanding (K2)
CO4	control the vibration and noise levels in a body	Applying (K3)
CO5	measure and analyze the vibration levels in a body	Applying (K3)

REFERENCES

1. Graham Kelly, Sand Shashidhar K. Kudari, "Mechanical Vibrations", Tata McGraw – Hill Publishing Com. Ltd., 2007
2. Singiresu S. Rao, "Mechanical Vibrations, "Pearson Education Incorporated, 2017
3. Ramamurti. V, "Mechanical Vibration Practice with Basic Theory", Narosa Publishing House, 2010
4. WilliamT. Thomson, "Theory of Vibration with Applications", Taylor & Francis, 2018

CO - PO MAPPING

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(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	1	-
CO2	3	3	3	2	1	2
CO3	3	3	3	2	1	2
CO4	3	3	3	2	1	2
CO5	3	3	3	2	1	-

PEN23101	RESEARCH METHODOLOGY AND IPR	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1. understand the formulation of research problem
2. be familiar with data collection and literature survey process
3. know the statistical concepts in experimentation
4. acquire knowledge in writing research proposal
5. learn about patent rights and its importance

UNIT I	RESEARCH PROBLEM FORMULATION	9

Meaning of research, Objectives of Research, Types of research, Significance of Research, Research process, Selecting the problem, Necessity of defining the problem, Meaning of Research design, Need for research design, features of a good design, Different research designs.

UNIT II	LITERATURE SURVEY	9

Quantitative and Qualitative data, Scaling, Scaling Techniques, Experiments and Surveys, Collection of primary and secondary data, Data preparation process. Research problems, Effective literature studies approaches, Survey for existing literature, Procedure for reviewing the literature, Analysis and assessment.

UNIT III	DESIGN OF EXPERIMENTS	9

Strategy of Experimentation - Typical applications of experimental design, Guidelines for designing experiments; Basic statistical concepts - Statistical concepts in experimentation, Regression approach to analysis of variance.

UNIT IV	RESEARCH PROPOSAL AND WRITING	9

Contents of a research proposal, Writing a research report - Research writing in general, Referencing, Writing a bibliography, Presentation and assessment by a review committee, Plagiarism, Research ethics.

UNIT V	INTELLECTUAL PROPERTY RIGHTS	9

Intellectual Property - Definition, WTO, Fundamentals of Patent, Copyright, Rights of the owner, Term of copyright, Register of trademark, Procedure for trade mark, Term of trademark; New Developments in IPR- Administration of patent system, IPR of Biological Systems, Computer Software.

	TOTAL PERIODS:	45

COURSE OUTCOMES At the end of the course, the students will be able to		BT MAPPED (Highest Level)
CO1	identify research problems.	Understanding (K2)
CO2	collect and prepare suitable data for research.	Applying (K3)
CO3	design experiments for different statistical concepts.	Understanding (K2)
CO4	write research proposals and reports.	Applying (K3)
CO5	apply the research work for patent through IPR.	Applying (K3)

REFERENCES

1. C.R Kothari and Gaurav Garg, "Research Methodology Methods and Techniques", 4th Edition, New Age International Publishers, 2019.
2. Ranjit Kumar, "Research Methodology": A step by Step Guide for beginners, 2nd Edition, Pearson Education, 2010.
3. Douglas C. Montgomery, "Design and Analysis of Experiments", 9th edition, Wiley Publishers, 2017.
4. Neeraj Pandey and Khushdeep Dharni, "Intellectual Property Rights", Prentice Hall India Learning, 2014.

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	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	1	-	-
CO2	3	3	-	1	2	-
CO3	3	3	3	2	2	-
CO4	3	3	-	-	1	1
CO5	3	-	-	2	2	3

PAC23101	ENGLISH FOR RESEARCH PAPER WRITING	2	0	0	0

COURSE OBJECTIVES

To enable the students to

1.	improve the writing skills and level of readability.
2.	learn about what to write in each section and to understand the skills required to develop a title.
3.	choose a topic of interest and paraphrase, summarize, using correct attribution and following documentation guidelines.
4.	craft a research paper in their discipline.
5.	ensure the good quality of a research paper at first-time submission

UNIT I	PLANNING AND PREPARATION	6

Precision of Words; Breaking up long sentences; Structuring Paragraphs and Sentences; Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness. Expressing independent thought with grace, clarity and force.

UNIT II	LITERATURE REVIEWS AND CITATIONS	6

Key skills required - write a title, an abstract, write an introduction, write the review of the literature, conduct a literature review of all current research in their field; Review of the Literature; Methods; Results; Discussion and Conclusions; citing references correctly and avoiding plagiarism.

UNIT III	WRITING STANDARDS	6

Useful phrases - to ensure paper is as good as it could possibly be the first-time submission - first draft, second draft, final draft of research report; journal article; literature review; chapters, grant proposal; Avoid inadequate support of generalizations, slipshod or hurried style, poor attention to detail, straying from directions, mechanical errors, underwritten and/or marred by confused purpose, lack of organization, repetition of ideas, improper use of words, and frequent grammatical, spelling and punctuation errors.

UNIT IV	STRUCTURE OF A PAPER	6

Details of all the parts, Clarifying Who Did What; Highlighting the Findings; Hedging and Criticizing; Skills to identify something we really need to know, some ways to find a topic; to venture out across the swamp of research without losing our bearings; Paraphrasing; Sections of a Paper - Abstract, Introduction to Free writing.

UNIT V	EDITING AND ORGANISING SKILLS	6

Skills required - write the Methods, write the Discussion, write the Results, write Conclusions; write about what we've learned truthfully so the reader really gets it in thought and expression, demonstrating a clear understanding and execution of the research.

	TOTAL PERIODS:	30

COURSE OUTCOMES At the end of the course, the students will be able to		BT MAPPED (Highest Level)
CO1	plan and write a research paper in their discipline	Understanding (K2)

CO2	understand the basics of citations, avoiding plagiarism and literature reviews	Applying (K3)
CO3	write paraphrase, results and conclusions.	Understanding (K2)
CO4	culminate the actual crafting and revising of a research paper	Applying (K3)
CO5	use suitable vocabulary, grammar and punctuation to write flawless piece of writing	Applying (K3)

REFERENCES

1. Goldbort R (2006) Writing for Science, Yale University Press.
2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press.
3. Highman N (1998), Handbook of Writing for the Mathematical Sciences, SIAM. Highman's book.
4. Adrian Wallwork , English for Writing Research Papers, Springer New York Dordrecht Heidelberg London, 2011

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	-	-	2	-	1
CO2	-	3	-	2	2	2
CO3	-	1	-	-	-	-
CO4	-	-	-	3	-	-
CO5	-	2	2	3	-	-

PED23105	COMPUTER AIDED DESIGN LABORATORY	0	0	4	2

COURSE OBJECTIVES

To enable the students to

1.	understand sketches for given mechanical component
2.	learn features of the software for solid modeling and surface modeling with the help of software tools
3.	model and assemble mechanical components like couplings, joints, Engine parts and miscellaneous components
4.	gain knowledge on drafting and form layouts for assembled components

CAD INTRODUCTION

1. Sketcher
2. Solid modeling & Surface Modeling - Extrude, Sweep, Trim etc., and Mesh of curves, freeform etc. Feature manipulation- Copy, Edit, Pattern, Suppress, History operations etc.
3. Assembly - Constraints, Exploded Views, Interference check.
4. Drafting - Layouts, Standard & Sectional Views, Detailing & Plotting.
5. Couplings –Flange, Universal, Oldham's, Muff, Gear couplings.
6. Joints –Knuckle, Gib & cotter, strap, sleeve & cotter joints.
7. Engine parts –Piston, connecting rod, cross-head (vertical and horizontal), stuffing box, multi-plate clutch.
8. Miscellaneous machine components –Screw jack, machine vice, tail stock, chuck, vane and gear pumps.
9. Assembly using Parametric and feature based modeling packages.

TOTAL PERIODS: 60

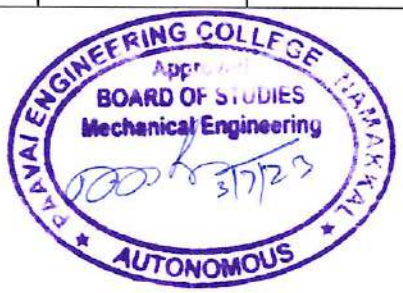
COURSE OUTCOMES At the end of the course, the students will be able to		**BT MAPPED** (Highest Level)
CO1	create sketches for given mechanical component	Understanding (K2)
CO2	use features of the software to develop solid modeling and surface modeling	Applying (K3)
CO3	modeling and assembling of mechanical components like couplings, joints, Engine parts and miscellaneous components	Understanding (K2)
CO4	draft and form layouts for assembled components	Applying (K3)

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	-	3	2	3	-
CO2	3	-	3	2	3	-
CO3	3	-	3	2	3	-
CO4	3	-	3	2	3	-



PED23201	FINITE ELEMENT METHODS IN MECHANICAL DESIGN	3	1	0	4

COURSE OBJECTIVES

To enable the students to

1.	learn mathematical models for one dimensional problems and their numerical solutions
2.	learn two dimensional scalar and vector variable problems to determine field variables
3.	learn isoparametric transformation and numerical integration for evaluation of element matrices
4.	study various solution techniques to solve Eigen value problems
5.	learn solution techniques to solve non-linear problems

UNIT I	FINITE ELEMENT ANALYSIS OF ONE DIMENSIONAL PROBLEMS	12

Historical Background – Weighted Residual Methods - Basic Concept of FEM – Variational Formulation of B.V.P. – Ritz Method – Finite Element Modelling – Element Equations – Linear and Higher order Shape functions – Bar, Beam Elements – Applications to Heat Transfer problems.

UNIT II	FINITE ELEMENT ANALYSIS OF TWO DIMENSIONAL PROBLEMS	12

Basic Boundary Value Problems in two-dimensions – Linear and higher order Triangular, quadrilateral elements – Poisson's and Laplace's Equation – Weak Formulation – Element Matrices and Vectors – Application to scalar variable problems - Introduction to Theory of Elasticity – Plane Stress – Plane Strain and Axisymmetric Formulation – Principle of virtual work – Element matrices using energy approach.

UNIT III	ISO-PARAMETRIC FORMULATION	12

Natural Co-ordinate Systems – Lagrangian Interpolation Polynomials – Iso parametric Elements –Formulation – Shape functions -one dimensional , two dimensional triangular and quadrilateral elements -Serendipity elements- Jacobian transformation - Numerical Integration – Gauss quadrature – one, two and three point integration.

UNIT IV	EIGEN VALUE PROBLEMS	12

Dynamic Analysis – Equations of Motion – Consistent and lumped mass matrices – Free Vibration analysis – Natural frequencies of Longitudinal, Transverse and torsional vibration – Solution of Eigenvalue problems - Introduction to transient field problems.

UNIT V	NON-LINEAR ANALYSIS	12

Introduction to Non-linear problems - some solution techniques- computational procedure material non-linearity- Plasticity and viscoplasticity, stress stiffening, contact interfaces- problems of gaps and contact - geometric non-linearity - modeling considerations - Free and Mapped meshing -Mesh quality- Error estimate.

	TOTAL PERIODS:	60

COURSE OUTCOMES At the end of the course, the students will be able to		BT MAPPED (Highest Level)
CO1	develop mathematical models for one dimensional problems and their numerical solutions	Understanding (K2)
CO2	determine field variables for two dimensional scalar and vector variable problems	Applying (K3)

CO3	apply iso-parametric transformation and numerical integration for evaluation of element matrices	Applying (K3)
CO4	apply various solution techniques to solve Eigen value problems	Applying (K3)
CO5	formulate solution techniques to solve non-linear problems	Applying (K3)

REFERENCES

1. Bathe K.J., "Finite Element Procedures in Engineering Analysis", Prentice Hall, 1990
2. David Hutton, "Fundamentals of Finite Element Analysis", Tata McGrawHill, 2005
3. Rao, S.S., "The Finite Element Method in Engineering", 6th Edition, Butterworth Heinemann,2018.
4. Reddy,J.N. "Introduction to the Finite Element Method", 4th Edition, Tata McGrawHill,2018

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	3	2
CO2	3	3	2	1	2	2
CO3	3	3	2	2	3	2
CO4	3	3	2	1	3	2
CO5	3	3	2	1	3	2

PED23202	INTEGRATED PRODUCT DEVELOPMENT	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1.	understand the principles of development process, product planning and customer need analysis
2.	enhance the understanding of product specifications, generate, screen and test concepts
3.	apply the principles of product architecture and the importance of industrial design principles
4.	expose the different Prototyping techniques for developing robust design
5.	learn the concepts of economics principles and project management practices

UNIT I	INTRODUCTION TO PRODUCT DESIGN	9

Characteristics of Successful Product development –Duration and Cost of Product Development – Challenges of Product Development - Product Development Processes and Organizations – Product Planning Process - Process of Identifying Customer Needs.

UNIT II	PRODUCT SPECIFICATIONS, CONCEPT GENERATION, SELECTION AND TESTING	9

Establish Target and Final product specifications – Activities of Concept Generation – Concept Screening and Scoring - Concept Testing Methodologies.

UNIT III	PRODUCT ARCHITECTURE AND INDUSTRIAL DESIGN	9

Product Architecture – Implications and establishing the architecture – Delayed Differentiation – Platform Planning – Related system level design issues - Need and impact of industrial design - Industrial design process - management of the industrial design process - assessing the quality of industrial design.

UNIT IV	DESIGN FOR MANFACTURE, PROTOTYPING AND ROBUST DESIGN	9

DFM Definition - Estimation of Manufacturing cost- Reducing the component costs, costs of supporting function and assembly costs – Impact of DFM decision on other factors - Prototype basics – Principles of prototyping – Prototyping technologies - Planning for prototypes - Robust design –Robust Design Process.

UNIT V	PRODUCT DEVELOPMENT ECONOMICS AND MANAGING PROJECTS	9

Economic Analysis – Elements of Economic Analysis - Understanding and representing tasks- Baseline Project Planning - Accelerating the project - Project execution – Postmortem project evaluation.

	TOTAL PERIODS:	45

COURSE OUTCOMES At the end of the course, the students will be able to		BT MAPPED (Highest Level)
CO1	familiarize with the principles of development process, product planning and customer need analysis	Understanding (K2)
CO2	utilize knowledge gained on product specifications, concept generation techniques for product development	Applying (K3)
CO3	apply the principles of product architecture and industrial design principles	Applying (K3)
CO4	demonstrate the different Prototyping techniques for developing robust design	Understanding (K2)

CO5	exhibit knowledge on the concepts of economics principles and project management practices	Applying (K3)

REFERENCES

1. Karl T.Ulrich, Steven D.Eppinger, Anita Goyal, "Product Design and Development", McGraw –Hill Education (India) Pvt. Ltd, 4th Edition, 2012.
2. Kenneth Crow, "Concurrent Engineering/Integrated Product Development". DRM Associates, 6/3,Via Olivera, Palos Verdes, CA 90274(310) 377-569,Workshop Book
3. Kevin N Otto, Kristin L Wood, "Product Design – Techniques in Reverse Engineering and New Product Development", Pearson Education, Inc, 2016.
4. Stephen Rosenthal, "Effective Product Design and Development", Business One Orwin Homewood, 1992.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	-	3	3
CO2	3	3	3	-	2	3
CO3	3	3	3	-	3	3
CO4	3	3	3	-	3	3
CO5	3	3	3	-	3	3

PED23203	MECHANICAL BEHAVIOR OF MATERIALS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1. learn different strengthening and failure mechanism of the metals
2. understand the behavior of materials under different types of loads
3. know various aspects of selection of materials and processing
4. get exposed to modern metallic materials and their composition
5. gain knowledge on non-metallic materials for engineering applications

UNIT I BASIC CONCEPTS OF MATERIAL BEHAVIOR — **9**

Engineering Design process and the role of materials; materials classification and their properties, Strengthening mechanisms-grain size reduction, solid solution strengthening, strain hardening, grain boundary strengthening, precipitation, particle, fibre and dispersion strengthening, Effect of temperature, strain and strain rate on plastic behavior–Super plasticity–Failure of metals.

UNIT II BEHAVIOUR UNDER CYCLIC LOADS AND DESIGN APPROACHES — **9**

Stress intensity factor and fracture toughness–Fatigue low and high cycle fatigue test, fracture mechanisms and Paris law.-Effect of surface and metallurgical parameters on fatigue– Safe life, Stress-life, strain-life and fail-safe design approaches-Fracture of non-metallic Materials–Failure analysis, sources of failure, and procedure of failure analysis.

UNIT III SELECTION OF MATERIALS — **9**

Selection of materials based on function, Objective, Constraints, free variables and service requirements – Relationship between materials selection and processing – Case studies in advanced materials selection with relevance to aero, auto, marine, machinery and nuclear applications.

UNIT IV MODERN METALLIC MATERIALS — **9**

Steels-Advanced high strength steel, Dual phase (DP) steel, Transformation induced plasticity(TRIP) Steel, Maraging steel, Nitrogen steel, Austenitic steel and Q&P steels – Intermetallics, Ni and Ti-aluminides – Alloys – Al, Mg, Cu, Super alloys- Iron base, Cobalt base, Nickel base. Metal matrix composites (MMC) and Nano Solids.

UNIT V NON METALLIC MATERIALS — **9**

Polymeric materials–Formation of polymer structure, properties and applications of engineering polymers, Environmental aspects of polymers – Ceramic- Advanced ceramics, WC, TIC, TaC, Al_2O_3, SiC, Si_3N_4CBN and diamond– Fracture of ceramics-Stress strain behavior Deformation behavior. Glasses - Clay products-refractory ceramics, Composite Materials - GFRP and CFRP laminated composite.

TOTAL PERIODS: 45

COURSE OUTCOMES At the end of the course, the students will be able to		**BT MAPPED** (Highest Level)
CO1	understand the different strengthening and failure mechanism of the metals	Understanding (K2)

CO2	comprehend the behavior of materials under different types of loads	Applying (K3)
CO3	analyze and apply various aspects of selection of appropriate materials	Analyzing (K4)
CO4	express knowledge on modern metallic materials and their composition	Understanding (K2)
CO5	demonstrate understand of non-metallic materials for engineering applications	Understanding (K2)

REFERENCES

1. George E.Dieter, Mechanical Metallurgy, McGraw Hill, 1988
2. Thomas H.Courtney, Mechanical Behavior of Materials,(2nd edition), McGraw Hill, 2000
3. Willam D. CallisterJr.and David G. Rethwisch, Callister's Materials Science and Engineering, (2nd edition)Wiley Editorial,2018
4. Flinn, R.A., and Trojan, P.K., Engineering Materials and their Applications, (4th Edition) Jaico,1999

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	1	1	2	1
CO2	3	2	1	1	2	1
CO3	3	2	1	1	2	1
CO4	3	2	1	1	2	1
CO5	3	2	1	1	2	1

PED23204	ADVANCED MECHANICS OF MATERIALS	3	1	0	4

COURSE OBJECTIVES

To enable the students to

1.	learn the concepts of theory of elasticity in three-dimensional stress system.
2.	study the shear center of various cross-sections and deflections in beams subjected to unsymmetrical bending.
3.	acquire knowledge on the stresses in flat plates and curved members.
4.	understand torsional stress of non-circular sections.
5.	know the stresses in rotating members, contact stresses in point and line contact applications.

UNIT I	ELASTICITY	12

Stress-Strain relations and general equations of elasticity in Cartesian, Polar and curvilinear coordinates, differential equations of equilibrium – compatibility - boundary conditions – representation of three - dimensional stress of a tension generalized hook's law - St. Venant's principle – plane stress - Airy's stress function. Energy methods.

UNIT II	SHEAR CENTRE AND UNSYMMETRICAL BENDING	12

Location of shear center for various thin sections - shear flows. Stresses and Deflections in beams subjected to unsymmetrical loading-kern of a section.

UNIT III	STRESSES IN FLAT PLATES AND CURVED MEMBERS	12

Circumference and radial stresses – deflections - curved beam with restrained ends - closed ring subjected to concentrated load and uniform load - chain links and crane hooks. Solution of rectangular plates – pure bending of plates – deflection – uniformly distributed load – various end conditions.

UNIT IV	TORSION OF NON-CIRCULAR SECTIONS	12

Torsion of rectangular cross section - St.Venants theory - elastic membrane analogy - Prandtl's stress function - torsional stress in hollow thin walled tubes.

UNIT V	STRESSES IN ROTATING MEMBERS AND CONTACT STRESSES	12

Radial and tangential stresses in solid disc and ring of uniform thickness and varying thickness allowable speeds. Methods of computing contact stress-deflection of bodies in point and line contact applications.

	TOTAL PERIODS:	60

COURSE OUTCOMES At the end of the course, the students will be able to		BT MAPPED (Highest Level)
CO1	apply the concepts of theory of elasticity in three-dimensional stress system.	Applying (K3)
CO2	determine the shear centre of various cross-sections and deflections in beams subjected to unsymmetrical bending.	Understanding (K2)
CO3	evaluate the stresses in flat plates and curved members.	Understanding (K2)
CO4	calculate torsional stress of non-circular sections.	Applying (K3)
CO5	compute the stresses in rotating members, contact stresses in point and line contact applications	Applying (K3)

REFERENCES

1. Arthur P Boresi, Richard J.Schmidt, "Advanced Mechanics of Materials", Wiley India Pvt.Ltd., 2009.
2. Hibbeler. R.C., "Mechanics of Materials", Prentice-Hall, 2018.
3. Robert D.Cook, Warren C.Young, "Advanced Mechanics of Materials", Prentice Hall, 1999.
4. Srinath. L.S., "Advanced Mechanics of Solids", Tata McGraw Hill, 2009.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	3	2
CO2	3	3	2	1	2	2
CO3	3	3	2	2	3	2
CO4	3	3	2	1	3	2
CO5	3	3	2	1	3	2

PAC23201	PEDAGOGY STUDIES	2	0	0	0

COURSE OBJECTIVES

To enable the students to

1. understand the aims, objectives and educational philosophies of education.
2. acquire the knowledge of Instructional objectives of teaching and teaching skills.
3. apply the knowledge of methods and strategies of teaching in real classroom situation.
4. utilize the instructional aids and tools for effective classroom teaching.
5. acquaint with the knowledge of professional development of teachers.

UNIT I	EDUCATION AND ITS PHILOSOPHY	6

Education- Definition, Aims, Objectives, Scope, Educational philosophy of Swami Vivekananda, Mahatma Gandhi, Rabindranath Tagore, Sri Aurobindo and J.Krishnamoorthy, Montessori, Jean - Jacques Rousseau, Friedrich Froebel and John Dewey. Current trends and issues in Education - Educational reforms and National policy on Education - 1968 and 1986 - its objectives and features.

UNIT II	INSTRUCTIONAL OBJECTIVES AND DESIGN	6

Instructional Objectives: Taxonomy of Educational objectives - Writing of general and specific objectives. Instructional design: Planning and designing the lesson, Writing of lesson plan: meaning, its need and importance, format of lesson plan. Types of lesson plan Skills of teaching: various ways of introducing lessons, explaining skills, problem solving skills, illustrative skills, scaffolding skills, integrating ICT skills, questioning skills, Reinforcement skills, skill of probing questions, skill of Stimulus variation and computation skills.

UNIT III	INSTRUCTIONAL METHODS AND STRATEGIES	6

Instructional strategies Lecture, demonstration, laboratory, Inductive method, Deductive method, Inquiry method, seminar, panel discussion, symposium, problem solving, project based learning (PBL), Learning by doing, workshop, role - play (socio-drama), Recent trends: Constructivist learning - Problem - based learning - Brain - based learning - Collaborative learning - Flipped learning - Blended learning - e-Learning trends – Video conferencing.

UNIT IV	INSTRUCTIONAL MEDIA	6

Key concepts in the selection and use of media in education, Developing learning resource material using different media, Instructional aids - types, uses, selection, preparation, utilization. Dale cone of Experience, Teacher's role in procuring and managing instructional Aids - Projected and non-projected aids, multimedia, video - teleconferencing etc.

UNIT V	TEACHER PREPARATION	6

Teacher - roles and responsibilities, functions, characteristics, competencies, qualities, Preparation of Professional teacher, Organizing professional aspects of teacher preparation programs, Professional Development of teachers - In-service training, Refresher programmes, workshop and higher studies.

	TOTAL PERIODS:	30

PRACTICUM

- Writing of three lesson plans
- Practice teaching for 15 days
- Preparation of one teaching aid
- A seminar on one educational philosophy
- Assignment on any of these five units

COURSE OUTCOMES At the end of the course, the students will be able to		**BT MAPPED** (Highest Level)
CO1	explain the educational philosophies of education.	Understanding (K2)
CO2	write instructional and specific objectives in lesson plan.	Applying (K3)
CO3	utilize the teaching skills and methods effectively.	Understanding (K2)
CO4	use instructional media efficiently.	Applying (K3)
CO5	update themselves in the area of professional development.	Applying (K3)

REFERENCES

1. National Policy on Education 1968 and 1986- National Policy on Education 1986-Programme of Action1992.
2. Benjamin S.Bloometal. (1987). Taxono my of educational objectives. Longman Group.
3. Siddiqui, Mujibul Hasan(2005). Techniques of classroom teaching A.P.H.
4. Jeffrey Bennett (2014).On Teaching Science: Principles and Strategies That Every Educator Should Know. Big Kid Science: Boulder, CO
5. Bawa,M.S.& Nagpal,B.M.(2010).Developing teaching competencies. New Delhi: Viva Book House.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	-	2	-	3	-	-
CO2	-	-	-	-	-	-
CO3	-	-	-	3	2	3
CO4	1	-	-	-	3	3
CO5	-	-	-	3	3	3

PED23205	SIMULATION AND ANALYSIS LABORATORY	0	0	4	2

COURSE OBJECTIVES

To enable the students to

1.	learn behaviour of machine elements under static loads
2.	gain knowledge on the analysis of mechanical systems under thermal loads
3.	use commercial software packages to simulate stress analysis of axis-symmetric components
4.	study response of different mechanisms using kinematics and dynamics simulation software

LIST OF EXPERIMENTS

Analysis of Mechanical Components – Use of commercial FEA Packages

Exercises shall include analysis of

1. Machine elements under Static loads
2. Thermal Analysis of mechanical systems
3. Modal Analysis
4. Stress Analysis of an Axis -Symmetric Component
5. Machine elements under Dynamic loads
6. Harmonic Response Analysis
7. Non-linear systems
8. Use of kinematics and dynamics simulation software
9. Analysis of velocity and acceleration for mechanical linkages of different mechanisms.

TOTAL PERIODS:	**60**

COURSE OUTCOMES At the end of the course, the students will be able to		**BT MAPPED** (Highest Level)
CO1	analyze behavior of machine elements under static loads	Analyzing (K4)
CO2	demonstrate the analysis of the mechanical systems under thermal loads	Applying (K3)
CO3	simulate and study the stress analysis of axis-symmetric components	Understanding (K2)
CO4	use kinematics and dynamics simulation software to study response of different mechanisms	Applying (K3)

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	3	2
CO2	3	3	3	2	3	2
CO3	3	3	3	2	3	2
CO4	3	3	3	2	3	2

PED23151	DESIGN FOR SUSTAINABILITY	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1.	identify the relevant process; applying the general design principles for manufacturability; GD &T.
2.	learn the design considerations while designing the cast and welded components.
3.	know the design considerations while designing the formed and machined components.
4.	apply design considerations for assembled systems.
5.	gain knowledge design considerations for environmental issues.

UNIT I	INTRODUCTION	9

Introduction - Economics of process selection - General design principles for manufacturability; Geometric Dimensioning & Tolerance (GD&T) – Form tolerancing: straightness, flatness, circularity, cylindricity – Profile tolerancing: profile of a line, and surface – Orientation tolerancing: angularity, perpendicularity, parallelism – Location tolerancing: position, concentricity, symmetry – run out tolerancing: circular and total–Supplementary symbols.

UNIT II	CAST AND WELDED COMPONENTS DESIGN	9

Design considerations for: Sand cast – Die cast – Permanent mold parts. Arc welding – Design considerations for: Cost reduction – Minimizing distortion – Weld strength – Weldment. Resistance welding–Design considerations for: Spot–Seam–Projection–Flash and Upset weldment.

UNIT III	FORMED AND MACHINED COMPONENTS DESIGN	9

Design considerations for: Metal extruded parts – Impact/Cold extruded parts – Stamped parts –Forged parts. Design considerations for: Turned parts– Drilled parts – Milled, planned, shaped and slotted parts–Ground parts.

UNIT IV	DESIGN FOR ASSEMBLY	9

Design for assembly – General assembly recommendations – Minimizing the no. of parts – Design considerations for: Rivets – Screw fasteners – Gasket and Seals – Press fits – Snap fits – Automatic assembly– Computer Application for DFMA.

UNIT V	DESIGN FOR ENVIRONMENT	9

Introduction– Environmental objectives–Global issues–Regional and local issues–Basic DFE methods– Design guide lines–Example application–Life cycle assessment–Basic method–AT&T's environmentally responsible product assessment-Weighted sum assessment method–Life cycle assessment method– Techniques to reduce environmental impact–Design to minimize material usage–Design for disassembly–Design for recyclability–Design for manufacture–Design for energy efficiency –Design to regulations and standards.

	TOTAL PERIODS:	45

COURSE OUTCOMES At the end of the course, the students will be able to		BT MAPPED (Highest Level)
CO1	apply the general design principles for manufacturability; GD&T.	Applying (K3)

CO2	utilize design considerations while designing the cast and welded components.	Applying (K3)
CO3	employ design considerations while designing the formed and machined components.	Understanding (K2)
CO4	justify the design considerations for assembled systems.	Applying (K3)
CO5	apply the design considerations to solve environmental issues.	Applying (K3)

REFERENCES

1. Boothroyd, G, 2nd Edition 2002, Design for Assembly Automation and Product Design. New York, Marcel Dekker.
2. Bralla, Design for Manufacture handbook, McGrawhill,1999
3. Boothroyd, G,Heartz and Nike, Product Design for Manufacture,MarcelDekker,1994
4. Fixel, J. Design for the Environment McGraw Hill., 2nd Edition 2009

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	1	2	2
CO2	3	2	3	2	2	2
CO3	3	2	3	2	2	2
CO4	3	2	3	1	2	2
CO5	3	2	3	1	2	2

PED23152	MECHANICS OF COMPOSITE MATERIALS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1.	learn the significance and future enhancements in composite materials.
2.	analyze the geometric and physical properties of typical composite materials.
3.	understand the concepts of mathematical relations and mechanical properties.
4.	get knowledge in failure theories and strength parameters.
5.	design and analyze the structure and various laminates of composite materials.

UNIT I	INTRODUCTION	9

Characteristics, Overview of advantage and limitations of composite materials, Significance and objectives of composite materials, Science and technology, current status and future prospectus.

UNIT II	BASIC CONCEPTS AND CHARACTERISTICS	9

Structural performance of conventional material, Geometric and physical definition, Material response, Classification of composite materials, Scale of analysis; Micromechanics, Basic lamina properties, Constituent materials and properties, Properties of typical composite materials.

UNIT III	ELASTIC BEHAVIOR OF UNIDIRECTIONAL LAMINA	9

Stress-strain relations, Relation between mathematical and engineering constants, transformation of stress, strain and elastic parameters.

UNIT IV	STRENGTH OF UNIDIRECTIONAL LAMINA	9

Micromechanics of failure; failure mechanisms, Macro-mechanical strength parameters, Macro mechanical failure theories, Applicability of various failure theories.

UNIT V	ELASTIC BEHAVIOR OF LAMINATE	9

Basic assumptions, Strain-displacement relations, Stress-strain relation of layer within a laminate, Force and moment resultant, General load–deformation relations, Analysis of different types of laminates. Design for structural composite materials.

	TOTAL PERIODS:	45

COURSE OUTCOMES At the end of the course, the students will be able to		BT MAPPED (Highest Level)
CO1	understand the significance and future enhancements in composite materials.	Understanding (K2)
CO2	demonstrate the geometric and physical properties of typical composite materials.	Applying (K3)
CO3	utilize the concepts of mathematical relations and mechanical properties.	Understanding (K2)
CO4	apply knowledge of failure theories and strength parameters.	Applying (K3)
CO5	design and analyze the structure and various laminates of composite materials	Applying (K3)

REFERENCES

1. Isaac M. Daniels, Ori Ishai, "Engineering Mechanics of Composite Materials", Oxford University Press, 1994.
2. Mathews, F. L. and Rawlings, R. D., "Composite Materials: Engineering and Science",CRC Press, Boca Raton, 2003.
3. Madhujit Mukhopadhyay, "Mechanics of Composite Materials and Structures", University Press, 2004.
4. Mazumdar S. K., "Composite Manufacturing – Materials, Product and Processing Engineering", CRC Press, Boca Raton, 02.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	-	2	-
CO2	3	3	2	-	2	-
CO3	3	3	2	-	2	-
CO4	3	3	2	-	2	-
CO5	3	3	2	-	2	-

PED23153	DESIGN OF HYDRAULIC AND PNEUMATIC SYSTEMS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1. familiarize the students with various hydraulic systems and hydraulic actuators.
2. understand the control elements and actuation systems.
3. learn to design Hydraulic circuits effectively.
4. acquire knowledge to design the pneumatic systems and circuits.
5. know about pneumatic equipment's, design calculation and use of microprocessors

UNIT I	OIL HYDRAULIC SYSTEMS AND HYDRAULIC ACTUATORS	9

Hydraulic Power Generators – Selection and specification of pumps, pump characteristics. Linear and Rotary Actuators – selection, specification and characteristics.

UNIT II	CONTROL AND REGULATION ELEMENTS	9

Pressure - direction and flow control valves - relief valves, non-return and safety valves – actuation systems.

UNIT III	HYDRAULIC SYSTEMS AND CIRCUITS	9

Reciprocation, quick return, sequencing, synchronizing circuits - accumulator circuits - industrial circuits – press circuits - hydraulic milling machine - grinding, planning, copying, - forklift, earth mover circuits- design and selection of components – safety and emergency mandrels.

UNIT IV	PNEUMATIC SYSTEMS AND CIRCUITS	9

Pneumatic fundamentals - FRL unit - control elements, position and pressure sensing – logic circuits – switching circuits - fringe conditions modules and these integration -sequential circuits - cascade methods - mapping methods – step counter method -compound circuit design - combination circuit design.

UNIT V	INSTALLATION, MAINTENANCE AND SPECIAL CIRCUITS	9

Pneumatic equipment's- selection of components - design calculations – application -fault finding – hydro pneumatic circuits - use of microprocessors for sequencing -PLC, Low cost automation -Robotic circuits.

	TOTAL PERIODS:	45

COURSE OUTCOMES At the end of the course, the students will be able to		BT MAPPED (Highest Level)
CO1	demonstrate knowledge on hydraulic power generator, pumps and various actuators.	Understanding (K2)
CO2	identify proper control and regulation elements.	Applying (K3)
CO3	design appropriate hydraulic circuits for various Engineering applications.	Understanding (K2)
CO4	describe design procedure for pneumatic circuits.	Applying (K3)
CO5	select suitable components for designing hydro pneumatic circuits.	Applying (K3)

REFERENCES

1. Antony Espossito, "Fluid Power with Applications", Prentice Hall, 2013

2. Bolton. W., "Pneumatic and Hydraulic Systems ", Butterworth –Heinemann, 1997

3. Andrew Parr, "Hydraulic and Pneumatics" (HB), Jaico Publishing House, 2011.

4. K.Shanmuga Sundaram, "Hydraulic and Pneumatic Controls: Understanding made Easy" S.Chand & Co Book publishers, New Delhi, 2006 (Reprint 2009).

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	-	3	1
CO2	3	2	2	-	3	1
CO3	3	2	2	-	3	1
CO4	3	2	2	-	3	1
CO5	3	2	2	-	3	1

PED23154	TRIBOLOGY IN DESIGN	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1.	impart the knowledge in friction and surface measurement
2.	understand the basics of theories of wear and wear prevention
3.	learn the bearing material properties which influence the tribological characteristics of surfaces and lubricants
4.	know about the design of bearings and its types
5.	gain knowledge on the analytical behavior and design of bearings based on analytical/theoretical approach

UNIT I	FRICTION AND SURFACE MEASUREMENT	9

Friction, theories of friction, Friction control, Surface texture and measurement, genesis of friction, instabilities and stick-slip motion.

UNIT II	WEAR	6

Wear, types of wear, theories of wear, wear prevention.

UNIT III	BEARING MATERIALS AND LUBRICANTS	6

Tribological properties of bearing materials and lubricants.

UNIT IV	BEARINGS	12

Lubrication, Reynolds's equation and its limitations, idealized bearings, infinitely long plane pivoted and fixed show sliders, infinitely long and infinitely short (narrow) journal bearings, lightly loaded infinitely long journal bearing (Petroff's solution), Finite Bearings, Design of hydrodynamic journal bearings.

UNIT V	THEORY OF HYDROSTATIC AND HYDRODYNAMIC LUBRICATION	12

Hydrostatic, squeeze film Circular and rectangular flat plates, variable and alternating loads, piston pin lubrications, application to journal bearings. Elasto-hydrodynamic lubrication – pressure viscosity term in Reynolds's equation, Hertz' theory, lubrication of spheres, gear teeth, Air lubricated bearings.

	TOTAL PERIODS:	45

COURSE OUTCOMES At the end of the course, the students will be able to		BT MAPPED (Highest Level)
CO1	understand theories of friction and surface measurement	Understanding (K2)
CO2	acquire knowledge on the theories of wear and prevention of wear	Applying (K3)
CO3	appropriately select materials and lubricants and suggest a tribological solution to a particular situation.	Understanding (K2)
CO4	design a bearing using various bearing charts.	Applying (K3)
CO5	identify between hydrostatic and dynamic lubrication.	Applying (K3)

REFERENCES

1. Majumdar, B.C, "Introduction to Tribology of Bearings", S.Chand, 2nd Edition, 2008

2. John Williams, "Engineering Tribology", Cambridge University Press, 2006

3. S.K.Basu, S.N.Sengupta & B.B.Ahuja ,"Fundamentals of Tribology", Prentice–Hall of India Pvt Ltd New Delhi., 2005

4. G.W.Stachowiak & A.W.Batchelor , Engineering Tribology, Butterworth - Heinemann, UK, 2005

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	3	1	1
CO2	3	3	1	3	1	1
CO3	3	3	1	3	1	1
CO4	3	3	1	3	1	1
CO5	3	3	3	3	1	1

PED23155	ADVANCED MECHANISMS IN DESIGN	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1.	learn the concepts of gross motion capability and develop multi loop kinematic chains and equivalent mechanisms
2.	study complex mechanisms to determine velocity and acceleration of output links.
3.	locate inflection points and to draw the inflection circle
4.	gain knowledge on the synthesis of planar mechanisms
5.	comprehend design of six bar coupler driven mechanisms and cam mechanisms

UNIT I	INTRODUCTION	9

Review of fundamentals of kinematics-classifications of mechanisms-components of mechanisms – mobility analysis – formation of one D.O.F. multi loop kinematic chains, Network formula – Gross motion concepts-Basic kinematic structures of serial and parallel robot manipulators-Compliant mechanisms - Equivalent mechanisms.

UNIT II	KINEMATIC ANALYSIS	9

Position Analysis – Vector loop equations for four bar, slider crank, inverted slider crank, geared five bar and six bar linkages. Analytical methods for velocity and acceleration Analysis– four bar linkage jerk analysis. Plane complex mechanisms-auxiliary point method. Spatial RSSR mechanism-Denavit-Hartenberg Parameters – Forward and inverse kinematics of robot manipulators.

UNIT III	PATH CURVATURE THEORY, COUPLER CURVE	9

Fixed and moving centrodes, inflection points and inflection circle. Euler Savary equation, graphical constructions – cubic of stationary curvature. Four bar coupler curve-cusp -crunode - coupler driven six-bar mechanisms-straight line mechanisms.

UNIT IV	SYNTHESIS OF FOUR BAR MECHANISMS	9

Type synthesis – Number synthesis – Associated Linkage Concept. Dimensional synthesis – function generation, path generation, motion generation. Graphical methods-Pole technique inversion technique-point position reduction-two, three and four position synthesis of four- bar mechanisms. Analytical methods- Freudenstein's Equation-Bloch's Synthesis.

UNIT V	SYNTHESIS OF COUPLER CURVE BASED MECHANISMS & CAM MECHANISMS	9

Hydrostatic, squeeze film Circular and rectangular flat plates, variable and alternating loads, piston pin lubrications, application to journal bearings. Elasto-hydrodynamic lubrication – pressure viscosity term in Reynolds's equation, Hertz' theory, lubrication of spheres, gear teeth, Air lubricated bearings.

	TOTAL PERIODS:	45

COURSE OUTCOMES	BT MAPPED
At the end of the course, the students will be able to	(Highest Level)

CO1	apply concepts of gross motion capability and develop multi loop kinematic chains and equivalent mechanisms	Applying (K3)
CO2	determine velocity and acceleration of complex mechanisms	Applying (K3)
CO3	evaluate inflection points and draw the inflection circle	Understanding (K2)
CO4	synthesis four bar mechanisms	Understanding (K2)
CO5	design of six bar coupler driven mechanisms and cam mechanisms	Applying (K3)

REFERENCES

1. Amitabha Ghosh and Asok Kumar Mallik, "Theory of Mechanism and Machines", EWLP, Delhi,1999.
2. Kenneth J, Waldron, Gary L. Kinzel, "Kinematics, Dynamics and Design of Machinery", John Wiley-sons, 2016.
3. Robert L.Norton., "Design of Machinery",Tata McGraw Hill, 2012
4. Uicker, J.J., Pennock, G. R. and Shigley, J.E., "Theory of Machines and Mechanisms", Oxford University Press, 2017.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	2	1
CO2	3	2	3	2	2	1
CO3	3	2	3	2	2	2
CO4	3	3	3	2	2	2
CO5	3	3	3	2	2	1

PED23156	PRODUCT LIFECYCLE MANAGEMENT	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1.	study history, concepts and terminology of PLM
2.	learn functions and features of PLM/PDM
3.	understand different modules offered in commercial PLM/PDM tools
4.	demonstrate PLM/PDM approaches for industrial applications
5.	use PLM/PDM with legacy data bases, CAx & ERP systems

UNIT I	HISTORY, CONCEPTS AND TERMINOLOGY OF PLM	12

Introduction to PLM, Need for PLM, opportunities of PLM, Different views of PLM – Engineering Data Management (EDM), Product Data Management (PDM), Collaborative Product Definition Management (cPDm), Collaborative Product Commerce (CPC), Product Lifecycle Management (PLM).PLM/PDM Infrastructure – Network and Communications, Data Management, Heterogeneous data sources and applications.

UNIT II	PLM/PDM FUNCTIONS AND FEATURES	10

User Functions – Data Vault and Document Management, Workflow and Process Management, Product Structure Management, Product Classification and Programme Management. Utility Functions – Communication and Notification, data transport, data translation, image services, system administration and application integration.

UNIT III	DETAILS OF MODULES IN APDM/PLM SOFTWARE	5

Case studies based on top few commercial PLM/PDM tools.

UNIT IV	ROLE OF PLM IN INDUSTRIES	12

Case studies on PLM selection and implementation (like auto, aero, electronic) - other possible sectors, PLM visioning, PLM strategy, PLM feasibility study, change management for PLM, financial justification of PLM, barriers to PLM implementation, ten step approach to PLM, benefits of PLM for–business, organization, users, product or service, process performance.

UNIT V	BASICS ON CUSTOMISATION/INTEGRATION OF PDM/PLM SOFTWARE	6

PLM Customization, use of EAI technology (Middleware), Integration with legacy data base, CAD, SLM and ERP.

	TOTAL PERIODS:	45

COURSE OUTCOMES At the end of the course, the students will be able to		BT MAPPED (Highest Level)
CO1	summarize the history, concepts and terminology of PLM	Understanding (K2)
CO2	use the functions and features of PLM/PDM	Applying (K3)
CO3	apply different modules offered in commercial PLM/PDM tools	Applying (K3)
CO4	implement PLM/PDM approaches for industrial applications	Understanding (K2)
CO5	integrate PLM/PDM with legacy data bases and ERP systems.	Understanding (K2)

REFERENCES

1. Michael Grieves, "Product Life Cycle Management", Tata McGraw Hill, 2006.
2. Antti Saaksvuori and Anselmi Immonen, "Product Lifecycle Management", Springer Publisher, 2008
3. John Stark, "Global Product: Strategy, Product Lifecycle Management and the Billion Customer Question", Springer Publisher, 2007
4. Ivica Crnkovic, Ulf Asklund and Annita Persson Dahlqvist, "Implementing and Integrating Product Data Management and Software Configuration Management", Artech House Publishers, 2003.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	1	3	3	2
CO2	3	3	1	3	3	2
CO3	3	3	1	3	3	2
CO4	3	3	1	3	3	2
CO5	3	3	1	3	3	2

PED23157	SURFACE ENGINEERING	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1. learn the basics of surface features and different types of friction in metals and nonmetals.
2. analyze the different types of wear mechanism and international standard used in friction and wear measurement
3. understand the different types of corrosion and its preventive measures.
4. study the different types of surface treatments and surface modification techniques.
5. comprehend different types of materials used in the friction and wear applications

UNIT I	FRICTION	7

Topography of Surfaces– Surface features – Properties and measurement– Surface interaction - Adhesive Theory of Sliding Friction–Rolling Friction- Friction properties of metallic and nonmetallic materials–Friction in extreme conditions –Thermal considerations in sliding contact.

UNIT II	WEAR	6

Introduction – Abrasive wear, Erosive, Cavitation, Adhesion, Fatigue wear and Fretting Wear Laws of wear – Theoretical wear models – Wear of metals and non-metals – International standards in friction and wear measurement methods.

UNIT III	CORROSION	10

Introduction – Principle of corrosion – Classification of corrosion – Types of corrosion – Factors influencing corrosion–Testing of corrosion–In-service monitoring, Simulated service, Laboratory testing – Evaluation of corrosion – Prevention of Corrosion – Material selection, Alteration of environment, Design, Cathodic and Anodic Protection, Corrosion inhibitors – Corrosion methods.

UNIT IV	SURFACE TREATMENTS	12

Introduction–Surface properties, Superficial layer–Changing surface metallurgy–Wear resistant coatings and Surface treatments – Techniques – PVD – CVD – Physical CVD – Ion implantation – Surface welding – Thermal spraying – Laser surface hardening and alloying, laser re-melting, and laser cladding. Applications of coatings and surface treatments in wear and friction control – Characteristics of Wear resistant coatings – New trends in coating technology –DLC – CNC – Thick coatings – Nano-engineered coatings – Other coatings, Corrosion resistant coating.

UNIT V	ENGINEERING MATERIALS	10

Introduction–Advanced alloys–Super alloys, Titanium alloys, Magnesium alloys, Aluminium alloys, and Nickel based alloys–Ceramics–Polymers–Biomaterials–Applications–Bio Tribology NanoTribology - Surface texturing, cold spray, short peening, Electroplating.

	TOTAL PERIODS:	45

COURSE OUTCOMES At the end of the course, the students will be able to		BT MAPPED (Highest Level)
CO1	understand the basics of surface features, laws of friction and different types of friction	Understanding (K2)
CO2	develop the knowledge of various wear mechanism and its measurement	Applying (K3)
CO3	gain knowledge on the types of corrosion and its preventive measures	Understanding (K2)
CO4	familiarize the types of surface properties and various surface modification techniques	Applying (K3)
CO5	analyze the different types of materials used in the friction and wear applications	Analyzing (K4)

REFERENCES

1. G.W.Stachowiak & A.W.Batchelor,"Engineering Tribology", Butterworth-Heinemann, UK, 2005
2. Rabinowicz.E,"Friction and Wear of materials",JohnWilley&Sons,UK,1995
3. Williams.J.A. "Engineering Tribology", OxfordUniv.Press,1994
4. S.K.Basu, S.N.Sengupta & B.B.Ahuja ,"Fundamentals of Tribology", Prentice –Hall of India Pvt. Ltd, New Delhi,2005.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	1	1	1	2
CO2	3	1	1	1	1	2
CO3	3	1	1	1	1	2
CO4	3	1	1	1	1	2
CO5	3	1	1	1	1	2

PED23158	OPTIMIZATION TECHNIQUES IN DESIGN	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1. study the basic concepts of unconstrained optimization techniques.
2. understand the basic concepts of constrained optimization techniques.
3. provide the mathematical foundation of artificial neural networks and swarm intelligence for design problems.
4. implement optimization approaches and to select appropriates solution for design application.
5. demonstrate selected optimization algorithms commonly used in static and dynamic applications.

UNIT I **UNCONSTRAINED OPTIMIZATION TECHNIQUES** **9**

Introduction to optimum design - General principles of optimization – Problem formulation & their classifications- Single variable and multivariable optimization, Techniques of unconstrained minimization – Golden section, Random, pattern and gradient search methods – Interpolation methods.

UNIT II **CONSTRAINED OPTIMIZATION TECHNIQUES** **9**

Optimization with equality and inequality constraints-Direct methods–Indirect methods using penalty functions, Lagrange multipliers-Geometric programming.

UNIT III **ARTIFICIAL NEURAL NETWORKS AND SWARM INTELLIGENCE** **9**

Introduction–Activation functions, types of activation functions, neural network architectures, Single layer feed forward network, multi layer feed forward network, Neural network applications. Swarm intelligence-Various animal behaviors, Ant Colony optimization, Particle Swarm optimization.

UNIT IV **ADVANCED OPTIMIZATION TECHNIQUES** **9**

Multistage optimization–dynamic programming, stochastic programming Multi objective optimization Genetic algorithms and Simulated Annealing technique - Fuzzy logic.

UNIT V **STATIC AND DYNAMIC APPLICATIONS** **9**

Structural applications – Design of simple truss members – Design of simple axial, transverse loaded members for minimum cost, weight – Design of shafts and torsionally loaded members –Design of springs. Dynamic Applications – Optimum design of single, two degree of freedom systems, vibration absorbers. Application in Mechanisms– Optimum design of simple linkage mechanisms.

TOTAL PERIODS: 45

COURSE OUTCOMES At the end of the course, the students will be able to		**BT MAPPED** (Highest Level)
CO1	summarize unconstrained optimization techniques in engineering design application.	Understanding (K2)
CO2	formulate constrained optimization techniques for various applications.	Applying (K3)
CO3	implement neural network technique to real world design problems.	Understanding (K2)
CO4	apply genetic algorithms to combinatorial optimization problems.	Applying (K3)

CO5	evaluate solutions by various optimization approaches for a design problem.	Applying (K3)

REFERENCES

1. Jang, J. S.R, Sun, C. T and Mizutani E., "Neuro-Fuzzy and Soft Computing", Pearson Education.2015,
2. JohnsonRay,C.,"Optimumdesignofmechanicalelements",Wiley,2nd Edition1980.
3. KalyanmoyDeb,"OptimizationforEngineeringDesign:AlgorithmsandExamples",PHI Learning Private Limited, 2nd Edition, 2012.
4. Rao Singiresu S., "Engineering Optimization – Theory and Practice", New Age International Limited, New Delhi, 3rd Edition, 2013.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	3	1
CO2	3	3	2	3	3	1
CO3	3	3	2	3	3	1
CO4	3	3	2	3	3	1
CO5	3	3	2	3	3	1

PED23159	MECHANICAL MEASUREMENTS AND ANALYSIS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1. understand the principle of force and strain measurement.
2. comprehend the vibration measurement and their applications.
3. gain knowledge on the principle behind acoustics and wind flow measurements.
4. familiarize with the distress measurements
5. realize the non-destructive testing principle and application

UNIT I	FORCES AND STRAIN MEASUREMENT	9

Strain gauge, principle, types, performance and uses. Photo elasticity–Principle and applications -Moire Fringe-Hydraulic jacks and pressure gauges–Electronic load cells–Proving Rings–Calibration of Testing Machines.

UNIT II	VIBRATION MEASUREMENTS	9

Characteristics of Structural Vibrations–Linear Variable Differential Transformer (LVDT)– Transducers for velocity and acceleration measurements. Vibration meter– Seismographs – Vibration Analyzer – Display and recording of signals – Cathode Ray Oscilloscope – XY Plotter – Chart Plotters–Digital data Acquisition systems.

UNIT III	ACOUSTICS AND WIND FLOW MEASUREMENTS	9

Principles of Pressure and flow measurements–pressure transducers–sound level meter– venturimeter and flow meters–wind tunnel and its use in structural analysis–structural modeling –direct and indirect model analysis

UNIT IV	DISTRESS MEASUREMENTS	9

Diagnosis of distress in structures–crack observation and measurements–corrosion of reinforcement in concrete – Half-cell, construction and use – damage assessment – controlled blasting for demolition.

UNIT V	NON DESTRUCTIVE TESTING METHODS	9

Load testing on structures, buildings, bridges and towers–Rebound Hammer –acoustice mission –ultrasonic testing principles and application–Holography–use of laser for structural testing–Brittle coating.

	TOTAL PERIODS:	45

COURSE OUTCOMES At the end of the course, the students will be able to		BT MAPPED (Highest Level)
CO1	calculate physical quantities such as forces and strains.	Understanding (K2)
CO2	evaluate different vibration measurements techniques.	Applying (K3)
CO3	measure physical quantities such as pressure and flow.	Understanding (K2)
CO4	utilize techniques involved in crack measurement.	Applying (K3)
CO5	select the appropriate nondestructive testing methods for various engineering applications.	Applying (K3)

REFERENCES

1. Bray Don E and Stanley, R.K., "Non-destructive Evaluation", McGraw Hill Publishing Company, N.Y.1989

2. Garas,F.K.,Clarke,J.LandArmerGST,"Structuralassessment",Butterworths,London,1987
3. James W. Dally and William Franklin Riley, "Experimental Stress Analysis", McGraw Hill, 3rd Edition,1991
4. Sadhu Singh, Experimental Stress Analysis, Khanna Publishers, New Delhi, 2009.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	1	3	1
CO2	3	3	2	-	3	1
CO3	3	3	2	-	3	-
CO4	3	3	2	1	3	-
CO5	3	3	2	1	3	1

PED23160	DESIGN FOR X	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1. learn relevant process; apply the general design principles for manufacturability; GD&T
2. study design considerations while designing the formed and machined components
3. gain knowledge on design considerations for assembled systems.
4. get exposure in maintenance systems and reliability based design
5. apply design considerations for environmental issues

UNIT I INTRODUCTION 9

General design principles for manufacturability - strength and mechanical factors, mechanisms selection, evaluation method, Process capability - Feature tolerances Geometric tolerances - Assembly limits - Datum features - Tolerance stacks.-factors influencing form design- working principle, Material, Manufacture, Design- Possible solutions - Materials choice –Influence of materials on form design - form design of welded members, forgings and castings.

UNIT II COMPONENT DESIGN - MACHINING CONSIDERATION 9

Design features to facilitate machining - drills - milling cutters - keyways - Doweling procedures, counter sunk screws - Reduction of machined area- simplification by separation - simplification by amalgamation - Design for machinability - Design for economy - Design for clampability – Design for accessibility.

UNIT III DESIGN FOR ASSEMBLY 9

Design for assembly – General assembly recommendations – Minimizing the no. of parts – Design considerations for: Rivets – Screw fasteners – Gasket & Seals – Press fits – Snap fits – Design for assembly – Product design for manual assembly - Product design for automatic assembly – Robotic assembly-Automatic assembly – Computer Application for DFMA -Case studies.

UNIT IV DESIGN FOR RELIABILITY AND MAINTAINABILITY 9

Reliability design process, system effectiveness, economic analysis and life cycle cost, reliability allocation, design methods, parts and material selection, derating, stress-strength and analysis, failure analysis, identification determination of causes, assessments of effects, computation of criticality index, corrective action, system safety – analysis of down-time – the repair time distribution, stochastic point processes system repair time, reliability under preventive maintenance state dependent system with repair. MTTR – mean system down time, repair vs replacement, replacement models, proactive, preventive, predictive maintenance maintainability and availability, optimization techniques for system reliability with redundancy heuristic methods applied to optimal system reliability.

UNIT V SUSTAINABLE DESIGN 9

Industrial ecology, multiple life cycle design, principles of design, green engineering, cradle to cradle design, The Natural Step, biomimicry, design for reuse, dematerialization, modularization, Design to minimize material usage

– Design for disassembly – Design for recyclability – design for flexibility, design for disassembly, design for inverse manufacturing, design for the environment, – Design for energy efficiency – Design to regulations and standards etc.

		TOTAL PERIODS:	45

COURSE OUTCOMES At the end of the course, the students will be able to		BT MAPPED (Highest Level)
CO1	select relevant process; apply the general design principles for manufacturability; GD&T	Understanding (K2)
CO2	apply design considerations while designing the formed and machined components	Applying (K3)
CO3	utilize design considerations for assembled systems.	Understanding (K2)
CO4	be exposed to maintenance systems and reliability based design	Applying (K3)
CO5	apply design considerations for environmental issues	Applying (K3)

REFERENCES

1. Boothroyd, G, 2006 Design for Assembly Automation and Product Design. New York, Marcel Dekker.
2. Bralla, Design for Manufacture handbook, McGraw hill, 2010.
3. Dickson, John. R, and Corroda Poly, Engineering Design and Design for Manufacture and Structural Approach, Field Stone Publisher, USA, 2006.
4. "Maintenance Engineering and Management": K.Venkataraman-PHI Learning - 2007 2. David J. Smith, "Reliability and Maintainability in Perspective", McMillan, 2nd Edition, 2002.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	1	3	1
CO2	3	3	2	-	3	1
CO3	3	3	2	-	3	-
CO4	3	3	2	1	3	-
CO5	3	3	2	1	3	1

PED23161	VEHICLE DYNAMICS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1. develop mathematical model of a system
2. gain knowledge on vehicular vibrations and response of vehicle
3. learn attire model based on required performance.
4. study various vehicle performance, control methodologies to ensure stability and ride comfort
5. comprehend the principles vertical, longitudinal and lateral dynamics vehicle design

UNIT I BASIS OF VIBRATION — **9**

Definitions, Modeling and Simulation, Global and Vehicle Coordinate System, Free, Forced, Undamped and Damped Vibration, Response Analysis of Single DOF, Two DOF, Multi DOF, Magnification factor, Transmissibility, Vibration absorber, Vibration measuring instruments, Torsional vibration, Critical speed

UNIT II TYRES — **9**

Tyre forces and moments, Tyre structure, Longitudinal and Lateral force at various lip angles, rolling resistance, Tractive and cornering property of tyre. Performance of tyre on wet surface. Ride property of tyres. Magic formulae tyre model, Estimation of tyre road friction. Teston Various road surfaces. Tyre vibration.

UNIT III VERTICAL DYNAMICS — **9**

Human response to vibration, Sources of Vibration. Design, analysis and computer simulation of Passive, Semi-active and Active suspension using Quarter car, half car and full car model .Influence of suspension stiffness, suspension damping, and tyre stiffness. Control law for LQR, H Infinite, Skyhook damping. Air suspension system and their properties.

UNIT IV LONGITUDINAL DYNAMICS AND CONTROL — **9**

Aerodynamic forces and moments. Equation of motion. Tyre forces, rolling resistance, Load distribution for three wheeler and four wheeler. Calculation of Maximum acceleration, Reaction forces for Different drives. Braking and Driving torque. Prediction of Vehicle performance. ABS, stability control, Traction control. Case Studies.

UNIT V LATERAL DYNAMICS — **9**

Steady state handling characteristics. Steady state response to steering input. Testing of handling characteristics. Transient response characteristics, Direction control of vehicles. Rollcenter, Rollaxis, Vehicle under side forces. Stability of vehicle on banked road and during turn. Effect of suspension on cornering.

TOTAL PERIODS: 45

COURSE OUTCOMES At the end of the course, the students will be able to		**BT MAPPED** (Highest Level)
CO1	understand the basics of finding vibration in vehicle components and measuring equipment	Understanding (K2)
CO2	develop the knowledge of various tyres model and their parameters.	Applying (K3)

CO3	design analysis and computer simulation of vertical dynamics in vehicles.	Understanding (K2)
CO4	acquire knowledge on the aerodynamic concepts in longitudinal dynamics and control in vehicle dynamics.	Applying (K3)
CO5	summarize the concepts in lateral dynamics of vehicles	Applying (K3)

REFERENCES

1. Thomas D. Gillespie, "Fundamentals of Vehicle Dynamics", Society of Automotive Engineers Inc, 1992
2. Hans B Pacejka, "Tire and Vehicle Dynamics", 2nd edition, SAE International, 2005
3. Rajesh Rajamani, "Vehicle Dynamics and Control", 1st edition, Springer, 2005
4. Wong. J. Y., "Theory of Ground Vehicles", 3rd Edition, Wiley-Interscience, 2001

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	1	3	1
CO2	3	3	2	-	3	1
CO3	3	3	2	-	3	-
CO4	3	3	2	1	3	-
CO5	3	3	2	1	3	1

PED23162	WEARABLE TECHNOLOGIES	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1. identify the guiding principles and challenges of Wearable Computing.
2. learn basics of different types of wearable sensors
3. study fundamental concepts and components required for flexible electronics
4. introduce the concept of energy harvesting systems from different sources
5. acquire knowledge on monitoring physiological parameters using wearable sensors

UNIT I INTRODUCTION **9**

Attributes of wearables, Meta-wearable, Challenges and opportunities, Future of wearables - Social aspects of wearability and interaction: Social interpretation of Aesthetics - Case study: Google glass - Wearable haptics: Need for wearable haptic devices - Categories of wearable haptic and tactile display – Wearable sensorimotor enhancer.

UNIT II WEARABLE SENSORS **9**

Chemical and Biochemical sensors, System design, Challenges in chemical Bio-chemical sensing, Application areas - Inertia sensors, Parameters from inertia sensors - Applications for wearable motion sensors - Measurement of energy expenditure by body worn heat flow sensors.

UNIT III FLEXIBLE ELECTRONICS **9**

Introduction, Thin-film transistors: Materials and Technologies, Review of Semi-conductors in flexible electronics - Low-power Integrated Circuit Design for Bio-potential sensing: Analog circuit design techniques - Low- power design for ADCs - Digital circuit design techniques - Architectural design for low-power bio-potential acquisition, Practical considerations.

UNIT IV ENERGY HARVESTING SYSTEMS **9**

Energy harvesting from human body: Temperature gradient, Foot motion - Wireless energy transmission - Energy harvesting from light and RF energy - Energy and power consumption issues, Future considerations.

UNIT V MONITORING PHYSICAL AND PHYSIOLOGICAL PARAMETERS **9**

Wearable sensors for physiological signal measurement - Physical measurement: Cardiovascular diseases, Neurological diseases, Gastrointestinal diseases - Wearable and noninvasive assistive technologies: Assistive devices for individuals with severe paralysis, Wearable tongue drive system, Sensor signal-processing algorithm, Dual-mode tongue drive system.

TOTAL PERIODS: 45

COURSE OUTCOMES At the end of the course, the students will be able to		**BT MAPPED** (Highest Level)
CO1	understand the guiding principles and challenges of Wearable Computing.	Understanding (K2)
CO2	express knowledge on basics of different types of wearable sensors	Applying (K3)
CO3	comprehend fundamental concepts and identify components required for flexible	Understanding (K2)

	electronics	
CO4	familiarize the concept of energy harvesting systems from different sources	Applying (K3)
CO5	explain aspects of monitoring physiological parameters using wearable sensors	Applying (K3)

REFERENCES

1. Edward Sazonov, Michael R Neuman, "Wearable Sensors: Fundamentals, Implementation and Applications", Academic Press, USA, 2014.
2. Tom Bruno , "Wearable Technology: Smart Watches to Google Glass for Libraries", Rowman & Littlefield Publishers, Lanham, Maryland, 2015.
3. Raymond Tong , "Wearable Technology in Medicine and Health Care", Academic Press, USA, 2018.
4. Haider Raad , "The Wearable Technology Handbook", United Scholars Publication, USA, 2017.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	1	-	1	2	2
CO2	3	1	1	1	2	2
CO3	3	1	1	1	2	2
CO4	3	1	1	1	2	2
CO5	3	1	-	1	2	2

PED23163	SOLID FREEFORM MANUFACTURING	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1.	acquaint the students with evolution of Solid Freeform Manufacturing (SFM) / Additive Manufacturing (AM), proliferation into various fields and its effects on supply chain.
2.	design for Additive Manufacturing (DFAM) and its importance in quality improvement of fabricated parts.
3.	gain knowledge on polymerization and sheet lamination processes and their applications.
4.	get expose with material extrusion and powder bed fusion processes.
5.	learn jetting and direct energy deposition processes and their applications.

UNIT I	INTRODUCTION	9

Need - Development of SFM systems – Hierarchical structure of SFM - SFM process chain –Classification – Applications. Case studies: Bio printing- Food Printing- Electronics printing – Rapid Tooling - Building printing. AM Supply chain. Economics aspect: Strategic aspect- Operative aspect.

UNIT II	DESIGN FOR ADDITIVE MANUFACTURING	9

Concepts and Objectives - AM Unique Capabilities - Part Consolidation - Topology Optimization - Lightweight Structures - DFAM for Part Quality Improvement - CAD Modeling – Model Reconstruction - Data Processing for AM - Data Formats - Data Interfacing - Part Orientation - Support Structure Design and Support Structure Generation - Model Slicing - Tool Path Generation. Design Requirements of Additive Manufacturing: For Part Production, For Mass Production, For Series Production. Case Studies.

UNIT III	VAT POLYMERIZATION AND SHEET LAMINATION PROCESSES	9

Stereolithography Apparatus (SLA): Principles – Photo Polymerization of SL Resins - Pre Build Process – Part-Building and Post-Build Processes - Part Quality and Process Planning, Recoating Issues - Materials - Advantages - Limitations and Applications. Digital Light Processing (DLP) - Materials - Process - Advantages and Applications. Laminated Object Manufacturing (LOM): Working Principles - Process - Materials, Advantages, Limitations and Applications. Ultrasonic Additive Manufacturing (UAM) - Process - Parameters - Applications. Case Studies.

UNIT IV	MATERIAL EXTRUSION AND POWDER BED FUSION PROCESSES	9

Fused deposition Modeling (FDM): Working Principles - Process - Materials and Applications. Design Rules for FDM. Selective Laser Sintering (SLS): Principles - Process - Indirect and Direct SLS - Powder Structure – Materials - Surface Deviation and Accuracy - Applications. Multijet Fusion. Selective Laser Melting (SLM) and Electron Beam Melting (EBM): Principles – Processes – Materials – Advantages - Limitations and Applications. Case Studies.

UNIT V	JETTING AND DIRECT ENERGY DEPOSITION PROCESSES	9

Binder Jetting: Three dimensional Printing (3DP): Principles – Process - Physics of 3DP – Types of printing: Continuous mode – Drop on Demand mode - Process – Materials - Advantages - Limitations - Applications. Material Jetting: Multi Jet Modelling (MJM) - Principles - Process - Materials - Advantages and Limitations. Laser

Engineered Net Shaping (LENS): Processes- Materials- Advantages - Limitations and Applications. Case Studies.			
		TOTAL PERIODS:	**45**
COURSE OUTCOMES At the end of the course, the students will be able to		**BT MAPPED** (Highest Level)	
CO1	relate the importance in the evolution of SFM/AM, proliferation into the various fields	Understanding (K2)	
CO2	analyze the design for AM and its importance in the quality of fabricated parts.	Analyzing (K4)	
CO3	build knowledge on principles and applications of polymerization and sheet lamination processes with case studies.	Understanding (K2)	
CO4	explain the principles of material extrusion and powder bed fusion processes and design guidelines.	Applying (K3)	
CO5	elaborate jetting and direct energy deposition processes and their applications.	Applying (K3)	

REFERENCES

1. Andreas Gebhardt and Jan-Steffen Hotter, "Additive Manufacturing:3D Printing for Prototyping and Manufacturing", Hanser publications Munchen, Germany, 2016.
2. Ben Redwood, Brian Garret, FilemonSchöffer, and Tony Fadel, "The 3D Printing Handbook: Technologies, Design and Applications", 3D Hubs B.V., Netherland, 2017.
3. Ian Gibson, David W. Rosen and Brent Stucker, "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing" Springer - New York, USA, 2nd Edition, 2015
4. Milan Brandt. "Laser Additive Manufacturing 1st Edition Materials, Design, Technologies, and Applications", Woodhead Publishing, UK, 2016.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
CO1	3	1	2	1	2	-
CO2	3	1	2	1	2	2
CO3	3	-	2	1	2	2
CO4	3	1	2	-	2	2
CO5	3	1	2	1	2	2

PED23164	BIO MATERIALS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1. study different concepts in selecting bio and smart materials
2. learn about dental material and its classifications
3. know the orthopaedic materials and its properties
4. understand wound dressing materials and surgical aids
5. gain knowledge on materials for cardiovascular and ophthalmology

UNIT I INTRODUCTION **9**

Human anatomy- tissues- organs- repair- regeneration- Wolff's Law – biomaterial – compatibility – classification - Biomimetics – Material response: swelling and leaching, corrosion and dissolution, deformation and failure, friction and wear – host response: the inflammatory process – coagulation and hemolysis- in vitro and in vivo evaluation of biomaterials – Testing and validation- government regulatory bodies.

UNIT II DENTAL MATERIALS **9**

Teeth composition, formation and properties – temporary fixation devices -classification - biomaterials used- metals and alloys- Fillings and restoration materials – oral and maxillofacial surgery – dental cements and dental amalgams – dental adhesives.

UNIT III ORTHOPAEDIC MATERIALS **9**

Bone composition, formation and regeneration - properties – defects - temporary fixation devices – joint replacement – biomaterials used in bone and joint replacement metals and alloys- stress shielding effect- bone tissue engineering.

UNIT IV WOUND DRESSING MATERIALS AND SURGICAL AIDS **9**

Skin structure – defects (burn, ulcer, trauma etc) and disease- skin regeneration – classification of regenerative material – Sutures- Adhesives – classification – Surgical tools materials – sterilization - Laparoscopic tools.

UNIT V CARDIOVASCULAR, OPTHALMOLOGY AND DRUG DELIVERY MATERIALS **9**

Blood clotting – blood theology– approaches to thrombo resistance materials development– blood vessels – The heart – aorta and valves – geometry of blood circulation – cardiac pacemakers – extracorporeal blood circulation devices. lungs – vascular implants: vascular graft, cardiac valve prostheses – Eye- defects – correction- Biomaterials in opthalmology – drug delivery methods and materials.

TOTAL PERIODS: 45

COURSE OUTCOMES At the end of the course, the students will be able to		**BT MAPPED** (Highest Level)
CO1	explain different concepts in selecting bio and smart materials	Understanding (K2)
CO2	explore dental material and its classifications	Applying (K3)

CO3	illustrate knowledge on orthopaedic materials and its properties	Understanding (K2)
CO4	comprehend wound dressing materials and surgical aids	Applying (K3)
CO5	select appropriate materials for cardiovascular and ophthalmology	Applying (K3)

REFERENCES

1. M. V. Gandhi and B. S. Thompson, "Smart Materials and Structures", Chapman and Hall, London, First Edition, 1992.
2. Sujata V., Bhat., "Biomaterials", Narosa Publication House, New Delhi, 2002.
3. Buddy D. Ratner (Editor), Allan S. Hoffman (Editor), Frederick J. Schoen (Editor), Jack E. Lemons, "Biomaterials Science: An Introduction to Materials in Medicine", Academic Press,2nd edition, 2004.
4. Mohsen Shahinpoor and Hans-Jorg Schneider "Intelligent Materials", RSC Publishing, 2008.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	3	3	2
CO2	3	2	2	3	3	2
CO3	3	2	2	3	2	2
CO4	3	3	2	3	2	2
CO5	3	3	2	3	2	2

PED23165	ADVANCED FINITE ELEMENT ANALYSIS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1. get exposure to solve problems involving plate and shell elements
2. learn concept of problems involving geometric and material non-linearity
3. study solution techniques to solve dynamic problems
4. familiarize with fluid mechanics and heat transfer problems
5. gain knowledge on error norms, convergence rates and refinement.

UNIT I BENDING OF PLATES AND SHELLS **9**

Review of Elasticity Equations – Bending of Plates and Shells – Finite Element Formulation of Plate and Shell Elements - Conforming and Non-Conforming Elements – C0 and C1 Continuity Elements –Degenerated shell elements-Application and Examples.

UNIT II NON-LINEAR PROBLEMS **9**

Introduction – Iterative Techniques – Material non-linearity – Elasto Plasticity – Plasticity – Visco Plasticity – Geometric Non linearity – large displacement Formulation –Solution procedure- Application in Metal Forming Process and Contact Problems.

UNIT III DYNAMIC PROBLEM **9**

Direct Formulation – Free, Transient and Forced Response – Solution Procedures – Eigen solution- Sub space Iterative Technique – Response analysis - Houbolt, Wilson, Newmark–Methods – Explicit & Implict Methods-Lanchzos, Reduced method for large size system equations.

UNIT IV FLUID MECHANICS AND HEAT TRANSFER **9**

Governing Equations of Fluid Mechanics – Solid structure interaction - Inviscid and Incompressible Flow – Potential Formulations – Slow Non-Newtonian Flow – Metal and Polymer Forming–Navier Stokes Equation–Steady and Transient Solution.

UNIT V ERROR ESTIMATES AND ADAPTIVE REFINEMENT **9**

Error norms and Convergence rates–h-refinement with adaptivity–Adaptive refinement.

TOTAL PERIODS: 45

COURSE OUTCOMES At the end of the course, the students will be able to		**BT MAPPED** (Highest Level)
CO1	solve problems involving plate and shell elements	Understanding (K2)
CO2	describe problems involving geometric and material non-linearity	Applying (K3)
CO3	formulate solution techniques to solve dynamic problems	Understanding (K2)
CO4	apply concepts of Finite Element Analysis to solve fluid mechanics and heat transfer problems	Applying (K3)
CO5	investigate error norms, convergence rates and refinement.	Applying (K3)

REFERENCES

1. Logan. D. L.,"A first course in Finite Element Method", Cengage Learning, 2012
2. Reddy, J.N. "An Introduction to Non linear Finite Element Analysis", 2nd Edition, Oxford, 2015
3. Robert D.Cook, David S.Malkus, Michael E.Plesha, Robert J.Witt, "Concepts and Applications of Finite Element Analysis", 4th Edition, Wiley Student Edition, 2004.
4. Tirupathi R. Chandrupatla and Ashok D.Belegundu,"Introduction to Finite Elements in Engineering", International Edition, Pearson Education Limited, 2014.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	2	2	3	2
CO2	3	3	2	1	2	2
CO3	3	3	2	2	3	2
CO4	3	3	2	1	3	2
CO5	3	3	2	1	3	2

PED23166	DESIGN OF HYBRID AND ELECTRIC VEHICLES	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1. learn fundamental concepts of electric and hybrid vehicle operation
2. understand the properties of batteries and its types.
3. gain knowledge about design of series hybrid electric vehicles.
4. comprehend design of parallel hybrid electric vehicles.
5. familiarize with electric vehicle drive train.

UNIT I	INTRODUCTION TO ELECTRIC VEHICLES	9

Electric Vehicles (EV) system- EV History – EV advantages – EV market – vehicle mechanics: roadway fundamentals- law of motion-vehicle kinetics- dynamics of vehicle motion – propulsion power–velocity and acceleration-propulsion system design.

UNIT II	ENERGY SOURCE	9

Battery basics-lead acid battery–alternative batteries–battery parameters-technical characteristics– battery power–alternative energy sources: Fuel cells-Fuel Cell characteristics-Fuel cell types.

UNIT III	SERIES HYBRID ELECTRIC DRIVE TRAIN DESIGN	9

Operation Patterns- Control Strategies-Sizing of the Major Components -Design of peaking power source- Traction Motor Size - Design of the Gear Ratio-Verification of Acceleration Performance- .Verification of grade ability--Design of Engine/Generator Size - Design of the Power Capacity- Design of the Energy Capacity –Fuel Consumption.

UNIT IV	PARALLEL HYBRID ELECTRIC DRIVE TRAIN DESIGN	9

Control Strategies of Parallel Hybrid Drive Train – Drive Train Parameters – Engine Power Capacity- Electric Motor Drive Power Capacity-Transmission Design- Energy Storage Design.

UNIT V	ELECTRIC VEHICLE DRIVE TRAIN	9

EV Transmission configurations–Transmission components–Ideal gear box–Gear ratio torque– speed characteristics-EV motor sizing–initial acceleration-rated vehicle velocity– maximum velocity – maximum gradability

	TOTAL PERIODS:	45

COURSE OUTCOMES At the end of the course, the students will be able to		BT MAPPED (Highest Level)
CO1	explain how a hybrid vehicle works and describe its main components and their function.	Understanding (K2)
CO2	choose proper energy storage systems for vehicle applications	Applying (K3)
CO3	design series hybrid electric vehicles.	Understanding (K2)
CO4	provide design for parallel hybrid electric vehicles.	Applying (K3)

CO5	describe the transmission components and their configurations for electric vehicles	Applying (K3)

REFERENCES

1. Ehsani,M, "Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design",CRC Press, 2005
2. Iqbal Hussain, "Electric & Hybrid Vehicles–Design Fundamentals", Second Edition, CRC Press, 2011.
3. James Larminie, "Electric Vehicle Technology Explained", John Wiley&Sons, 2003.
4. Sandeep Dhameja, "Electric Vehicle Battery Systems", Newnes, 2000.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2	1	2
CO2	3	2	3	2	1	2
CO3	3	2	3	2	1	2
CO4	3	2	3	2	1	2
CO5	3	2	3	2	1	2

PED23167	BEARING DESIGN AND ROTOR DYNAMICS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1. understand classification and selection of bearings
2. gain knowledge on design of fluid film bearings
3. learn about rolling contacts selection of rolling bearings
4. familiarize with rotor dynamics for rigid and flexible supports
5. study dynamics of rotors mounted on hydro dynamic bearings

UNIT I **CLASSIFICATION AND SELECTION OF BEARINGS** **9**

Selection criteria – Dry and Boundary Lubrication Bearings-Hydrodynamic and Hydrostatic bearings-Electro Magnetic bearings – Dry bearings – Rolling Element bearings-Bearings for Precision. Applications-Foil Bearings-Special bearings- Selection of plain Bearing materials – Metallic and Non-metallic bearings-Materials for rolling bearings.

UNIT II **DESIGN OF FLUID FILM BEARINGS** **9**

Design and performance analysis of Thrust and Journal bearings – Full, partial, fixed and pivoted journal bearings design procedure-Minimum film thickness – lubricant flow and delivery – power loss, Heat and temperature distribution calculations- Design based on Charts & Tables Design of Hydrostatic, Thrust and Journal bearings-Stiffness consideration-flow regulators and pump design in hydrostatic bearings-Foil bearings-Air Bearings

UNIT III **SERIES HYBRID ELECTRIC DRIVE TRAIN DESIGN** **9**

Contact Stresses in Rolling bearings – Centrifugal stresses – Elasto hydrodynamic lubrication - Fatique life calculations - Bearing operating temperature - Lubrication- Selection of lubricants-Internal clearance – Shaft and housing fit- -Mounting arrangements. Manufacturing methods-Ceramic bearings-Rolling bearing cages-bearing seals selection.

UNIT IV **ROTOR DYNAMICS** **9**

Motion of the shaft in the bearing-Rotor supported on rigid and flexible supports-Campbell diagram, Rotor Dynamic Analyses- Un damped critical speed - Unbalance response- Damped eigenvalue analysis- Bearing stiffness and damping coefficients - Mechanics of Hydro dynamic Instability – Half frequency whirl and Resonance whip bearing instability and Oil Whirl Technologies to Improve the Stability of Rotor-bearing Systems - Design configurations of stable journal bearings.

UNIT V **DYNAMICS OF ROTORS MOUNTED ON HYDRO DYNAMIC BEARINGS** **9**

Hydrodynamic Lubrication equation for dynamic loadings-Squeeze film effects in journal bearings and thrust bearings-Rotating loads, alternating and impulse loads in journal bearings–Journal Centre Trajectory-Analysis of short bearings under dynamic conditions-Finite difference solution for dynamic conditions

TOTAL PERIODS: **45**

COURSE OUTCOMES	BT MAPPED

At the end of the course, the students will be able to		(Highest Level)
CO1	explain classification and selection of bearings	Understanding (K2)
CO2	design fluid film bearings for various applications	Applying (K3)
CO3	select rolling bearings for different rolling contacts	Understanding (K2)
CO4	elaborate on rotor dynamics for rigid and flexible supports	Applying (K3)
CO5	illustrate knowledge on dynamics of rotors mounted on hydro dynamic bearings	Applying (K3)

REFERENCES

1. Neale,M.J. "Tribology Hand Book", Butterworth Heinemann, United Kingdom, 2001
2. Cameron,A. "Basic Lubrication Theory", Ellis Herward Ltd.,UK,1981
3. Williams.J.A. "Engineering Tribology", Oxford Univ.Press,1994
4. S.K.Basu, S. N. Sengupta & B. B.Ahuja ,"Fundamentals of Tribology", Prentice – Hall of India Pvt Ltd, New Delhi, 2005.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	2	1	2
CO2	3	2	3	2	1	2
CO3	3	2	3	2	1	2
CO4	3	2	3	2	1	2
CO5	3	2	3	2	1	2

PED23168	MATERIAL HANDLING SYSTEMS AND DESIGN (Use of Approved Data Book is Permitted)	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1. understand the fundamental concepts of design of hoists .
2. explore design of various drives for hoisting gears
3. learn about conveyer systems for material flow in different industrial production systems
4. get exposure to design of elevators for various manufacturing and service applications.
5. study integrated mechanical system design for machine tools

UNIT I INTRODUCTIONS AND DESIGN OF HOISTS **9**

Types, selection and applications, Design of hoisting elements: Welded and roller chains-Hemp and wire ropes - Design of ropes, pulleys, pulley systems, sprockets and drums, Load handling attachments. Design of forged hooks and eye hooks – crane grabs - lifting magnets –Grabbing attachments-Design of arresting gear -Brakes: shoe, band and cone types.

UNIT II DRIVES OF HOISTING GEAR **9**

Hand and power drives - Traveling gear - Rail traveling mechanism - cantilever and mono rail cranes-slewing, ji band luffing gear-cog wheel drive-selecting the motor ratings.

UNIT III CONVEYORS **9**

Types-description-design and applications of Belt conveyors, apron conveyors and escalators Pneumatic conveyors, Screw conveyors and vibratory conveyors.

UNIT IV ELEVATORS **9**

Bucket elevators: design - loading and bucket arrangements - Cage elevators - shaft way, guides, counter weights, hoisting machine, safety devices-Design of fork lift trucks.

UNIT V DYNAMICS OF ROTORS MOUNTED ON HYDRO DYNAMIC BEARINGS **9**

Integrated Design of systems - Valve Gear Mechanisms, Portable Air Compressor, Hay-Bale lifter, Cam Testing Machine, Power Screws, Gear Box Design more than six speed.

TOTAL PERIODS: 45

COURSE OUTCOMES At the end of the course, the students will be able to		**BT MAPPED** (Highest Level)
CO1	explain the fundamental concepts of design of hoists .	Understanding (K2)
CO2	design various drives for hoisting gears	Applying (K3)
CO3	describe conveyer systems for material flow in different industrial production systems	Understanding (K2)
CO4	demonstrate knowledge on design of elevators for various manufacturing applications.	Applying (K3)

CO5	integrate mechanical system design for machine tools with different components	Applying (K3)

REFERENCES

1. Alexandrov,M.,Materials Handling Equipments,MIRPublishers,1981.
2. Norton.L Robert. "Machine Design–An Integrated Approach" Pearson Education, 2nd Edition, 2005.
3. Rudenko,N, Materials handling equipment,ELnveePublishers,1970.
4. Spivakovsy, A.O.and Dyachkov,V.K., Conveying Machines, Volumes I and II, MIR Publishers,1985.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	1	2	1
CO2	3	2	3	1	2	1
CO3	3	2	3	1	2	1
CO4	3	2	3	1	2	1
CO5	3	2	3	1	2	1

PED23169	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1. gain knowledge on artificial intelligence.
2. understand the concepts of Machine Learning.
3. appreciate supervised learning and their applications.
4. learn the concepts and algorithms of unsupervised learning.
5. explore the theoretical and practical aspects of Probabilistic Graphical Models.

UNIT I ARTIFICIAL INTELLIGENCE — 9

Artificial intelligence – Basics – Goals of artificial intelligence– AI techniques–problem representation in AI – Problem reduction and solution techniques - Application of AI and KBES in Robots.

UNIT II INTRODUCTION TO MACHINE LEARNING — 9

Machine Learning–Types of Machine Learning –Machine Learning process- preliminaries, testing Machine Learning algorithms, turning data into Probabilities, and Statistics for Machine Learning- Probability theory – Probability Distributions – Decision Theory.

UNIT III SUPERVISED LEARNING — 9

Linear Models for Regression – Linear Models for Classification- Discriminant Functions, Probabilistic Generative Models, Probabilistic Discriminative Models – Decision Tree Learning – Bayesian Learning, Naïve Bayes – Ensemble Methods, Bagging, Boosting, Neural Networks, Multilayer Perceptron, Feed- forward Network, Error Back propagation - Support Vector Machines.

UNIT IV UNSUPERVISED LEARNING — 9

Clustering- K-means – EM Algorithm- Mixtures of Gaussians –Dimensionality Reduction, Linear Discriminant Analysis, Factor Analysis, Principal Components Analysis, Independent Components Analysis.

UNIT V PROBABILISTIC GRAPHICAL MODELS — 9

Graphical Models – Undirected Graphical Models – Markov Random Fields – Directed Graphical Models – Bayesian Networks – Conditional Independence properties – Markov Random Fields - Hidden Markov Models – Conditional Random Fields (CRFs).

TOTAL PERIODS: 45

COURSE OUTCOMES At the end of the course, the students will be able to		**BT MAPPED** (Highest Level)
CO1	optimize the robots using Artificial Intelligence.	Understanding (K2)
CO2	design a learning model appropriate to the application.	Applying (K3)
CO3	implement Probabilistic Discriminative and Generative algorithms for an application of your choice and analyze the results.	Understanding (K2)
CO4	use a tool to implement typical Clustering algorithms for different types of	Applying (K3)

	applications.	
CO5	identify applications suitable for different types of Machine Learning with suitable justification.	Applying (K3)

REFERENCES

1. Christopher Bishop, "Pattern Recognition and Machine Learning" Springer, 2007.
2. Stephen Marsland, "Machine Learning – An Algorithmic Perspective", Chapman and Hall, CRC Press, Second Edition, 2014.
3. Kevin P. Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press, 2012.
4. Ethem Alpaydin, "Introduction to Machine Learning", MIT Press, Third Edition, 2014.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	3	1	2	1
CO2	3	2	3	1	2	1
CO3	3	2	3	1	2	1
CO4	3	2	3	1	2	1
CO5	3	2	3	1	2	1

PED23170	INDUSTRIAL INTERNET OF THINGS	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1.	understand the fundamentals of Internet of Things
2.	learn about the basics of IOT protocols
3.	gain knowledge on bigdata analytics and software defined networks
4.	get exposed to the concept of IOT security
5.	explore Industrial IOT case studies in different domains

UNIT I	INTRODUCTION AND ARCHITECTURE OF IOT	9

Introduction – Definition and characteristics of IoT – Physical and Logical Design of IoT - Communication models and APIs – Challenges in IoT - Evolution of IoT- Components of IoT – A Simplified IoT Architecture – Core IoT Functional Stack.

UNIT II	INDUSTRIAL IOT	9

IIoT-Introduction, Industrial IoT: Business Model and Reference Architecture: IIoT-Business Models, Industrial IoT- Layers: IIoT Sensing, IIoT Processing, IIoT Communication, IIoT Networking.

UNIT III	IIOT ANALYTICS	9

Big Data Analytics and Software Defined Networks, Machine Learning and Data Science, Julia Programming, Data Management with Hadoop.

UNIT IV	IOT SECURITY	9

Industrial IoT: Security and Fog Computing - Cloud Computing in IIoT, Fog Computing in IIoT, Security in IIoT.

UNIT V	CASE STUDY	9

Industrial IOT- Application Domains: Oil, chemical and pharmaceutical industry, Applications of UAVs in Industries, Real case studies: Milk Processing and Packaging Industries, Manufacturing Industries.

	TOTAL PERIODS:	45

COURSE OUTCOMES At the end of the course, the students will be able to		BT MAPPED (Highest Level)
CO1	describe the fundamentals of Internet of Things	Understanding (K2)
CO2	apply the basics of IOT protocols	Applying (K3)
CO3	illustrate bigdata analytics and software defined networks	Understanding (K2)
CO4	implement the concepts of IOT security	Applying (K3)
CO5	investigate case studies in different domains of industrial IOT	Applying (K3)

REFERENCES

1. Industry 4.0: The Industrial Internet of Things", by Alasdair Gilchrist (Apress), 2017
2. "Industrial Internet of Things: Cyber manufacturing Systems "by Sabina Jeschke, Christian Brecher, Houbing Song, Danda B. Rawat (Springer), 2017

3. The Industrial Internet of Things (IIoT): Intelligent Analytics for Predictive Maintenance by R. Anandan, Suseendran Gopalakrishnan, Souvik Pal, Noor Zaman, Scrivener Publishing LLC, February 2022.

4. "Internet of Things", Greg Dunko, Joydeep Misra, Josh Robertson, Tom Snyder, Bridgera LLC, 2017.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	3	3	2	3	1
CO2	3	3	3	2	3	1
CO3	3	3	3	2	3	1
CO4	3	3	3	2	3	1
CO5	3	3	3	2	3	1

PMR23001	MATERIALS CHARACTERIZATION TECHNIQUES	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1.	analyze the different spectroscopic methods and fundamentals of Vibrational Spectroscopy
2.	apply the effects of X-Ray techniques and chemical analysis
3.	understand the Electron Microscopy and Transmission Electron Microscopy
4.	study the thermal analysis and learn basic theory of Instrumentation
5.	acquire knowledge on Electrical Characterization and Non-destructive testing

UNIT I SPECTROSCOPIC METHODS **9**

Atomic absorption spectrometry (AAS), Atomic fluorescence spectrometry (AFS) and Atomic emission spectrometry (AES) - Fundamentals and instrumentation, Vibrational spectroscopy - Raman and Infrared, Principles of Vibrational spectroscopy, Infrared and Raman activity, Applications.

UNIT II X-RAY TECHNIQUES **9**

X-ray diffraction- Generation and characteristics of x-ray, Lattice planes and Bragg's law, Theory of diffraction, Wide angle XRD; X-ray fluorescence spectroscopy- Fundamental principles, Chemical analysis, Wave length dispersive spectroscopy and energy dispersive spectroscopy, Applications.

UNIT III ELECTRON MICROSCOPY **9**

Scanning electron microscopy (SEM), Instrumentation, Electron beam-specimen interaction, Specimen preparation, Energy dispersive spectroscopy (EDS) in electron microscopes; Transmission electron microscopy (TEM) - Basics of TEM, Electron sources, Specimen preparation, Image modes, Image contrast, Electron diffraction, understanding diffraction pattern, High resolution TEM, FESEM.

UNIT IV THERMAL ANALYSIS **9**

Thermo gravimetric analysis (TGA), Differential thermal analysis (DTA), Differential scanning calorimetry (DSC), Dynamic mechanical analysis (DMA), Thermo-mechanical analysis (TMA) and Dynamic mechanical thermal analysis (DMTA), Basic theory, Instrumentation and applications.

UNIT V ELECTRICAL AND MAGNETIC PROPERTIES **9**

Two probe and four probe methods for electrical characterization, Vibrating sample magnetometer (VSM) for magnetic property analysis, Applications. Non-destructive testing: Radiography, Ultrasonic, Acoustic emission, Thermography, Holography, Basic principles, Applications.

TOTAL PERIODS: 45

COURSE OUTCOMES At the end of the course, the students will be able to		**BT MAPPED** (Highest Level)
CO1	learn the different spectroscopic methods and fundamentals of Vibrational Spectroscopy	Understanding (K2)
CO2	know the effects of X-Ray techniques and chemical analysis	Applying (K3)

CO3	analyze the Electron Microscopy and Transmission Electron Microscopy	Analyzing (K4)
CO4	develop the thermal analysis and learn basic theory of Instrumentation	Applying (K3)
CO5	understand Electrical Characterization and Non-destructive testing	Understanding (K2)

REFERENCES

1. S. Zhang, Lin Li, A. Kumar, Materials Characterisation Techniques, CRC press, 2008.
2. Y. Leng, Materials Characterisation: Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia), 2008.
3. R.M. Silverstein, Spectrometric identification of organic compounds, 7th ed., John Wiley and Sons, 2007.
4. B. Raj, T. Jayakumar, M. Thavasimuthu, Practical Non-Destructive Testing, 2nd ed., Narosa Publishing House, 2002.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	-	-	-
CO2	3	2	3	-	-	-
CO3	3	1	3	-	-	-
CO4	3	2	2	-	-	-
CO5	3	2	3	-	-	-

PMR23002	COMPOSITE MATERIALS AND TESTING	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1. learn the types of composites, FRP and Particulate composites
2. acquire knowledge on types of Reinforcement and fibres
3. understand the characteristics of Metal Matrix Composites
4. study the Ceramic Metal Matrix, properties and various types of CMC
5. demonstrate the different types of testing of composites, Electrical and Thermal conductivity test

UNIT I TYPES OF COMPOSITES 9

Fundamentals of composites - need for composites -Types, Polymer matrix composites (PMC), Carbon matrix Composites or Carbon-Carbon Composites, Metal matrix composites (MMC), Ceramic matrix composites (CMC). Fiber Reinforced Composites, Fiber Reinforced Polymer (FRP) Composites, Particulate Composites. Applications of various types of composites.

UNIT II TYPES OF REINFORCEMENTS/FIBERS 9

Role and Selection of reinforcement materials.Types of fibres: Glass fibers, Carbon fibers, Aramid fibers, Metal fibers, Alumina fibers, Boron Fibers, Silicon carbide fibers, Quartz and Silica fibers, Multiphase fibers, Whiskers, Flakes.

UNIT III METAL MATRIX COMPOSITES 9

Characteristics of MMC, Various types of Metal matrix composites Alloy vs. MMC, Advantages of MMC, Limitations of MMC, Metal Matrix, Processing of MMC – Powder metallurgy process - diffusion bonding – stir casting – squeeze casting.

UNIT IV CERAMIC MATRIX COMPOSITES 9

Engineering ceramic materials – properties – advantages – limitations – Monolithic ceramics - Need for CMC – Ceramic matrix - Various types of Ceramic Matrix composites- oxide ceramics – non oxide ceramics – aluminium oxide – silicon nitride –Sintering - Hot pressing – Cold isostatic pressing (CIPing) – Hot isostatic pressing (HIPing).

UNIT V TESTING OF COMPOSITES 9

Mechanical testing of composites: tensile, compressive, Flexural, Impact and Hardness, electrical conductivity test, Thermal properties tests: Coefficient of Thermal Expansion and Thermal-Conductivity - Tensile hole testing, high temperature testing and wear test.

TOTAL PERIODS: 45

COURSE OUTCOMES At the end of the course, the students will be able to		**BT MAPPED** (Highest Level)
CO1	understand the the types of composites, FRP and Particulate composites	Understanding (K2)
CO2	know the types of Reinforcement and fibres	Applying (K3)
CO3	analyze the characteristics of Metal Matrix Composites	Analyzing (K4)

CO4	learn the Ceramic Metal Matrix, properties and various types of CMC	Applying (K3)
CO5	do the different types of testing of composites, Electrical and Thermal conductivity test	Applying (K3)

REFERENCES

1. Mechanical Metallurgy, G. Dieter, 3rd Edition, McGraw Hill, 1986.
2. Engineering Mechanics and Composite Materials, Isaac M Daniels and Ori Ishai, Second Edition, Oxford University Press, 2005
3. Engineering Materials: Polymers, Ceramics and Composites, Second Edition, A.K.Bhargava, Prentice Hall India, 2012.
4. Materials characterization, Vol. 10, ASM hand book, 2019.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:

(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	-	2	2
CO2	3	2	3	-	1	1
CO3	3	1	3	3	2	2
CO4	3	2	2	2	3	3
CO5	3	2	3	-	2	2

PMR23003	SOFT COMPUTING	3	0	0	3

COURSE OBJECTIVES

To enable the students to

1.	classify the various soft computing frame works
2.	familiarize with the design of neural networks, fuzzy logic and fuzzy systems
3.	learn mathematical background for optimized genetic programming
4.	get exposed to neuro-fuzzy hybrid systems and its applications
5.	understand various hybrid soft computing techniques and apply in real time problems

UNIT I	INTRODUCTION TO SOFT COMPUTING	9

Soft Computing Constituents-From Conventional AI to Computational Intelligence- Artificial neural network: Introduction, characteristics- learning methods – taxonomy – Evolution of neural networks - basic models - important technologies - applications. Fuzzy logic: Introduction - crisp sets- fuzzy sets - crisp relations and fuzzy relations: cartesian product of relation - classical relation, fuzzy relations, tolerance and equivalence relations, non-iterative fuzzy sets. Genetic algorithm Introduction - biological background - traditional optimization and search techniques - Genetic basic concepts.

UNIT II	NEURAL NETWORKS	9

Supervised learning network: perceptron networks - adaptive linear neuron, multiple adaptive linear neuron, BPN, RBF, associative memory network: auto-associative memory network, hetero-associative memory network, BAM, hopfield networks, unsupervised learning networks: Kohonen self-organizing feature maps, LVQ – CP networks.

UNIT III	FUZZY LOGIC	9

Membership functions: features, fuzzification, methods of membership value assignments Defuzzification: lambda cuts - methods - fuzzy arithmetic and fuzzy measures: fuzzy arithmetic - extension principle - fuzzy measures - measures of fuzziness -fuzzy integrals - fuzzy rule base and approximate reasoning : truth values and tables, fuzzy propositions, formation of rules decomposition of rules, aggregation of fuzzy rules, fuzzy reasoning-fuzzy inference systems overview of fuzzy expert system-fuzzy decision making.

UNIT IV	GENETIC ALGORITHM	9

Genetic algorithm- Introduction - biological background - traditional optimization and search techniques - Genetic basic concepts - operators – Encoding scheme – Fitness evaluation – crossover - mutation - genetic programming – multilevel optimization – real life problem- advances in GA .

UNIT V	HYBRID SOFT COMPUTING TECHNIQUES AND APPLICATIONS	9

Neuro-fuzzy hybrid systems - genetic neuro hybrid systems - genetic fuzzy hybrid and fuzzy genetic hybrid systems - Applications: optimization of traveling salesman problem using genetic algorithm approach, hybrid systems in image processing, soft computing based hybrid fuzzy controllers.

	TOTAL PERIODS:	45

COURSE OUTCOMES At the end of the course, the students will be able to		BT MAPPED (Highest Level)
CO1	apply various soft computing concepts for practical applications	Applying (K3)
CO2	choose and design suitable neural network for real time problems	Applying (K3)
CO3	use fuzzy rules and reasoning to develop decision making and expert system	Understanding (K2)
CO4	explain the importance of optimization techniques and genetic programming	Applying (K3)
CO5	review the various hybrid soft computing techniques and apply in real time problems	Applying (K3)

REFERENCES

1. J.S.R.Jang, C.T. Sun and E.Mizutani, "Neuro-Fuzzy and Soft Computing", PHI / Pearson Education 2004.
2. S.N.Sivanandam and S.N.Deepa, "Principles of Soft Computing", Wiley India Pvt Ltd, 2011.
3. George J. Klir, Ute St. Clair, Bo Yuan, "Fuzzy Set Theory: Foundations and Applications" Prentice Hall, 1997.
4. David E. Goldberg, "Genetic Algorithm in Search Optimization and Machine Learning" Pearson Education India, 2013.

CO - PO MAPPING

Mapping of Course Outcomes with Programme Outcomes:
(1/2/3 indicates strength of correlation) 3-Strong, 2-Medium , 1-Weak

COs	Programme Outcomes(POs)					
	PO1	PO2	PO3	PO4	PO5	PO6
CO1	3	2	2	2	2	2
CO2	3	2	3	1	3	1
CO3	3	1	3	2	2	2
CO4	3	2	2	2	3	3
CO5	3	2	3	1	2	2