

ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
CHOICE BASED CREDIT SYSTEM
REGULATIONS – 2023

M.E. PRODUCT DESIGN AND DEVELOPMENT
(FULL – TIME & PART TIME MODE)

VISION OF THE DEPARTMENT

Department of Mechanical Engineering strives to be recognized globally for excelling in Engineering education and research leading to innovative, entrepreneurial and competent Graduates in Mechanical Engineering and allied disciplines.

MISSION OF THE DEPARTMENT

Department of Mechanical Engineering shall contribute to the educational, economic and social development by:

- Providing world class education by fostering effective teaching learning process that is supported through pioneering and cutting-edge research to make impactful contribution to the society.
- Attracting highly motivated students with enthusiasm, aptitude, and interest in the field of Mechanical and allied Engineering disciplines.
- Expanding the frontiers of Engineering and science in technological innovation while ensuring academic excellence and scholarly learning in a collegial environment.
- Excelling in industrial consultancy and research leading to innovative technology development and transfer.
- Serving the society with innovative and entrepreneurially competent graduates for the national and international community towards achieving the sustainable development goals.

Program Educational Objectives (PEOs)

The following are the Program Educational Objectives of Product Design & Development:

- **PEO 1:** Achieve success in careers that deal with the design, simulation and analysis of engineering systems, experimentation and testing, manufacturing, technical services, and research.
- **PEO 2:** Communicate effectively with peers, and updating and adapting their core knowledge and abilities to ethically compete in the ever changing multicultural global enterprise.
- **PEO 3:** Conduct multi-disciplinary research and development (via graduate study or industry) resulting in tangible applications that advance technology and foster innovation in order to compete successfully in the global economy.
- **PEO 4:** Exchange and apply knowledge to create new opportunities that advance our society and proactively address through team efforts to solve a variety of technical, environmental and societal problems.
- **PEO 5:** Actively embrace impactful leadership roles in the practice of Product Design & Development in industry and government organizations (including both traditional and emerging technical areas) as well as public service organizations.

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Program Outcomes (POs)

The following are the Program Outcomes of Product Design & Development. The Graduate of Product Design & Development will be able to:

- **PO 1:** An ability to independently carry out research/investigation and development work to solve practical problems.
- **PO 2:** An ability to write and present a substantial technical report/document.
- **PO 3:** An ability to demonstrate a degree of mastery in product design & development to meet societal and industrial needs (mastery should be at a level higher than the requirements in the appropriate bachelor programme).
- **PO 4:** An ability to design solutions for complex product design and development problems or processes that meet the specified needs with appropriate consideration for the public safety along with cultural, societal, and environmental considerations.
- **PO 5:** An ability to utilize modern tool to create, select, and apply appropriate techniques, resources, and modern engineering toward successful product design and development.
- **PO 6:** An ability to understand ethical and professional responsibility in product design and development for self-education and ability for life-long learning.

Mapping of PEO with PO & PSO:

PEO	PO					
	1	2	3	4	5	6
1	3	3	3	2	2	2
2	3	3	3	2	3	2
3	2	2	2	2	2	2
4	2	2	2	2	2	2
5	1	1	1	1	1	1

Program Articulation Matrix (Full Time):

Year	Sem.	Courses	PO						
			1	2	3	4	5	6	
I	I	Advanced Numerical Methods	2		1	1	2	2	
		Research Methodology and IPR							
		Integrated Product Design and Development	3	3	3	3	2	3	
		Reverse Engineering	2	1	3	3	3	3	
		Product Lifecycle Management	2	1	2	2	3	3	
		Design and Analysis of Advanced Mechanisms	2		3	2.4	1	1.6	
		Design Practice with CAD Tools Laboratory	1	3	2	3	3	3	
		Multi body Dynamics Laboratory	3	2	3	3	2	1	
	II	I	Creativity and Innovation Management	3	1	2	2	1	2
			Finite Element Methods in Mechanical Design	3		3	2.8	1	1
		II	Additive Manufacturing for Product Development	2.6	2.4	2.4	2.2	2.6	2.4
			Professional Elective – I						
			Professional Elective – II						
			Professional Elective – III						
			Finite Element Modelling and Simulation Laboratory	3	2	3	3	2	1
			Product Design Studio	3	3	3	3	3	3
			Internship / Industrial Training	3	3	3	3	3	3
II	III	Professional Elective – IV							
		Professional Elective – V							
		Professional Elective – VI							

		Project Work – I	3	3	3	3	2	3
	IV	Project Work – II	3	3	3	3	2	3
PEC		Computer Graphics	3		3	3	2	1
		Design for Sustainability	3		3	2	2	3
		Design of Hybrid and Electric Vehicles	2		3	1	3	2
		Design of Hydraulic and Pneumatic Systems	3		3	2	2	1
		Design with Advanced Materials	3		3	1	2	2
		Engineering Fracture Mechanics	3		3	2	1	1
		Optimization Techniques in Design	3		3	3	2	3
		Surface Engineering	3		3	2	2	2
		Vehicles Dynamics	2		3	2	2	1
		Vibration Analysis and Control	3		3	2	2	1
		Computational Fluid Dynamics for Mobility Systems	3	1.4			3	1.2
		Product Design for Manufacturing	3	2	3	3	2	2
		Automated Product Manufacturing Systems	3	2	3	3	2	2
		Human Factors Engineering in Product Design	2	2	3	3	1	3
		Intellectual Property Rights in Product Design	2	3	3	2	1	3
		Metals and Non-Metals for Product Design	3	2	3	3	3	3
		Quality and Financial Concepts in Product Development	2	2	3	2	1	3
		Tool Design for Products	3	1	3	3	2	2



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REGULATIONS - 2023
CHOICE BASED CREDIT SYSTEM
M.E. PRODUCT DESIGN AND DEVELOPMENT (FULL-TIME MODE)
I TO IV SEMESTER CURRICULUM AND SYLLABI
SEMESTER I

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	MA3155	Advanced Numerical Methods	FC	4	0	0	4	4
2.	PD3151	Integrated Product Design and Development	PCC	3	0	0	3	3
3.	PD3101	Reverse Engineering	PCC	2	0	2	4	3
4.	PD3152	Product Lifecycle Management	PCC	2	0	2	4	3
5.	ED3152	Design and Analysis of Advanced Mechanisms	PCC	3	0	0	3	3
6.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3
PRACTICAL								
7.	ED3161	Design Practice with CAD Tools Laboratory	PCC	0	0	4	4	2
8.	ED3162	Multi Body Dynamics Laboratory	PCC	0	0	4	4	2
TOTAL				16	1	12	29	23

SEMESTER – II

SL. NO.	Course Code	Course Title	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
Theory								
1.	PD3251	Creativity and Innovation Management	PCC	3	0	0	3	3
2.	ED3251	Finite Element Methods in Mechanical Design	PCC	3	0	0	3	3
3.	PD3201	Additive Manufacturing for Product Development	PCC	2	0	2	4	3
4.		Professional Elective – I	PEC	3	0	0	3	3
5.		Professional Elective – II	PEC	3	0	0	3	3
6.		Professional Elective – III	PEC	3	0	0	3	3
Practical								
7.	ED3261	Finite Element Modelling and Simulation Laboratory	PCC	0	0	4	4	2
8.	PD3211	Product Design Studio	PCC	0	0	4	4	2
9.	PD3212	Internship / Industrial Training	ECC	-	-	-	-	2
TOTAL				17	0	10	27	24

SEMESTER – III

SL. NO.	Course Code	Course Title	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
Theory								
1.		Professional Elective – IV	PEC	3	0	0	3	3
2.		Professional Elective – V	PEC	3	0	0	3	3
3.		Professional Elective – VI	PEC	3	0	0	3	3
Practical								
4.	PD3311	Project Work – I	EEC	0	0	12	12	6
Total				9	0	12	21	15

SEMESTER – IV

SL. NO.	Course Code	Course Title	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
Practical								
1.	PD3411	Project Work – II	EEC	0	0	24	24	12
Total				0	0	24	24	12

Total No. of Credits: 74

ANNA UNIVERSITY, CHENNAI
UNIVERSITY DEPARTMENTS
REGULATIONS - 2023
CHOICE BASED CREDIT SYSTEM
M.E. PRODUCT DESIGN AND DEVELOPMENT (PART – TIME MODE)
I TO VI SEMESTER CURRICULUM AND SYLLABI
SEMESTER – I

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
Theory								
1.	MA3155	Advanced Numerical Methods	FC	4	0	0	4	4
2.	RM3151	Research Methodology and IPR	MC	2	1	0	3	3
3.	PD3151	Integrated Product Design and Development	PCC	3	0	0	3	3
Practical								
4.	ED3161	Design Practice with CAD Tools Laboratory	PCC	0	0	4	4	2
TOTAL				9	1	4	14	12

SEMESTER – II

L. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
Theory								
1.	PD3251	Creativity and Innovation Management	PCC	3	0	0	3	3
2.	ED3251	Finite Element Methods in Mechanical Design	PCC	3	0	0	3	3
3.	PD3201	Additive Manufacturing for Product Development	PCC	2	0	2	4	3
Practical								
4.	ED3261	Finite Element Modelling and Simulation Laboratory	PCC	0	0	4	4	2
TOTAL				8	0	6	14	11

SEMESTER – III

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
Theory								
1.	PD3101	Reverse Engineering	PCC	2	0	2	4	3
2.	PD3152	Product Lifecycle Management	PCC	2	0	2	4	3
3.	ED3152	Design and Analysis of Advanced Mechanisms	PCC	3	0	0	3	3
Practical								
4.	ED3162	Multi Body Dynamics Laboratory	PCC	0	0	4	4	2
TOTAL				7	0	8	15	11

SEMESTER – IV

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
Theory								
1.		Professional Elective – I	PEC	3	0	0	3	3
2.		Professional Elective – II	PEC	3	0	0	3	3
3.		Professional Elective – III	PEC	3	0	0	3	3
Practical								
4.	PD3211	Product Design Studio	PCC	0	0	4	4	2
TOTAL				9	0	4	13	11

SEMESTER – V

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
Theory								
1.		Professional Elective – IV	PEC	3	0	0	3	3
2.		Professional Elective – V	PEC	3	0	0	3	3
3.		Professional Elective - VI	PEC	3	0	0	3	3
Practical								
4.	PD3311	Project Work – I	EEC	0	0	12	12	6
TOTAL				9	0	12	21	15

SEMESTER – VI

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
Practical								
1.	PD3411	Project Work – II	EEC	0	0	24	24	12
TOTAL				0	0	24	24	12

Total No. of Credits: 72

FOUNDATION COURSE (FC)

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MA3155	Advanced Numerical Methods	FC	4	0	0	4	4

MANDATORY COURSE (MC)

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	RM3151	Research Methodology and IPR	RMC	2	1	0	3	3

PROGRAM CORE COURSES (PCC)

S. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	PD3151	Integrated Product Design and Development	PCC	3	0	0	3	3
2.	PD3101	Reverse Engineering	PCC	2	0	2	4	3
3.	PD3152	Product Lifecycle Management	PCC	2	0	2	4	3
4.	ED3152	Design and Analysis of Advanced Mechanisms	PCC	3	0	0	3	3
5.	PD3251	Creativity and Innovation Management	PCC	3	0	0	3	3
6.	ED3251	Finite Element Methods in Mechanical Design	PCC	3	0	0	3	3
7.	PD3201	Additive Manufacturing for Product Development	PCC	2	0	2	4	3
8.	ED3161	Design Practice with CAD Tools Laboratory	PCC	0	0	4	4	2
9.	ED3162	Multi-body Dynamics Laboratory	PCC	0	0	4	4	2
10.	ED3261	Finite Element Modelling and Simulation Laboratory	PCC	0	0	4	4	2
11.	PD3211	Product Design Studio	PCC	0	0	4	4	2

PROFESSIONAL ELECTIVE COURSES (PEC)

S. No.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	ED3051	Computer Graphics	PEC	3	0	0	3	3
2.	ED3053	Design for Sustainability	PEC	3	0	0	3	3
3.	ED3057	Design of Hybrid and Electric Vehicles	PEC	3	0	0	3	3
4.	ED3055	Design of Hydraulic and Pneumatic Systems	PEC	3	0	0	3	3
5.	ED3151	Design with Advanced Materials	PEC	3	0	0	3	3
6.	ED3253	Engineering Fracture Mechanics	PEC	3	0	0	3	3
7.	ED3054	Optimization Techniques in Design	PEC	3	0	0	3	3
8.	ED3056	Surface Engineering	PEC	3	0	0	3	3

9	ED3058	Vehicle Dynamics	PEC	3	0	0	3	3
10.	ED3252	Vibration Analysis and Control	PEC	2	0	2	4	3
11.	IC3253	Computational Fluid Dynamics for Mobility Systems	PEC	2	0	2	4	3
12.	MS3052	Product Design for Manufacturing	PEC	3	0	0	3	3
13.	PD3001	Automated Product Manufacturing Systems	PEC	3	0	0	3	3
14.	PD3002	Human Factors Engineering in Product Design	PEC	3	0	0	3	3
15.	PD3003	Intellectual Property Rights in Product Design	PEC	3	0	0	3	3
16.	PD3004	Metals and Non-Metals for Product Design	PEC	3	0	0	3	3
17.	PD3005	Quality and Financial Concepts in Product Development	PEC	3	0	0	3	3
18.	PD3006	Tool Design for Products	PEC	3	0	0	3	3

EMPLOYABILITY ENHANCEMENT COURSES (EEC)

S. No.	Course Code	Course Title	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	PD3212	Internship / Industrial Training (Full Time only)	EEC	-	-	-	-	2
2.	PD3311	Project Work – I	EEC	0	0	12	12	6
3.	PD3411	Project Work – II	EEC	0	0	24	24	12

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OBJECTIVES:

- To impart knowledge in understanding the advantages of various solution procedures of solving the system of linear and nonlinear equations.
- To give a clear picture about the solution methods for solving the BVPs and the system of IVPs.
- To acquire knowledge in solving time dependent one and two dimensional parabolic PDEs by using various methodologies.
- To strengthen the knowledge of finite difference methods for solving elliptic equations.
- To get exposed to the ideas of solving PDEs by finite element method.

UNIT I ALGEBRAIC EQUATIONS 12

Systems of linear equations: Gauss Elimination method, pivoting techniques, Thomas algorithm for tridiagonal system – Jacobi, Gauss Seidel, SOR iteration methods - Systems of nonlinear equations: Fixed point iterations, Newton Method, Eigenvalue problems: power method, Faddeev – Leverrier Method.

UNIT II ORDINARY DIFFERENTIAL EQUATIONS 12

Runge Kutta Methods for system of IVPs, numerical stability, Adams-Bashforth multistep method, solution of stiff ODEs, shooting method, BVP: Finite difference method, collocation method, orthogonal collocation method, Galerkin finite element method.

UNIT III FINITE DIFFERENCE METHOD FOR TIME DEPENDENT PARTIAL DIFFERENTIAL EQUATION 12

Parabolic equations: explicit and implicit finite difference methods, weighted average approximation - Dirichlet and Neumann conditions – Two dimensional parabolic equations – ADI method; First order hyperbolic equations – method of characteristics, Lax - Wendroff explicit and implicit methods; numerical stability analysis, method of lines – Wave equation: Explicit scheme-Stability of above schemes.

UNIT IV FINITE DIFFERENCE METHODS FOR ELLIPTIC EQUATIONS 12

Laplace and Poisson's equations in a rectangular region: Five point finite difference schemes, Leibmann's iterative methods, Dirichlet and Neumann conditions – Laplace equation in polar coordinates: finite difference schemes – approximation of derivatives near a curved boundary while using a square mesh.

UNIT V FINITE ELEMENT METHOD 12

Partial differential equations – Finite element method - collocation method, orthogonal collocation method, Galerkin finite element method.

TOTAL: 60 PERIODS**OUTCOMES:**

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

CO1 Get familiarized with the methods which are required for solving system of linear, nonlinear equations and

eigenvalue problems.

CO2 Solve the BVPs and the system of IVPs by appropriate methods discussed.

CO3 Solve time dependent parabolic PDEs by using various methodologies up to dimension two.

CO4 Solve elliptic equations by finite difference methods.

CO5 Use the ideas of solving PDEs by finite element method.

REFERENCES:

1. Burden, R.L., and Faires, J.D., "Numerical Analysis – Theory and Applications", Cengage Learning, India Edition, New Delhi, 2010.
2. Gupta S.K., "Numerical Methods for Engineers", New Age Publishers, 3rd Edition, New Delhi, 2015.
3. Jain M. K., Iyengar S. R. K., Jain R.K., "Computational Methods for Partial Differential Equations", New Age Publishers, 2nd Edition, New Delhi, 2016.
4. Morton K.W. and Mayers D.F., "Numerical solution of partial differential equations", Cambridge University press, Cambridge, 2005.
5. Sastry S.S., "Introductory Methods of Numerical Analysis", Prentice - Hall of India Pvt. Limited, 5th Edition, New Delhi, 2012.
6. Saumyen Guha and Rajesh Srivastava, "Numerical methods for Engineering and Science", Oxford Higher Education, New Delhi, 2010.

CO-PO Mapping:

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



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PD3151

INTEGRATED PRODUCT DESIGN AND DEVELOPMENT

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COURSE OBJECTIVES: To understand and apply the principles and concepts in Integrated Product Design and Development.

UNIT I INTRODUCTION TO PRODUCT DEVELOPMENT 9

Introduction – Characteristics of Successful Product Development – Product Development Team – Challenges of Product Development – Duration and Cost of Product Development – Product Development Process – Concept Development: The Front-End Process – Adapting the Generic Product Development Process – Product Development Process Flows – Product Development Organizations – Tournament Structure of Opportunity Identification – Opportunity Identification Process.

UNIT II PRODUCT PLANNING, CUSTOMER NEEDS IDENTIFICATION AND PRODUCT SPECIFICATION 9

Product Planning Process – Identifying Customer Needs – Importance of Latent Needs – Process of Identifying Customer Needs – Definition of Specifications – Time to Establish Specification – Establishing Target Specifications – Setting the Final Specifications.

UNIT III PRODUCT CONCEPT GENERATION, SELECTION AND TESTING 9

Activity of Concept Generation – Concept Selection – Concept Screening – Concept Scoring – Caveats – Concept Testing.

UNIT IV PRODUCT ARCHITECTURE, INDUSTRIAL DESIGN, DESIGN FOR MANUFACTURING 9

Product Architecture – Definition – Implications – Establishing the Architecture – Delayed Differentiation – Platform Planning – Related System-Level Design Issues – Industrial Design – Assessing the Need for Industrial Design – Impact of Industrial Design – Industrial Design Process – Management of the Industrial Design Process – Assessing the Quality of Industrial Design – Design for Manufacturing – DFM Process.

UNIT V PROTOTYPING, PRODUCT DEVELOPMENT ECONOMICS AND MANAGEMENT 9

Prototyping – Principles, Technologies & Planning – Product Development Economics – Elements of Economic Analysis – Economic Analysis Process – Managing Projects – Understanding and Representing Tasks – Baseline Project Planning - Accelerating Projects – Project Execution – Postmortem Project Evaluation.

TOTAL: 45 PERIODS

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

- CO1** Apply the principles of concept development process and opportunity identification process.
- CO2** Apply the principle of product planning; customer needs analysis and set product specifications for new product design and development.
- CO3** Generate, select, screen, test concepts for new product design and development.
- CO4** Apply the principles of product architecture, industrial design and design for manufacturing in new product development.
- CO5** Apply the principles of prototyping techniques. Apply the concepts of economics principles; project management practices in accelerating the new product development activity.

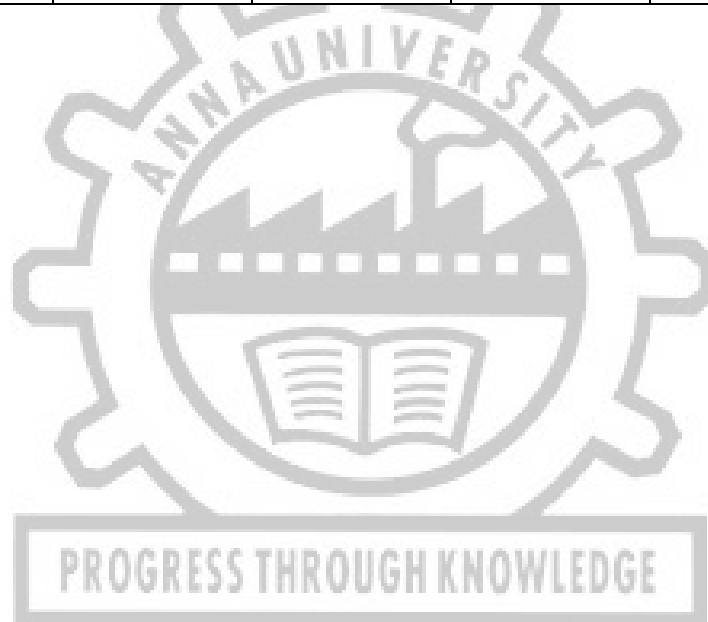
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REFERENCE BOOKS:

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". DRMAssociates, 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
5. Stuart Pugh, "Total Design – Integrated Methods for successful Product Engineering", Addison Wesley Publishing, Newyork, NY, 1991.

CO	PO					
	1	2	3	4	5	6
1	3	3	3	3	2	3
2	3	3	3	3	2	3
3	3	3	3	3	2	3
4	3	3	3	3	2	3
5	3	3	3	3	2	3
Avg.	3	3	3	3	2	3



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COURSE OBJECTIVES: To understand and apply the principles and concepts in Reverse Engineering for Product Design and Development.

UNIT I INTRODUCTION TO REVERSE ENGINEERING 6

Introduction to Reverse Engineering – The Generic Process – Phase 1: Scanning: Contact Scanners and Noncontact Scanners – Phase 2: Point Processing – Phase 3: Application Geometric Model Development – Computer-aided Reverse Engineering – Computer Vision and Reverse Engineering – Structured-light Range Imaging – Scanner Pipeline.

UNIT II REVERSE ENGINEERING HARDWARE & SOFTWARE 6

Reverse Engineering Hardware – Contact Methods – Noncontact Methods – Destructive Method – Reverse Engineering Software – Reverse Engineering Software Classification – Reverse Engineering Phases – Fundamental Reverse Engineering Operations.

UNIT III SELECTION OF A REVERSE ENGINEERING SYSTEM 6

The Selection Process – Point Capture Devices – Triangulation Approaches – Time-of-flight or Ranging Systems – Structured-light and Stereoscopic Imaging Systems – Issues with Light-based Approaches - Tracking Systems – Internal Measurement Systems – Destructive Systems – Some Comments on Accuracy – Positioning the Probe – Post processing the Captured Data – Handling Data Points – Curve and Surface Creation – Inspection Applications – Manufacturing Approaches.

UNIT IV REVERSE ENGINEERING & SOLID FREE-FROM MANUFACTURING 6

Introduction to Rapid Prototyping (Solid Freeform Manufacturing) – Brief on Current Techniques, Materials & Applications – Modeling Cloud Data in Reverse Engineering – Data Processing for Rapid Prototyping – Integration of RE and RP (SFM) for Layer-based Model Generation – Adaptive Slicing Approach for Cloud Data Modeling – Planar Polygon Curve Construction for a Layer – Determination of Adaptive Layer Thickness.

UNIT V REVERSE ENGINEERING APPLICATIONS & LEGAL ASPECTS 6

Reverse Engineering Applications in – Automotive Industry – Aerospace Industry – Medical Device Industry – Legal Aspects of Reverse Engineering.

Laboratory Experiments 30

List of Experiments

1. Surface measurement – CMM.
2. 3D Laser scanning of components.
3. Reverse engineering of Automotive components-cam shaft.
4. Reverse engineering of dental components - Bio medical applications.

TOTAL:60 PERIODS

COURSE OUTCOMES:

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

- CO1** Apply the fundamental concepts and principles of reverse engineering for product design and development.
- CO2** Apply the principles of hardware and software in reverse engineering for product design and development.
- CO3** Select the appropriate reverse engineering system for product design and development.
- CO4** Apply the relations between rapid prototyping (solid free-form manufacturing) and reverse engineering for product design and development.
- CO5** Apply reverse engineering principles in various fields of engineering along with the various legal aspect and in product design and development

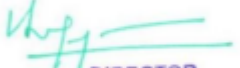
REFERENCES:

1. Vinesh Raj and Kiran Fernandes, "Reverse Engineering: An Industrial Perspective", Springer-Verlag London Limited 2008.
2. Wego Wang, Reverse Engineering Technology of Reinvention, CRC Press, 2011.
3. Kathryn, A. Ingle, "Reverse Engineering", McGraw-Hill, 1994.
4. Linda Wills, "Reverse Engineering", Kluwer Academic Publishers, 1996.
5. Donald R. Honsa, "Co-ordinate Measurement and Reverse Engineering", American Gear Manufacturers Association.

CO	PO					
	1	2	3	4	5	6
1	2	1	3	3	3	3
2	2	1	3	3	3	3
3	2	1	3	3	3	3
4	2	1	3	3	3	3
5	2	1	3	3	3	3
Avg.	2	1	3	3	3	3



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COURSE OBJECTIVES: To understand and apply the principles and concepts in Product Life-Cycle Management for Product Design and Development.

UNIT I INTRODUCTION TO PLM 6

Definition of PLM; PLM Initiative; PLM Paradigm – P, L and M of PLM – Scope of PLM – PLM Paradigm – Benefits of PLM – Spread of PLM – Overcoming Problems & Enabling Opportunities – PLM Environment – Issues in the Traditional Environment – Product Data Issues – A Complex, Changing Environment – Example from “Before PLM” – Product Pains: Aerospace Products; Power Plants; Automotive Products – Product Opportunities.

UNIT II PLM ENVIRONMENT: BUSINESS PROCESS 6

Business Processes in the PLM Environment – Relevance of Business Processes in PLM – Definitions & Introductions for Business Process – Business Process Reality in a Typical Company – Business Process Activities in the PLM Initiative – Learning from Experience with Business Process.

UNIT III PLM ENVIRONMENT: PRODUCT DATA 6

Product Data in the PLM Environment – Relevance of Product Data in PLM – Product Data Reality in a Typical Company – Product Data Activities in the PLM Initiative – Learning from Experience with Product Data.

UNIT IV PLM ENVIRONMENT: INFORMATION SYSTEMS 6

Information Systems in the PLM Environment – Relevance of Information Systems Applications in PLM – PLM Applications in the Product Lifecycle – Generic and Specific PLM Applications – PDM System: A Special Application – Importance of the PDM System in PLM – Reality in a Typical Company – Application Activities in the PLM Initiative – Best Practice PDM System Selection – Learning from Experience with Information Systems.

UNIT V PLM ENVIRONMENT: PROJECT MANAGEMENT 6

Project/Program Management in the PLM Environment – Skills and Relevance – Definitions and Introduction with Project Management – Project Management Reality in a Typical Company – Project Management Activities in the PLM Initiative – Learning from Experience with Project Management.

Laboratory Experiments 30

List of Experiments:

1. Getting Started with PLM software’s Engineering BOM
2. Working with CAD Parts
3. Creating and Attaching Specifications
4. Creating Engineering Bill of Materials
5. Releasing Parts Using the ECM Process
6. Use Matrix Query Language (MQL) to fetch the info from Database (DB) and test queries on PLM.

TOTAL: 60 PERIODS

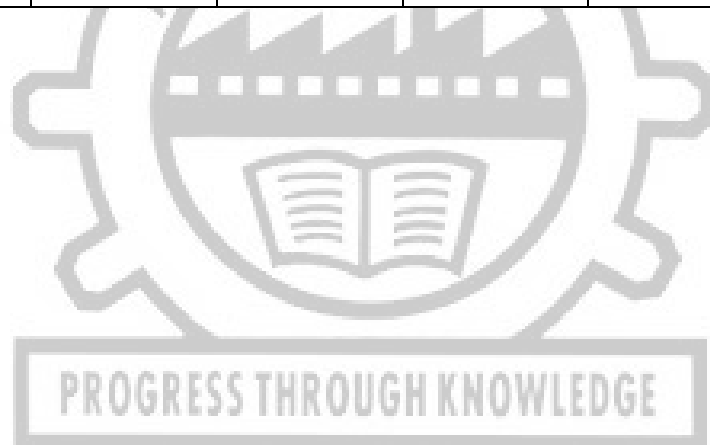
COURSE OUTCOMES: Upon completion of this course, the students will be able to:

- CO1** Apply the fundamental concepts and principles behind PLM in Product Design & Development.
- CO2** Apply the business process concept of PLM in Product Design & Development.
- CO3** Apply the product data concept of PLM in Product Design & Development.
- CO4** Apply the information systems concept of PLM in Product Design & Development.
- CO5** Apply the project management concept of PLM in Product Design & Development.

REFERENCES:

1. John Stark, "Product Lifecycle Management: 21st Century Paradigm for Product Realisation", Springer Publisher, 2011 (2nd Edition).
2. John Stark, "Global Product: Strategy, Product Lifecycle Management and the Billion Customer Question", Springer Publisher, 2007.
3. Antti Saaksvuori and AnselmiImmonen, "Product Lifecycle Management, Springer Publisher, 3rd Ed., 2008.
4. Michael Grieves, "Product Life Cycle Management", Tata McGraw Hill, 2006.
5. IvicaCrnkovic, Ulf Asklund and Annita Persson Dahlqvist, "Implementing and Integrating Product Data Management and Software Configuration Management", Artech House Publishers, 2003.

CO	PO					
	1	2	3	4	5	6
1	2	1	2	2	3	3
2	2	1	2	2	3	3
3	2	1	2	2	3	3
4	2	1	2	2	3	3
5	2	1	2	2	3	3
Avg.	2	1	2	2	3	3



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COURSE OBJECTIVES: The main learning objective of this course is to prepare the students for acquiring the knowledge on various mechanisms and its design and simulation.

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 AND CAM MECHANISMS 9

Cognate Linkages-parallel motion Linkages. Design of six bar mechanisms-single dwell-double dwell-double stroke. Geared five bar mechanism-multi-dwell. Cam Mechanisms- determination of optimum size of cams. Mechanism defects.

TOTAL:45 PERIODS

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

- CO1** Apply concepts of gross motion capability and develop multi loop kinematic chains and equivalent mechanisms
- CO2** Determine velocity and acceleration of complex mechanisms
- CO3** Evaluate inflection points and draw the inflection circle
- CO4** Synthesize planar mechanisms
- CO5** Design of six bar coupler driven mechanisms and cam mechanisms

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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. Sandor G.N., and Erdman A.G., "Advanced Mechanism Design Analysis and Synthesis", Prentice Hall, 1984.
5. Uicker, J.J., Pennock, G. R. and Shigley, J.E., "Theory of Machines and Mechanisms", Oxford University Press, 2017.

CO	PO					
	1	2	3	4	5	6
1	2		3	2	1	2
2	2		3	3	1	2
3	2		3	2	1	1
4	2		3	3	1	2
5	2		3	2	1	1
Avg.	2		3	2.4	1	1.6



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OBJECTIVES:

To impart knowledge on

- Formulation of research problems, design of experiment, collection of data, interpretation and presentation of result
- Intellectual property rights, patenting and licensing

UNIT I RESEARCH PROBLEM FORMULATION 9

Objectives of research, types of research, research process, approaches to research; conducting literature review- information sources, information retrieval, tools for identifying literature, Indexing and abstracting services, Citation indexes, summarizing the review, critical review, identifying research gap, conceptualizing and hypothesizing the research gap

UNIT II RESEARCH DESIGN AND DATA COLLECTION 9

Statistical design of experiments- types and principles; data types & classification; data collection - methods and tools

UNIT III DATA ANALYSIS, INTERPRETATION AND REPORTING 9

Sampling, sampling error, measures of central tendency and variation,; test of hypothesis- concepts; data presentation- types of tables and illustrations; guidelines for writing the abstract, introduction, methodology, results and discussion, conclusion sections of a manuscript; guidelines for writing thesis, research proposal; References – Styles and methods, Citation and listing system of documents; plagiarism, ethical considerations in research

UNIT IV INTELLECTUAL PROPERTY RIGHTS 9

Concept of IPR, types of IPR – Patent, Designs, Trademarks and Trade secrets, Geographical indications, Copy rights, applicability of these IPR; , IPR & biodiversity; IPR development process, role of WIPO and WTO in IPR establishments, common rules of IPR practices, types and features of IPR agreement, functions of UNESCO in IPR maintenance.

UNIT V PATENTS 9

Patents – objectives and benefits of patent, concept, features of patent, inventive steps, specifications, types of patent application; patenting process - patent filling, examination of patent, grant of patent, revocation; equitable assignments; Licenses, licensing of patents; patent agents, registration of patent agents.

TOTAL: 45 PERIODS**COURSE OUTCOMES**

Upon completion of the course, the student can

- CO1: Describe different types of research; identify, review and define the research problem
 CO2: Select suitable design of experiment s; describe types of data and the tools for collection of data
 CO3: Explain the process of data analysis; interpret and present the result in suitable form
 CO4: Explain about Intellectual property rights, types and procedures
 CO5: Execute patent filing and licensing

REFERENCES:

1. Cooper Donald R, Schindler Pamela S and Sharma JK, "Business Research Methods", Tata McGraw Hill Education, 11e (2012).
2. Soumitro Banerjee, "Research methodology for natural sciences", IISc Press, Kolkata, 2022.
3. Catherine J. Holland, "Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets", Entrepreneur Press, 2007.
4. David Hunt, Long Nguyen, Matthew Rodgers, "Patent searching: tools & techniques", Wiley, 2007.
5. The Institute of Company Secretaries of India, Statutory body under an Act of parliament, "Professional Programme Intellectual Property Rights, Law and practice", September 2013.

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COURSE OBJECTIVES: The main learning objective of this course is to prepare the students to generate the geometric model using commercial CAD tools.

List of Experiments

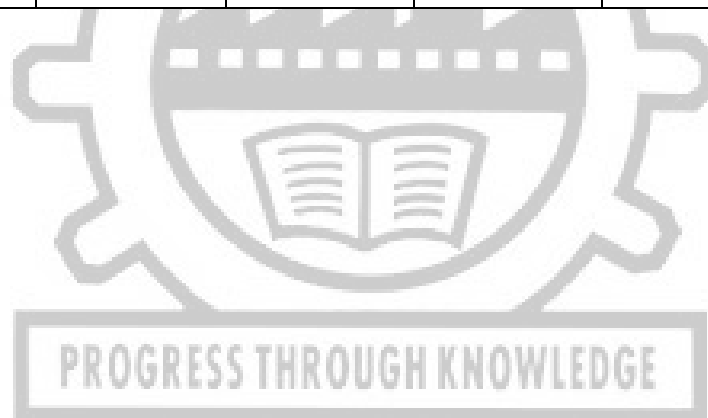
- CAD Introduction.
- Sketcher
- Solid modeling –Extrude, Revolve, Sweep, etc. and Variational sweep, Loft, etc.
- Surface modeling –Extrude, Sweep, Trim .etc. and Mesh of curves, Free form etc.
- Feature manipulation – Copy, Edit, Pattern, Suppress, History operations etc.
- Assembly-Constraints, Exploded Views, Interference check, Mass and CG.
- Drafting-Layouts, Standard & Sectional Views, Detailing & Plotting

TOTAL:60 PERIODS

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

- CO1** Utilize CAD software to create Geometric Constructions and apply principles of technical drawings to create different 3D models
- CO2** construct solid models, assemblies, and detail drawings using a feature-based parametric design CAD program, while capturing design intent in the models
- CO3** solve design problems in parts and assemblies at the intermediate level.

CO	PO					
	1	2	3	4	5	6
1	3	3	3	3		2
2	3	3	3	3		2
3	3	2	3	3	1	2
Avg.	3	2.7	3	3	0.3	2



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COURSE OBJECTIVES: The main learning objective of this course is to prepare the students for understanding the forces and torques that come into action in various kinds of mechanical systems.

List of Experiments:

1. Free fall of rigid body
2. Projectile motion
3. Simulation of simple Pendulum
4. Simulation of Compound Pendulum
5. Kinematic Analysis four bar and slider crank mechanism and its inversions
6. Dynamic Analysis four bar and slider crank mechanism and its inversions
7. Design of cam Profile for various follower output motion
8. Kinematic & Dynamic Analysis of Gear Tracks
9. Vibration Analysis SDOF and MDOF
10. Project on virtual product design using Commercial Software Package

TOTAL:60 PERIODS

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

CO1 Model different systems and import them into the multi body dynamic software

CO2 Conduct multi body dynamic tests and obtain required dynamic properties by

CO3 Use the above data in additional stress analysis software

CO	PO					
	1	2	3	4	5	6
1	3	2	3	3	2	1
2	3	2	3	3	2	1
3	3	2	3	3	2	1
Avg.	3	2	3	3	2	1



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COURSE OBJECTIVES: To understand and apply the principles and concepts in Creativity and Innovation Management for Product Design and Development.

UNIT I CREATIVITY THEORY, HEURISTICS & MODEL 9

Directed creativity: Five Mental Actions in Directed Creativity – Five Factors Driving the Need for Creativity and Innovation in Organizations – Two Key Challenges on the Road to Innovation – Quality Management & Creativity and Innovation – Proper Definition of Creativity & Innovation with Practical Advice – A High-level Model of Mechanics of Mind – Role of Perception in Creative Thinking with Practical Advice – Role of Memory in Creative Thinking with Practical Advice – Role of Judgment in Creative Thinking with Practical Advice – Amabile's Seven Heuristics on Creativity – Perkin's Ten Heuristics on Creativity – Plsek's Eight Heuristics on Creativity – Model of Directed Creativity Process.

UNIT II CREATIVITY PRINCIPLES & TOOLS 9

Creative Thinking Tools: Trans-disciplinary Analogy – Stepping Stones – Dreamscape – Manipulative Verbs – Three basic principles: Attention – Escape – Movement – Tools for Preparation Phase – Tools for Imagination Phase – Harvesting Ideas – Eight Steps to Transforming Organization – Tools for Development and Action Phase – Idea Enhancement Checklist – Documenting Idea – Techniques for Action Phase.

UNIT III CREATIVITY DESIGN & APPLICATION 9

ICEDIP: Inspiration, Clarification, Distillation, Perspiration, Evaluation and Incubation – Norman's Three Levels of Emotional Design: Visceral, Behavioral and Reflective – Application of Creativity in Process Design & Reengineering – Application of Creativity in Customer Needs Analysis – Application of Creativity in Innovative Product and Service Design – Symptoms of Stuck Thinking – Seven Tools in Creative Problem Solving and Incremental Quality Improvement.

UNIT IV INNOVATION PRINCIPLES & PRACTICES 9

Routine and Inventive Problems – Difficulty of a Problem – Psychological Inertia – Methods of Creativity Activation – Checklists and Questionnaires – Morphological Box – Decision Aids – Problem Solving and Information – Requirements for Inventive Problem Solving – Necessary Qualities for the Solver of Non-routine Problems – Altshuller's Engineering Parameters – Altshuller's Inventive Principles – Altshuller's Contradiction Matrix Algorithm.

UNIT V INNOVATION MANAGEMENT 9

Disruptive Innovation Model – Disruption at Work: How Minimis Upended Integrated Steel Companies – Two Types of Disruption: New-Market Disruptions – Low-End Disruptions – Three Litmus Tests – Three Approaches to Creating New-Growth Businesses – New Market Disruptions: Three Case Histories – Product Architectures and Integration – Process of commoditization and de-commoditization – Two Processes of Strategy Formulation – Role of Senior Executive in Leading New Growth

TOTAL: 45 PERIODS

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

- CO1** Apply the heuristics of theory of creativity in new product design and development.
- CO2** Apply the tools for creativity in new product design and development.
- CO3** Apply the design principles of creativity in new product design and development.
- CO4** Apply the various innovation principles and practices in new product design and development.
- CO5** Apply the principles of innovation management in new product design and development.

REFERENCES:

1. Paul E. Plsek, "Creativity, Innovation and Quality", ASQ Quality Press, Milwaukee, Wisconsin, 2000.
2. Donald A. Norman, "Emotional Design", Perseus Books Group, New York, 2004.
3. Geoffrey Petty, "How to be better at Creativity", The Industrial Society, 1999.
4. Semyon D. Savransky, "Engineering of Creativity – TRIZ", CRC Press, New York, USA, 2000.
5. Clayton M. Christensen and Michael E. Raynor, "The Innovator's Solution", Harvard Business School Press, Boston, USA, 2003.

CO	PO					
	1	2	3	4	5	6
1	3	1	2	2	1	2
2	3	1	2	2	1	2
3	3	1	2	2	1	2
4	3	1	2	2	1	2
5	3	1	2	2	1	2
Avg.	3	1	2	2	1	2



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COURSE OBJECTIVES: To develop a thorough understanding of the basic principles of the finite element analysis techniques with an ability to effectively use the tools of the analysis for solving practical problems arising in engineering design.

UNIT I FINITE ELEMENT ANALYSIS OF ONE DIMENSIONAL PROBLEMS 9

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 9

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 9

Natural Co-ordinate Systems – Lagrangian Interpolation Polynomials – Isoparametric 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 9

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 9

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: 45 PERIODS

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

- CO1** Develop mathematical models for one dimensional problems and their numerical solutions.
- CO2** Determine field variables for two dimensional scalar and vector variable problems.
- CO3** Apply Isoparametric transformation and numerical integration for evaluation of element matrices.
- CO4** Apply various solution techniques to solve Eigen value problems.
- CO5** Formulate solution techniques to solve non-linear problems.

REFERENCES:

1. Bathe K.J., “Finite Element Procedures in Engineering Analysis”, Prentice Hall, 1990.
2. David Hutton, “Fundamentals of Finite Element Analysis”, Tata Mc Graw Hill, 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 Mc Graw Hill,2018.
5. Seshu.P, “Text Book of Finite Element Analysis”, PHI Learning Pvt. Ltd., New Delhi, 2012.
6. Tirupathi R.Chandrupatla and Ashok D.Belegundu, “Introduction to Finite Elements in Engineering”, International Edition, Pearson Education Limited, 2014.

CO	PO					
	1	2	3	4	5	6
1	3		3	3	1	1
2	3		3	2	1	1
3	3		3	3	1	1
4	3		3	3	1	1
5	3		3	2	1	1
Avg.	3		3	2.6	1	1



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PD3201	ADDITIVE MANUFACTURING FOR PRODUCT DEVELOPMENT	L	T	P	C
		2	0	2	3

COURSE OBJECTIVES:

- To gain knowledge on evolution of Prototyping (RP/AM/SFM) and the importance of DfAM in improving the quality.
- To acquaint with various Prototyping (RP/AM/SFM) Technologies and hybrid processes, along with their material science and applications in different fields.

UNIT I INTRODUCTION TO ADDITIVE MANUFACTURING 6

Introduction to Prototyping – Need – RP evolution – Distinction between AM (RP) & CNC machining – Development of SFM systems – Hierarchical structure of AM (RP) – AM (RP) process chain – Classification – AM (RP) Supply chain – Economics aspect: Strategic aspect – Operative aspect.

UNIT II DESIGN FOR ADDITIVE MANUFACTURING 6

Concepts and Objectives – General Guidelines for DfAM – DfAM tools – Requirements of DfAM methods – AM Unique Capabilities – Design Consideration in AM – Part Consolidation – Computational tools for design analysis- Topology Optimization – Lightweight Structures – Generative design – DfAM for Part Quality Improvement – CAD Modeling – Model Reconstruction – Data Processing for AM – Data Formats: STL, AMF,PLY, VRML – Data Interfacing – Part Orientation – Support Structure Design and Support Structure Generation – Model Slicing – Tool Path Generation.

UNIT III VAT POLYMERIZATION, MATERIAL EXTRUSION; & SHEET LAMINATION TECHNOLOGIES 6

Vat polymerization: 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 – Capabilities – Limitations and Applications. Digital Light Processing (DLP) – Materials – Process – Capabilities and Applications. Continuous Liquid Interface Production (CLIP) – Materials – Process – Capabilities and Applications.

Material extrusion: Fused deposition Modeling (FDM): Working Principles – Process – Materials – Capabilities and Applications. Design Rules for FDM.

Sheet lamination processes: Laminated Object Manufacturing (LOM): Working Principles – Process – Materials – Capabilities – Limitations and Applications.

UNIT IV POWDER BED FUSION, BINDER JETTING, MATERIAL JETTING TECHNOLOGIES 6

Powder Bed Fusion: Selective Laser Sintering (SLS): Principles – Process – Indirect and Direct SLS – Powder Structure – Materials – Surface Deviation and Accuracy – Capabilities – Applications – Multi-jet Fusion Principles – Processes – Materials – Capabilities and Applications. Selective Laser Melting (SLM) and Electron Beam Melting (EBM): Principles – Processes – Materials – Capabilities – Limitations and Applications.

Binder Jetting: Three-Dimensional Printing (3DP): Principles – Process – Physics of 3DP – Materials – Capabilities – Limitations – Applications.

Material Jetting: Multi Jet Modelling (MJM) – Principles – Process – Materials – Capabilities and Application.

UNIT V DIRECT ENERGY DEPOSITION & HYBRID AM TECHNOLOGIES 6

Direct Energy Deposition: Laser Engineered Net Shaping (LENS): Processes – Materials – Capabilities – Limitations and Applications.

Ultrasonic Additive Manufacturing (UAM) – Process – Parameters – Capabilities – Applications. Case Studies.

Hybrid Additive Manufacturing – Need – Principles – Part Quality and Process Efficiency. Wire Arc Additive Manufacturing (WAAM) Processes – Materials – Capabilities – Limitations and Applications – Case Studies

Each student has to develop digital and physical prototype models of a new product / existing product with enhanced feature involving the industrial, bio medical and consumer products. The fabricated models are to be in the form of AM models.

TOTAL: 60 PERIODS

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

- CO1** Explore the importance in the evolution of SFM/AM, proliferation into the various fields and its effects on supply chain
- CO2** Recognize the importance of DfAM in improving the quality of fabricated parts and understand the guidelines of DfAM
- CO3** Acquire knowledge on principles and applications of vat polymerization, material extrusion and sheet lamination processes with case studies.
- CO4** Acquire knowledge on principles of powder bed fusion, jetting, direct energy deposition and hybrid processes
- CO5** Understand the properties and characteristics of materials used in SFM/AM and explore the applications in various fields.

REFERENCES:

1. Ian Gibson, David W. Rosen and Brent Stucker, "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing" Springer - New York, USA, 3rd Edition, 2021. ISBN-978- 3-030-56126-0.
2. Andreas Gebhardt and Jan-Steffen Hotter, "Additive Manufacturing: 3D Printing for Prototyping and Manufacturing", Hanser publications Munchen, Germany, 2016. ISBN: 978-1-56990-582-1.
3. A Practical Guide to Design for Additive Manufacturing, Diegel, Olaf, Axel Nordin, and Damien Motte, Springer, 2020.
4. Liou, L.W. and Liou, F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development, CRC Press, 1st Edition, 2019 FL, USA. ISBN-9780429029721
5. Ben Redwood, Brian Garret, Filemon Schoffer, and Tony Fadel, "The 3D Printing Handbook: Technologies, Design and Applications", 3D Hubs B.V., Netherland, 2017. ISBN-13: 978-9082748505.
6. Milan Brandt., "Laser Additive Manufacturing 1st Edition Materials, Design, Technologies, and Applications", Woodhead Publishing, UK, 2016. ISBN-9780081004333.

CO	PO					
	1	2	3	4	5	6
1	1	2	2	1	2	2
2	3	3	2	2	2	3
3	3	2	3	3	3	2
4	3	3	2	3	3	2
5	3	2	3	2	3	3
Avg.	2.6	2.4	2.4	2.2	2.6	2.4

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ED3261

FINITE ELEMENT MODELLING AND SIMULATION LABORATORY

L	T	P	C
0	0	4	2

COURSE OBJECTIVES: The main learning objective of this course is to prepare the students for effectively using analysis tools for solving practical problems.

List of Experiments:

1. Force and Stress analysis using link elements in Trusses.
2. Stress and deflection analysis in beams with different support conditions.
3. Stress analysis of flat plates.
4. Stress analysis of axi-symmetric components.
5. Thermal stress and heat transfer analysis of plates.
6. Thermal stress analysis of cylindrical shells.
7. Vibration analysis of spring-mass systems.
8. Modal analysis of Beams.
9. Harmonic, transient and spectrum analysis of simple systems.
10. Analysis of machine elements under dynamic loads
11. Analysis of non-linear systems

TOTAL: 60

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

CO1 Solve the engineering problems numerically with Computer Aided Finite Element Analysis packages

CO2 Create Finite Element Model to accurately simulate the physical behavior.

CO3 Demonstrate problem-solving skills by Result and Post-Processing the solution

CO	PO					
	1	2	3	4	5	6
1	3		3	2	1	1
2	3		3	2	1	1
3	3	3	3	2	1	1
Avg.	3	1	3	2	1	1

PROGRESS THROUGH KNOWLEDGE

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PD3211

PRODUCT DESIGN STUDIO

L T P C
0 0 4 2

COURSE OBJECTIVES: To understand and apply the principles and concepts in Integrated Product Design and Development for Innovative Product with hands on training.

Each student has to develop digital and physical prototype models of a new product / existing product with enhanced feature involving the following areas:

- Automotive components
- Tool and die components
- Press tool components
- Consumer product
- Injection moulded products.

The fabricated models may be in the form of RP models, clay models, sheet metal models or cardboard models etc. The design and development of the product will be reviewed in two stages for awarding internal marks. The end semester examination mark will be based on the project report (Introduction; Literature survey; Methodology; Simulation; Experimentation; Analysis and Discussion; and Conclusion) and their demonstration followed by oral examination of their new product by internal examiner.

TOTAL: 60

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

CO1 Apply theoretical knowledge to design and development of innovative product concepts.

CO2 Create physical prototype models of product concepts using prototyping techniques.

CO3 Analyse and evaluate the physical prototype of product concepts.

CO	PO					
	1	2	3	4	5	6
1	3	3	3	3	3	3
2	3	3	3	3	3	3
3	3	3	3	3	3	3
Avg.	3	3	3	3	3	3

PROGRESS THROUGH KNOWLEDGE

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COURSE OBJECTIVES: To understand, learn and apply the principles and practices in Product Design / Development / Manufacture / Service organization through hands on training.

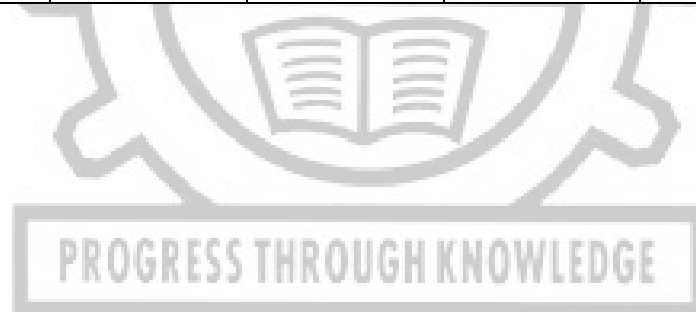
Each student has to undergo Industrial training for a minimum period of four weeks during the upcoming summer vacation (i.e., between II and III Semester). The Internship / Industrial Training has to be undergone continuously for the entire period. The industry must be a product design / development / manufacture / service organization. The student must produce an authentic letter or certificate of their completion of Internship / Industrial Training from the concerned Organization. The End Semester Examination must be conducted at the start of III Semester. The mark will be based on the project report (Introduction; Project or Training details; Discussion; and Conclusion) and their presentation followed by oral examination on the same by internal examiner.

TOTAL: -

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

- CO1** Understand the theoretical knowledge behind design / development / Manufacture / Service of innovative products.
CO2 Apply the practical skills in design / development / Manufacture / Service of innovative products.
CO3 Prepare and present a project or training report professionally.

CO	PO					
	1	2	3	4	5	6
1	3	3	3	3	3	3
2	3	3	3	3	3	3
3	3	3	3	3	3	3
Avg.	3	3	3	3	3	3



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COURSE OBJECTIVES: The main learning objective of this course is to prepare the students for identifying a specific problem for the current need of the society and or industry, through detailed review of relevant literature, developing an efficient methodology to solve the identified specific problem.

Each PG student shall work individually on a selected specific topic in the area of Product Design & Development which shall be approved by the Head of the Division under the supervision of a Faculty Member (Guide / Supervisor) who is familiar in the selected specific topic. The selected specific topic maybe theoretical and or experimental and or simulation and or case study. The students' Project Work – I shall be evaluated through Internal Examination and End Semester Examination.

The Internal Examination must be conducted periodically (Zeroth, First, Second and Third) through Project Work Review Presentation Meetings followed by questions from the panel of Review Committee Members comprising of two expert faculty members and a project coordinator.

At the end of the semester, a detailed report on the work done by the PG student must be submitted with the approval from the Guide/Supervisor and the Review Committee Members. The Project Work – I Report must contain the Introduction with clear definition along with detailed review of relevant literature on the selected specific problem; an efficient methodology to solve the selected specific problem along with necessary hypothesis and or experimental setup and or simulation and or case study for carrying out the research project work along with preliminary results; discussions, relevant conclusions and future direction along with specified references.

The End Semester Examination must be conducted through Project Work Presentation followed by questions from the panel of Examiners comprising an External Examiner and Project Coordinator as Internal Examiner.

TOTAL: 180

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

CO1 Demonstrate a sound technical knowledge in their selected project topic.

CO2 Select and identify the problem statement along with scope and boundary; assimilate detailed review of relevant literature; formulate an efficient methodology to solve the selected specific problem.

CO3 Propose product design & development solutions to complex problems using a systematic approach.

CO	PO					
	1	2	3	4	5	6
1	3	3	3	3	2	3
2	3	3	3	3	2	3
3	3	3	3	3	2	3
Avg.	3	3	3	3	2	3

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COURSE OBJECTIVES: The main learning objective of this course is to prepare the students for solving the specific problem for the current need of the society and or industry, through the formulated efficient methodology, and to develop necessary skills to critically analyse and discuss in detail regarding the project results and making relevant conclusions.

The student may continue to work on the Project Work – I's selected topic as per the formulated efficient methodology under the same Faculty Member (Guide/Supervisor). The students' Project Work – II shall be evaluated through Internal Examination and End Semester Examination.

The Internal Examination must be conducted periodically (First, Second and Third) through Project Work Review Presentation Meetings followed by questions from the panel of Review Committee Members comprising of two expert faculty members and a project coordinator.

At the end of the semester, a detailed report on the work done by the PG student must be submitted with the approval from the Guide/Supervisor and the Review Committee Members. The Thesis (Project Work – II Report) must contain the Introduction with clear definition along with detailed review of relevant literature on the selected specific problem; an efficient methodology to solve the selected specific problem along with necessary theoretical hypothesis and or experimentation and or simulation and or case study for carrying out the research project work along with complete results with critical analysis and detail discussions, followed by relevant conclusions, along with specified references.

The End Semester Examination must be conducted through Project Work Presentation followed by questions from the panel of Examiners comprising an External Examiner and Project Coordinator as Internal Examiner.

TOTAL: 360

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

- CO1** Demonstrate a sound technical knowledge of their selected project topic.
- CO2** Propose product design & development solutions to complex problems using a systematic approach.
- CO3** Demonstrate the knowledge, skills and attitudes of a professional engineer to take up any challenging practical problem in the field of product design & development and find optimum solutions to it.

CO	PO					
	1	2	3	4	5	6
1	3	3	3	3	2	3
2	3	3	3	3	2	3
3	3	3	3	3	2	3
Avg.	3	3	3	3	2	3

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COMPUTER GRAPHICS

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COURSE OBJECTIVES: To impart knowledge on computer graphics which are used routinely in diverse areas as science, engineering, medicine, etc.

UNIT I INTRODUCTION TO COMPUTER GRAPHICS FUNDAMENTALS 9

Scan-Conversion of a Lines (Digital Differential Analyzer Algorithm, Bresenham's Line Drawing Algorithm – Scan-Conversion of Circle and Ellipse (Bresenham's Method of Circle Drawing, Midpoint Circle Algorithm) – Drawing Ellipses and Other Conics – Introduction to 2D and 3D transformations – Transformation Matrix – Types of Transformations in Two-Dimensional Graphics: Identity Transformation, Scaling, Reflection, Shear Transformations, Rotation, Translation, Rotation about an Arbitrary Point, Combined Transformation – Introduction to Clipping – Two-Dimensional Clipping, Point Clipping, Line Clipping – Introduction to a Polygon Clipping – Viewing and Clipping in Three Dimensions – Three-Dimensional Viewing Transformations – Text Clipping.

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 bicubic surface – Bezier surface and B-Spline 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 VISIBLE SURFACE AND OBJECT RENDERING 9

Introduction to visible and hidden surfaces – Coherence for visibility – Extents and Bounding Volumes – Back Face Culling – Painter's Algorithm, Z-Buffer Algorithm, Floating Horizon Algorithm, Roberts Algorithm – Introduction to Object-Rendering, Light Modeling Techniques, illumination Model, Shading, Flat Shading, Polygon Mesh Shading, Gouraud Shading Model, Phong Shading, Transparency Effect, Shadows, Texture and Object Representation, Ray Tracing, Ray Casting, Radiosity, Color Models.

UNIT V ASSEMBLY OF PARTS AND PRODUCT LIFE CYCLE 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 – Product life cycle.

TOTAL: 45 PERIODS

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

- CO1** Solve 2D and 3D transformations for the basic entities like line and circle.
- CO2** Formulate the basic mathematics fundamental to CAD system.
- CO3** Use the different geometric modeling techniques like feature-based modeling, surface modeling and solid modeling.
- CO4** Create geometric models through animation and transform them into real world systems
- CO5** Simulate assembly of parts using Computer-Aided Design software

REFERENCES:

1. Boothroyd, G, "Assembly Automation and Product Design", Marcel Dekker, New York, 1991.
2. Chitale A.K and Gupta R.C., "Product Design and Manufacturing", PHI Learning Private Limited, 6th Edition, 2015.
3. David Rogers, James Alan Adams, "Mathematical Elements for Computer Graphics", 2nd Edition, Tata McGraw-Hill, 2002.
4. Donald D Hearn and M. Pauline Baker, "Computer Graphics C Version", Prentice Hall, Inc., 2nd Edition, 1996.
5. Ibrahim Zeid, "Mastering CAD/CAM", McGraw Hill, 2nd Edition, 2006.
6. William M Newman and Robert F.Sproull "Principles of Interactive Computer Graphics", Mc Graw Hill Book Co., 1st Edition, 2001.

CO	PO					
	1	2	3	4	5	6
1	3		3	3	2	1
2	3		3	3	2	1
3	3		3	3	2	1
4	3		3	3	2	1
5	3		3	3	2	1
Avg.	3		3	3	2	1



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COURSE OBJECTIVES: The main learning objective of this course is to prepare the students for understanding the design for sustainable behaviour and design practices.

UNIT I INTRODUCTION 9

Addressing sustainability by design – Challenges-evolution for sustainability – Need and impact – Responses from design – Product lifecycle design – Design for eco-efficient product service systems –Eco design principles and strategies – Green design – Principles and strategies.

UNIT II DESIGN FOR SUSTAINABLE BEHAVIOUR 9

Triggering and supporting changes in human behaviour – Comprehensive action determination model (CADM) – Design practices – Decision support framework for promoting sustainable behaviour – Benefits – DfSB Methods and tools – Middle ground – Individual cognitive methods – Context driven methods – Future research direction.

UNIT III DESIGN FOR ENVIRONMENT 9

Environmental objectives – Global issues – Regional and local issues – Basic DFE methods – Design guide lines – Example application – Lifecycle assessment – Basic method – AT&T's environmentally responsible product assessment – Weighted sum assessment method – Lifecycle 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.

UNIT IV PRODUCT SERVICE DESIGN FOR SUSTAINABILITY 9

Design of individual products to integrated set of products and services – Categories – Need to implement – Design practice – PSS design for sustainability examples – Methods and tools – Benefits and limitations – Future research direction – Case studies.

UNIT V SYSTEMIC DESIGN AND FUTURE OF DESIGN FOR SUSTAINABILITY 9

Sustainable productive systems at a territorial scale – Design practice – Design for sustainability transitions – Framework to capture DfS – Approach – Innovation levels – Evolution of DfS – Design to regulations and standards.

TOTAL:45 PERIODS

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

- CO1** Address the need, challenges and impact the need for sustainable design
- CO2** Understand the design for sustainable behaviour and design practices
- CO3** Evaluate design considerations for environmental issues
- CO4** Know the design categories in the product service design and future research directions
- CO5** Understand the evolution of Design for sustainability and its framework

REFERENCES:

1. Fabrizio Ceschin and Idil Gaziulusoy, "Design for sustainability: A Multi-level Framework from Products to Socio-technical System", Routledge focus on environment and sustainability,2020.
2. Boothroyd,G, "Design for Assembly Automation and Product Design", NewYork, Marcel Dekker, 1980.
3. J. G. Bralla, "Design for Manufacture Handbook", McGrawhill,1999.
4. Boothroyd, G, Hartz and Nike, "Product Design for Manufacture", Marcel Dekker,1994.
5. Dickson, John.R, and Corroda Poly, "Engineering Design and Design for Manufacture and Structural Approach", Field Stone Publisher, USA,1995.
6. Fixel, J., "Design for the Environment", McGraw Hill., 1996

7. Graedel T.E. and B. R. Allenby, "Design for the Environment", Pearson, 1996.
8. Kevin Otto and Kristin Wood, "Product Design", Pearson Publication, (Fourth Impression), 2009.

CO	PO					
	1	2	3	4	5	6
1	3		3	2	2	3
2	3		3	2	2	3
3	3		3	2	2	3
4	3		3	2	2	3
5	3		3	2	2	3
Avg.	3		3	2	2	3



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COURSE OBJECTIVES: The main learning objective of this course is to prepare the students for designing hybrid and electric vehicles.

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- introduction to types of hybrid vehicles.

UNIT II ENERGY SOURCE 9

Introduction to engine power train - Battery basics- lead acid battery –lithium ion battery – alternative batteries – battery parameters- technical characteristics – battery power – Battery Thermal Management System - 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 gradability - 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: 45

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

- CO1** Explain the working of hybrid vehicle and describe its main components and their function
- CO2** Choose proper energy storage systems for vehicle applications
- CO3** Design series hybrid electric vehicles.
- CO4** Design parallel hybrid electric vehicles.
- CO5** Describe the transmission components and their configurations for electric vehicles

REFERENCES:

1. Ehsani, M, “Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design”, CRC Press, 2005
2. “Hybrid Electric Vehicle Technology Assessment: Methodology, Analytical Issues, and Interim Results,” Center for Transportation Research Argonne National Laboratory, United States Department of Energy.
3. Iqbal Hussain, “Electric & Hybrid Vehicles – Design Fundamentals”, Second Edition, CRC Press, 2011.
4. James Larminie, “Electric Vehicle Technology Explained”, John Wiley & Sons, 2003.
5. Sandeep Dhameja, “Electric Vehicle Battery Systems”, Newnes, 2000
.http://nptel.ac.in/courses/108103009/.

CO	PO					
	1	2	3	4	5	6
1	2		3	1	3	2
2	2		3	1	3	2
3	2		3	1	3	2
4	2		3	1	3	2
5	2		3	1	3	2
Avg.	2		3	1	3	2



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COURSE OBJECTIVES: The main learning objective of this course is to prepare the students for imparting knowledge on fluid power principles and inculcating the skills to design and develop hydraulic and Pneumatic circuits.

UNIT I FLUID POWER PRINCIPLES AND HYDRAULIC PUMPS 9

Introduction to Fluid power – Advantages and Applications – Fluid power systems – Types of fluids - Properties of fluids and selection – Basics of Hydraulics – Pascal’s Law – Principles of flow - Friction loss – Work, Power and Torque- Problems, Sources of Hydraulic power : Pumping Theory— Pump Classification – Construction, Working, Design, Advantages, Disadvantages, Performance, Selection criteria of pumps – Fixed and Variable displacement pumps – Problems.

UNIT II HYDRAULIC ACTUATORS AND CONTROL COMPONENTS 9

Hydraulic Actuators: Cylinders – Types and construction, Application, Hydraulic cushioning – Rotary Actuators – Hydraulic motors - Control components: Direction Control, Flow control and pressure control valves – Types, Construction and Operation – Accessories: Reservoirs, Accumulators, Pressure Intensifiers, Heat Exchangers, Pressure Gages - Pressure Switches– Filters –types and selection- Applications – Fluid Power ANSI Symbols – Problems.

UNIT III HYDRAULIC CIRCUITS AND SYSTEMS 9

Accumulators, Intensifiers, Industrial hydraulic circuits – Regenerative, Pump Unloading, Double Pump, Pressure Intensifier, Air-over oil, Sequence, Reciprocation, Synchronization, Fail-Safe, Speed Control, Deceleration circuits, Sizing of hydraulic systems, Hydrostatic transmission, Electro hydraulic circuits – Servo and Proportional valves – Applications- Mechanical, hydraulic servosystems – Maintenance of Hydraulic Systems.

UNIT IV PNEUMATIC AND ELECTRO PNEUMATIC SYSTEMS 9

Properties of air –Air preparation and distribution – Filters, Regulator, Lubricator, Muffler, Air control Valves, Quick Exhaust Valves, Pneumatic actuators, Design of Pneumatic circuit –classification single cylinder and multi cylinder circuits – Cascade method –Integration of fringe circuits, Electro Pneumatic System – Elements – Relay ladder diagram – timer circuits –Problems, PLC – Logic ladder diagram – Controlling Fluid power actuators.

UNIT V TROUBLE SHOOTING AND APPLICATIONS 9

Installation, Selection, Maintenance, Trouble Shooting and Remedies in Hydraulic and Pneumatic systems, Conditioning of hydraulic fluids Design of hydraulic circuits for Drilling, Planning, Shaping, Surface grinding, Press and Forklift applications. Design of Pneumatic circuits for metal working, handling, clamping counter and timer circuits. – Low cost Automation – Hydraulic and Pneumatic power packs.

TOTAL: 45

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

CO1 Apply the principles of fluid power systems, and select relevant hydraulic pumps for the fluid power applications.

CO2 Select necessary control components and hydraulic actuators for the fluid power applications.

CO3 Design and develop hydraulic circuits and systems.

CO4 Design and develop pneumatic circuits and systems.

CO5 Solve problems and troubles in fluid power systems.

REFERENCES:

1. Anthony Esposito, “Fluid Power with Applications”, Prentice Hall, 2009.
2. James A. Sullivan, “Fluid Power Theory and Applications”, Prentice Hall, 1997.
3. Shanmuga Sundaram. K., “Hydraulic and Pneumatic Controls”. Chand & Co, 2006.
4. Jagadeesha. T., “Pneumatics Concepts, Design and Applications “, Universities Press, 2015.
5. Joshi.P., Pneumatic Control”, Wiley India, 2008.
6. Srinivasan.R., “Hydraulic and Pneumatic Controls”, Vijay Nicole Imprints, 2008.
7. Majumdar, S.R., “Oil Hydraulics Systems – Principles and Maintenance”, Tata McGraw Hill, 2001.

CO	PO					
	1	2	3	4	5	6
1	3		3	2	2	1
2	3		3	2	2	1
3	3		3	2	2	1
4	3		3	2	2	1
5	3		3	2	2	3
Avg.	3		3	2	2	1.4



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COURSE OBJECTIVES: The main learning objective of this course is to prepare the students for acquiring the knowledge on the mechanical behaviour of both metallic and non-metallic materials under different loading and temperature conditions.

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 nonmetallic Materials – Failure analysis, sources of failure, 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).

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, Al₂O₃, SiC, Si₃N₄ CBN and diamond – Fracture of ceramics-Stress strain behavior-Deformation behavior. Glasses-Clay products-refractory ceramics, Composite Materials-GFRP and CFRP laminated composite.

TOTAL: 45

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

- CO1** Analyze the different strengthening and failure mechanism of the metals
- CO2** Apply the effects of metallurgical parameters in the materials design
- CO3** Analyze the relationship between the selection of materials and processing
- CO4** Develop the novel material through understanding the properties of the existing metallic materials
- CO5** Analyze the different materials used in the engineering applications

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. Callister Jr.and David G. Rethwisch, Callister's Materials Science and Engineering,(2nd Edition) Wiley Editorial, 2018.
4. Charles, J.A., Crane, F.A.A. and Fumess, J.A.G., Selection and use of engineering materials,(34th edition), Butterworth-Heiremann, 1997.
5. Flinn, R.A., and Trojan, P.K., Engineering Materials and their Applications, (4th Edition) Jaico, 1999.
6. Metals Hand book, Vol.10, Failure Analysis and Prevention, (10th Edition), Jaico, 1999.
7. Ashby M.F., Materials Selection in Mechanical Design, 2nd Edition, Butter worth.
8. www.astm.org/labs/pages/131350.htm.

CO	PO
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	1	2	3	4	5	6
1	3		3	1	2	2
2	3		3	1	2	2
3	3		3	1	2	2
4	3		3	1	2	2
5	3		3	1	2	2
Avg.	3		3	1	2	2



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COURSE OBJECTIVES: The main learning objective of this course is to prepare the students to acquire knowledge on mechanics of cracked components of different modes by which these components fail under static and fatigue load conditions.

UNIT I ELEMENTS OF SOLID MECHANICS 9

Introduction to Failure and Fracture – Spectacular Failures-Basics Principles – Governing equations for the deformable body – Stress-Strain relations and general equations of elasticity in Cartesian and Polar Coordinates – Vectors and tensors – Differential equations of equilibrium – Compatibility – Boundary conditions – Representation of three-dimensional stress system – Generalized hook's law – Plane stress and strain problems – Airy's stress function – Methods of formulation of Governing Differential equations for plane elasticity – Naviers Equation – Biharmonic equation in Cartesian and Polar coordinates.

UNIT II STRESS AND DISPLACEMENT AROUND THE CRACK TIP FOR DIFFERENT MODES OF FRACTURE 9

Brittle and Ductile Fracture – Modes of Fracture – Weakness of the components due to Flaws – Need for Linear Elastic Fracture Mechanics (LEFM) – Evaluation of Structural Design – Stress and displacement around the crack tip in K – Annulus for Mode-I and Mode-II plane crack problems – Stress and displacement around the crack tip in K – Annulus for Mode III crack problems.

UNIT III STATIONARY CRACK UNDER STATIC LOADING 9

Griffith analysis – Irwin's approximation – CTOD and stress ahead of the crack tip – Westergaard solutions: Analytical Calculations for SIF for different crack geometries – Critical crack length and fracture stress calculations – Two dimensional elastic fields – Analytical solutions for small scale yielding near a crack front – Plastic zone size – Specimen size calculations: K_{1c} Testing for Fracture toughness of the Material

UNIT IV FATIGUE FAILURE AND ENVIRONMENTAL-ASSISTED FRACTURE 9

Introduction to fatigue failure – S-N Curve – Crack Initiation – Crack propagation – Effect of an Overload – Variable amplitude Fatigue load – Crack closure – Characteristics of fatigue crack – Paris Law – Fatigue Crack Growth Test to evaluate Paris constants – Life calculations for a given load amplitude – Effects of changing the load spectrum Environmental-assisted Fracture – Micro mechanisms – Factors influencing Environmental-assisted fracture – Environment-assisted Fatigue Failure affecting fatigue performance, fatigue loading, constant and variable amplitude loading.

UNIT V APPLICATIONS OF FRACTURE MECHANICS 9

J-integral, Mixed-mode fracture, Crack arrest methodologies – Case studies: Analysis on failed components and design for the extension of its life.

TOTAL: 45

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

- CO1** Formulate the governing equations for elastic problems.
- CO2** Evaluate the stresses/displacements around the crack tip for different modes of fracture.
- CO3** Estimate the k_{1c} /SIF/critical flaws/failure stresses for different crack geometries.
- CO4** Assess the life of the cracked components under different types of repeated/variable fatigue loads and for designing for its life extension
- CO5** Analyze the failed engineering components under different modes of fracture.

REFERENCES:

1. Broek, David, "Elementary Engineering Fracture Mechanics ", Springer Netherlands, 1982.
2. John M.Barson and Stanely T.Rolfe, "Fatigue and fracture control in structures", Butterworth-Heinemann; 3rd edition. 1999.
3. Kare Hellan, "Introduction of Fracture Mechanics", McGraw-Hill Book Company, 1985.
4. Prashant Kumar, "Elements of Fracture Mechanics", Tata McGraw-Hill Publishing Company Ltd, 2009.
5. Ted L. Anderson, "Fracture Mechanics: Fundamentals and Applications", CRC Taylor and Francis, 4th Edition, 2017 .
6. Tribikram Kundu, "Fundamentals of Fracture Mechanics", Ane Books Pvt. Ltd. New Delhi/ CRC Press, 1st Indian Reprint, 2012.

CO	PO					
	1	2	3	4	5	6

1	3		3	2	1	1
2	3		3	2	1	1
3	3		3	2	1	1
4	3		3	2	1	1
5	3		3	2	1	1
Avg.	3		3	2	1	1



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COURSE OBJECTIVES: The main learning objective of this course is to prepare the students for imparting knowledge on various categories of existing engineering problems and solutions to such problems through different optimization techniques and approaches.

UNIT I UNCONSTRAINED OPTIMIZATION TECHNIQUES 9

Introduction to optimum design - General principles of optimization – Statement of an Optimization Problem & their classifications – Single variable and multi variable optimization, Techniques of unconstrained minimization – Exhaustive Search, Dichotomous Search, Interval Halving Method, Fibonacci Method and Golden section, Random, Steepest Descent Method.

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, multilayer 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.

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. Design of brakes, gears and gear boxes.

Dynamic Applications – Optimum design of single, two degree of freedom systems, vibration absorbers. Application in Mechanisms – Optimum design of simple linkage mechanisms.

TOTAL: 45 PERIODS

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

- CO1** Formulate unconstrained optimization techniques in engineering design application.
- CO2** Formulate constrained optimization techniques for various application.
- CO3** Implement neural network technique to real world design problems.
- CO4** Apply genetic algorithms to combinatorial optimization problems.
- CO5** Evaluate solutions by various optimization approaches for a design problem.

REFERENCES:

1. Goldberg, David.E, "Genetic Algorithms in Search, Optimization and Machine Learning", Pearson,2009.
2. Jang, J.S.R,Sun,C.TandMizutaniE., "Neuro-FuzzyandSoftComputing", PearsonEducation.2015,
3. Johnson Ray,C., "Optimumdesignofmechanicalelements", Wiley,2ndEdition1980.
4. KalyanmoyDeb, "OptimizationforEngineeringDesign:AlgorithmsandExamples", PHI LearningPrivate Limited,2nd Edition,2012.
5. Rao Singiresu S., "Engineering Optimization – Theory and Practice", New Age International Limited, New Delhi, 3rd Edition, 2013.
6. Rajasekaran S and Vijayalakshmi Pai, G .A, "Neural Networks, Fuzzy Logic and Genetic Algorithms" , PHI, 2011.

CO	PO
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	1	2	3	4	5	6
1	3		3	3	2	3
2	3		3	3	2	3
3	3		3	3	2	3
4	3		3	3	2	3
5	3		3	3	2	3
Avg.	3		3	3	2	3



Attested

COURSE OBJECTIVES: The main learning objective of this course is to prepare the students for imparting knowledge on surface engineering and surface modification methods to solve the industrial problems.

UNIT I FRICTION, WEAR AND LUBRICATION 9

Topography of Surfaces – Surface features – Surface interaction – Adhesive Theory of Sliding Friction – Rolling Friction – Friction properties of metallic and non-metallic materials – Friction in extreme conditions – Thermal considerations in sliding contact – Introduction to wear – Abrasive wear, Erosive, Cavitation, Adhesion, Fatigue wear and Fretting Wear – Laws of wear – Wear of metals and non-metals – Lubrication – Introduction, types of lubricants and their industrial uses, lubricant additives.

UNIT II CORROSION 9

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.

UNIT III SURFACE TREATMENTS 9

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 – Friction Stir Processing (FSP).

UNIT IV ENGINEERING MATERIALS 9

Introduction – Advanced alloys – Super alloys, Titanium alloys, Magnesium alloys, Aluminium alloys, and Nickel based alloys – Ceramics – Polymers – Biomaterials – Applications – Bio Tribology – Nano Tribology.

UNIT V SURFACE MEASURING INSTRUMENTS 9

Need for surface properties and measurement – International standards in friction and wear measurement – Construction and working principle of tribometer – Scratch tester – Construction and working principle of Optical Microscope (OM), Scanning Electron Microscope (SEM) and Transmission Electron Microscope (TEM) instruments – Sample preparation techniques for OM, SEM and TEM analysis – Construction and working principle of Atomic Force Microscope (AFM) and Scanning Tunneling Microscope (STM) instruments – Sample preparation techniques for AFM and STM analysis.

TOTAL: 45

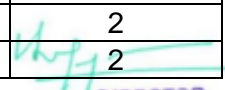
COURSE OUTCOMES: Upon completion of this course, the students will be able to:

- CO1** Understand the basics of surface features, laws of friction, and different types of friction
- CO2** Understand the types of corrosion and its preventive measures
- CO3** Understand the types of surface properties and various surface modification techniques
- CO4** Understand the different types of materials used in friction and wear applications
- CO5** Develop knowledge of the need for surface-measuring instruments

REFERENCES:

1. G.W.Stachowiak& A.W .Batchelor, “Engineering Tribology”, Butterworth-Heinemann, UK,2005
2. Rabinowicz.E, “Friction and Wear of materials”, John Willey & Sons,UK,1995
3. Halling, J. (Editor), “Principles of Tribology “, Macmillian – 1984.
4. Williams J.A. “Engineering Tribology”, Oxford Univ. Press, 1994.
5. S.K.Basu, S.N.Sengupta&B.B.Ahuja, ”Fundamentals of Tribology”, Prentice –Hall of India Pvt. Ltd New Delhi, 2005.
6. Fontana G., “Corrosion Engineering”, McGraw Hill, 1985.

CO	PO					
	1	2	3	4	5	6
1	3		3	3	2	2
2	3		3	2	2	2

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3	3		3	1	2	2
4	3		3	1	2	2
5	3		3	3	2	2
Avg.	3		3	2	2	2



ED3058

VEHICLE DYNAMICS

Attended
L T P C
3 0 0 3

COURSE OBJECTIVES: The main learning objective of this course is to prepare the students for applying

the principles of tire mechanics, steering, vertical, longitudinal and lateral dynamics in vehicle design.

UNIT I TYRE MECHANICS 9

Tyre Classification, Tyre specification, Tyre forces and moments, Tyre structure, Rolling resistance and effect of various parameters on rolling resistance, Longitudinal forces, Lateral forces, Mechanism of force generation, Tractive and cornering property of tyre, Camber Thrust, Aligning Moment, Conicity and Plysteer, Performance of tyre on wet surface, Magic formulae tyre model, Tyre vibration.

UNIT II STEERING DYNAMICS 9

Steering Linkages, Steering Geometry Error, Front Wheel Geometry, Steering system forces and moments, Steering system models, Effect of steering ratio, understeer and braking stability on steering system, Influence of front wheel drive, Four wheel steer, Steering of Vehicle with trailer.

UNIT III VERTICAL DYNAMICS 9

Human response to vibration, Sources of Vibration. Passive, Semi-active and Active suspension. Suspension Models-Quarter car, half car and full car model. Suspension isolation, Influence of suspension stiffness, suspension damping, and tyre stiffness. Active control, Control law for LQR, H-Infinite, Skyhook damping.

UNIT IV LONGITUDINAL DYNAMICS AND CONTROL 9

Aerodynamic forces and moments. Equation of motion. Load distribution for three wheeler and four wheeler. Calculation of Maximum acceleration, Reaction forces for Different drives. Brake force distribution, braking efficiency and braking distance. Prediction of Vehicle performance, ABS, stability control, Traction control.

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. Roll center, Rollaxis, Vehicle under side forces. Stability of vehicle on banked road and during turn. Effect of suspension on cornering.

TOTAL: 45 PERIODS

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

- CO1** Create a tire model based on required performance
- CO2** Apply various vehicle performance and control methodologies to ensure stability and enhance ride properties
- CO3** Formulate and develop mathematical model of a system
- CO4** Predict vehicle performance, control methodologies to ensure stability and ride comfort.
- CO5** Apply vertical, longitudinal and lateral dynamics vehicle design.

REFERENCES:

1. Singiresu S. Rao, "Mechanical Vibrations", 5th Edition, Prentice Hall, 2010.
2. J. Y. Wong, "Theory of Ground Vehicles", 3rd Edition, Wiley-Interscience, 2001.
3. Rajesh Rajamani, "Vehicle Dynamics and Control", 1st edition, Springer, 2005.
4. Thomas D. Gillespie, "Fundamentals of Vehicle Dynamics", Society of Automotive Engineers Inc, 1992.
5. G. Nakhaie Jazar, "Vehicle Dynamics: Theory and Application", 1st Edition, Springer, 2008.

CO	PO					
	1	2	3	4	5	6
1	3		3	1	2	1

2	3		3	2	2	1
3	3		3	2	2	1
4	3		3	2	2	1
5	3		3	2	2	1
Avg.	3		3	1.8	2	1



ED3252

VIBRATION ANALYSIS AND CONTROL

Attested
L T P C
2 0 2 3

COURSE OBJECTIVES: The main learning objective of this course is to prepare the students to acquire

knowledge on Vibration, and its control strategies for practical applications.

UNIT I FUNDAMENTALS OF VIBRATION 6

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 6

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

UNIT III MULTI-DEGREE FREEDOM SYSTEM AND CONTINUOUS SYSTEM 6

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 – Longitudinal Vibration of Rods.

UNIT IV VIBRATION AND NOISE CONTROL 6

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 6

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.

Laboratory Experiments 30

List of Experiments:

1. Verification of law of springs in an undamped spring-mass system arranged in series, parallel and series-parallel fashions
2. Determination of stiffness and natural frequency of undamped spring-mass systems arranged in series, parallel and series-parallel fashions
3. Determination of natural frequency a single rotor shaft system
4. Determination of critical speed of shaft
5. Dynamic balancing of a rotor
6. Determination of natural frequency, damping coefficient and mode shapes of specimens supported at its ends
7. Forced vibration of a component vibrated through sine and random profiles – Determination of natural frequency and durability

TOTAL 60

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

- CO1** Apply the basic concepts of vibration in damped and undamped systems and the concepts of dynamic balancing technique to balance various components
- CO2** Determine the natural frequencies and mode shapes of the two-degree freedom systems.
- CO3** Calculate the natural frequencies and mode shapes of the multi-degree freedom and continuous systems
- CO4** Control the vibration and noise levels in a body
- CO5** Measure and analyze the vibration levels in a body

REFERENCES:

1. Singiresu S. Rao, "Mechanical Vibrations", Pearson Education Inc., 2017.
2. Graham Kelly. S and Shashidhar K. Kudari, "Mechanical Vibrations", Tata McGraw –Hill Publishing Com. Ltd., 2007.

3. William T. Thomson, "Theory of Vibration with Applications", Taylor & Francis, 2003.
4. Ramamurti. V, "Mechanical Vibration Practice with Basic Theory", Narosa Publishing House, 2000.
5. Rao V Dukkupati, "Vibration Analysis", Narosa Publishing House, 2004.

CO	PO					
	1	2	3	4	5	6
1	3		3	2	2	1
2	3		3	2	2	1
3	3		3	2	2	1
4	3		3	2	2	1
5	3		3	2	2	1
Avg.	3		3	2	2	1



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COURSE OBJECTIVES

1. To make the students to understand the basic principles of fluid flow, heat transfer, computational fluid dynamics (CFD) and its applications
1. To enlighten the students on the fundamental governing equations and turbulence models used in CFD solvers
2. To enable the students to understand grid generation techniques and post processing techniques.

UNIT I INTRODUCTION 6

Introduction to fluid flow and heat transfer – Mathematical description of fluid flow and heat transfer, incompressible and compressible flows, turbulent flows, boundary layer theory. Introduction to Computational Fluid Dynamics (CFD) – Objectives, modelling process, 2D and 3D simulations, advantages, limitations, application domains, software tools.

UNIT II GOVERNING EQUATIONS 6

Mass and momentum conservation equations, Energy conservation equation, Equation of state, Species transport equations, Scalar transport equations. Turbulence models – RANS, LES and DNS models.

UNIT III GRID GENERATION AND POST PROCESSING TECHNIQUES 6

Surface preparation, Volume meshing – cell types, structured, unstructured and hybrid meshing. Considerations for accurate and fast solutions. Mesh generation techniques, dynamic meshing, overset meshing, mesh size control, y^+ and wall layer, adaptive mesh refinement, grid independence study. Post processing techniques – Vector plot, scalar plot, streamline plot, flow animation, x-y plot, surface area and mass flow integrated reports

UNIT IV NUMERICAL METHODS 6

Finite volume method, Discretization schemes – First order, higher order and hybrid schemes, stability of schemes. Steady and unsteady flow solvers – CG and AMG solvers, SIMPLE, SIMPLER & PISO solution algorithms. Initial and boundary conditions, material properties, solver control, convergence criteria, parallel processing.

UNIT V ADVANCED CFD SIMULATIONS 6

Compressible flow, conjugate heat transfer, VOF, MRF, porous media, radiation, combustion and emission simulations. Fluid flow and heat transfer modelling of IC engine, thermal systems, power generation and storage systems, turbomachinery etc. Introduction to fluid-structure interaction modelling

TOTAL: 30 PERIODS**LABORATORY EXPERIMENTS (30 PERIODS):**

1. Prepare a closed surface geometry for a given application as per given dimensions
2. Clean-up a raw geometry for the given flow domain and mark different boundaries
3. Prepare surface mesh and volume mesh as per given size and quality criteria
4. Prepare volume meshing with different grid controls like wall layering, boundary refinement, etc.
5. Perform a simple fluid flow analysis as per given problem description
6. Perform a simple heat transfer analysis as per given problem description
7. Perform an advanced CFD analysis as per given problem description.

COURSE OUTCOMES:

On successful completion of this course the student will be able to

- CO1** Understand the basic principles of fluid flow, heat transfer, computational fluid dynamics (CFD) and its applications
- CO2** Analyse the governing equations and boundary conditions
- CO3** Create grid for any simulation domain and post process various simulations

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- CO4** Setup solvers and perform all common simulations
CO5 Perform advance fluid flow and heat transfer simulations

REFERENCES:

1. Versteeg and Malalasekera, N, "An Introduction to computational Fluid Dynamics The Finite Volume Method," Pearson Education, Ltd., Second Edition, 2014.
2. Ghoshdastidar, P.S., "Computer Simulation of Flow and Heat Transfer", Tata McGraw-Hill Publishing Company Limited, New Delhi, 1998.
3. Muralidhar, K., and Sundararajan, T., "Computational Fluid Flow and Heat Transfer", Narosa Publishing House, New Delhi, 2003.
4. Subas and V.Patankar "Numerical heat transfer fluid flow", Hemisphere Publishing Corporation,1980.
5. Jiyuan Tu, Guan Heng Yeoh, Chaogun Liu, "Computational Fluid Dynamics A Practical Approach" Butterworth – Heinemann An Imprint of Elsevier, Madison, U.S.A., 2008
6. John D. Anderson . JR. "Computational Fluid Dynamics The Basics with Applications" McGraw-Hill International Editions, 1995.

CO	PO					
	1	2	3	4	5	6
1	3	2	1	1	1	1
2	3	1	2	1	1	-
3	3	1	2	3	1	-
4	3	1	2	3	3	-
5	3	2	2	3	3	3
Avg.	3	2	2	2	3	2



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COURSE OBJECTIVES: To understand and apply the principles of economics in process selection and the design recommendations for casting, forming, machining, welding and assembly.

UNIT I INTRODUCTION AND CASTING 9

Introduction – Economics of process selection – General design principles for manufacturability;
Design considerations for: Sand cast parts – Permanent mold cast parts – Investment cast parts – Die cast parts.

UNIT II FORMING 9

Design considerations for: Metal extruded parts – Stamped parts – Cold headed parts – Forged parts.

UNIT III MACHINING 9

Design considerations for: Turned parts – Drilled parts – Milled parts - Planed, shaped and slotted parts– Broached parts – Cylindrically Ground parts (Center & Centerless).

UNIT IV WELDING 9

Arc welding – Design considerations for: Cost reduction – Minimizing distortion – Weld strength – Weldment & heat treatment. Resistance welding – Design considerations for: Spot – Seam. Soldering & Brazing: Design recommendations.

UNIT V ASSEMBLY 9

Design for assembly – Minimizing the no. of parts – Guidelines for assembly improvement – Design considerations for: Rivets – Screw fasteners – Automatic assembly. Case studies.

TOTAL: 45 HOURS

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

- CO1:** Apply the principles of economics in process selection. Apply the design recommendations for casting.
CO2: Apply the design recommendations for forming.
CO3: Apply the design recommendations for machining.
CO4: Apply the design recommendations for welding.
CO5: Apply the design recommendations for assembly.

REFERENCES:

1. James G. Bralla, "Handbook of Product Design for Manufacture", McGraw Hill Book Co., 1986.
2. Henry Peck, "Designing for Manufacture", Sir Isaac Pitman & Sons Ltd., 1973.
3. Matousek, "Engineering Design", Blackie & Sons, 1956.
4. O. Molloy, E.A. Warman, S. Tilley, "Design for Manufacturing and Assembly Concepts, Architectures and Implementation", Springer, 2012.
5. Ancuta Carmen Păcurar (Ed), "Applications of Design for Manufacturing and Assembly", IntechOpen Publishers, 2019.

CO	PO					
	1	2	3	4	5	6
1	3	2	3	3	2	2
2	3	2	3	3	2	2
3	3	2	3	3	2	2
4	3	2	3	3	2	2
5	3	2	3	3	2	2
Avg.	3	2	3	3	2	2

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COURSE OBJECTIVES: To understand and apply the principles of automation in product manufacturing systems.

UNIT I INTRODUCTION TO AUTOMATED MANUFACTURING SYSTEMS 9

Production Systems – Automation in Production Systems – Automation Principles & Strategies – Manufacturing Industries and Products – Manufacturing Operations – Production Facilities (Low – Medium – High) – Production Performance Metrics – Manufacturing Costs.

UNIT II AUTOMATION AND CONTROL TECHNOLOGIES 9

Basic Elements of an Automated System – Advanced Automation Functions – Levels of Automation – Fundamentals of NC Technology – Computers and Numerical Control – Applications of NC – NC Part Programming – Robot Anatomy and Related Attributes – Robot Control Systems – End Effectors – Applications of Industrial Robots – Robot Programming – Robot Accuracy and Repeatability.

UNIT III ADVANCED MANUFACTURING SYSTEMS 9

Cellular Manufacturing Systems (CMS): Group Technology – Part Families – Machine Groups – Cellular Manufacturing – Applications – Analysis – Rank-order Clustering Technique – Hollier Method (Arranging Machines in a GT Cell) – Opitz Parts Classification and Coding System. Flexible Manufacturing Systems (FMS): Definition – Flexibility Test – Types – Components – Applications – Benefits – Analysis – Bottleneck Model.

UNIT IV MATERIAL HANDLING & IDENTIFICATION 9

Material Handling Equipment – Material Transport Equipment – Introduction to Storage Systems – Automated Storage Systems – Overview of Automatic Identification Methods – Bar Code Technology – Radio Frequency Identification – Other AIDC Technologies.

UNIT V MANUFACTURING SUPPORT SYSTEMS 9

Process Planning – Make or Buy Decision – Computer-Aided Process Planning (CAPP) – Retrieval & Generative CAPP – Production (Manufacturing) Planning: Aggregate Production Planning – Master Production Schedule – Material Requirements Planning (MRP-I) – Capacity Planning – Production (Manufacturing) Control – Shop Floor Control (SFC) – Inventory Control (IC) – Manufacturing Resource Planning (MRP-II) – Enterprise Resource Planning (ERP).

TOTAL: 45

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

- CO1** Apply the principles of automation in manufacturing systems.
- CO2** Apply the concepts of automation control technologies in CNC programming and Industrial Robots.
- CO3** Apply the group technology and flexibility concepts in Cellular Manufacturing Systems and Flexible Manufacturing Systems respectively.
- CO4** Apply the principles of material handling and identification technologies in modern manufacturing systems.
- CO5** Apply the principles of process planning, production planning and control in modern manufacturing systems.

REFERENCES:

1. Mikell P. Groover, "Automation, Production Systems, and Computer – Integrated Manufacturing", 4th Ed., PHI Learning Pvt. Ltd., New Delhi, 2018.
2. Chris McMahon and Jimmie Browne, "CAD/CAM – Principles, Practice and Manufacturing Management", 2nd Ed., Pearson Education, Asia, 2001.
3. Ibrahim Zeid and R. Sivasubramanian, "CAD / CAM – Theory and Practice", 2nd Ed., Tata McGraw Hill, 2010.
4. P. N. Rao, "CAD /CAM – Principles and Applications", 2nd Ed., Tata McGraw Hill, 2004.

5. P. Radhakrishnan, S. Subramanyan and V. Raju, "CAD / CAM / CIM", 2nd Edition, New Age International (Pvt.) Ltd. Publishers, 2003.

CO	PO					
	1	2	3	4	5	6
1	3	2	3	3	2	2
2	3	2	3	3	2	2
3	3	2	3	3	2	2
4	3	2	3	3	2	2
5	3	2	3	3	2	2
Avg.	3	2	3	3	2	2



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COURSE OBJECTIVES: To understand and apply the principles and concepts in Human Factor Engineering for Product Design and Development.

UNIT I INTRODUCTION & DESIGN TO FIT TASKS, PROCESSES, AND PEOPLE 9

Introduction - Ergonomic Design - Human-Centered Design - Ergonomic Criteria - Models of Human Performance - Macro-ergonomics - Ergonomic Methods - Ergonomic Design Principles - Visual Graphs of Operations - Analysis of Tasks and Jobs.

UNIT II DESIGN OF THE PHYSICAL ENVIRONMENT, WORK AREAS, TOOLS, AND EQUIPMENT 9

Cleanliness, Clutter, and Disorder - Temperature and Humidity - Lighting and Illumination - Noise - Applied Anthropometry - Design of Work Areas and Stations - Design of Tools and Equipment - Protective Equipment for the Operator.

UNIT III DESIGN & ANALYSIS OF PHYSICAL TASKS - MEASURING & PREDICTING HUMAN PERFORMANCE – LEARNING CURVE 9

Methods Improvement - Motion and Micro-motion Study - Manual Materials Handling - Probabilistic Assumptions - Time Study - Performance Leveling - Determining Allowances - Maintaining Standards - Indirect Performance Measurement - Criteria Other Than Time - Synthetic Data Systems - Standard Data Systems - Cognitive Modeling - Learning Curve Models - Fitting Learning Curves.

UNIT IV DESIGN OF COMMUNICATION, DISPLAY & CONTROL 9

Communication Theory - Human Information Processing - Display Design - Hazard Communication - Control Systems - Manual Control - Design of Controls - Fuzzy Control - Supervisory Control.

UNIT V DESIGN OF PRODUCT QUALITY & MACRO-ERGONOMICS OF OCCUPATIONAL SAFETY AND HEALTH 9

Quality Management and Customer-Driven Design - Usability Analysis and Testing - Designed Experiments - Fundamental Concepts of Industrial Safety and Health - Contemporary Occupational Health and Safety Management - Hazards and Control Measures - Warnings and Safety Programs.

TOTAL: 45

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

- CO1** Apply the fundamental concepts and principles of ergonomics in product design and development
- CO2** Apply the principles of work place design & equipment design in product design and development
- CO3** Apply the principles of physical task design in product design and development. Apply the measurement and prediction methods of human performance with relation to learning curve theory in product design and development.
- CO4** Apply the principles of communication, display & control design in product design and development
- CO5** Apply the principles of product quality in product design and development. Apply the principles of macro-ergonomics of occupational safety and health.

REFERENCES:

1. Mark R. Lehto & James R. Buck, "Introduction to Human Factors & Ergonomics for Engineers", Taylor & Francis, NewYork, 2008.
2. Chandler Allen Phillips, "Human Factors Engineering", John Wiley and sons, New York,2000
3. Mark S Sanders, "Human Factors in Engineering and Design", McGraw Hill, New York,1993.
4. Martin Helander, "A guide to Human Factors and Ergonomics", 2nd Edition, CRC, Taylor & Francis Group 2006.
5. McCormik, J., "Human Factors Engineering and Design", McGraw Hill, 1992.

CO	PO					
	1	2	3	4	5	6
1	2	2	3	3	1	3
2	2	2	3	3	1	3
3	2	2	3	3	1	3
4	2	2	3	3	1	3
5	2	2	3	3	1	3
Avg.	2	2	3	3	1	3



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COURSE OBJECTIVES: To understand and apply the principles and concepts in IPR for Product Design and Development.

UNIT I IMPORTANCE OF IPR IN PRODUCT DESIGN 9

Introduction – Legal Concept of Property – Kinds of Properties - Movable Property - Immovable Property. I.P. and Classification of I.P.– Patents, Industrial Designs, Copy Right, Trade Mark, Trade Secret - Importance of I.P. and Terms of protection, Legal scopes and challenges, national and international protection.

UNIT II PROTECTING INVENTIONS THROUGH PATENTS 9

What are Inventions? – Patentable Inventions - Inventions not patentable – Objectives of Patent protection - Recognised conditions for Patentability – Originality of Inventions – Novelty – Non-obviousness – Utility - Exclusive rights conferred by a Patent – National Protection – International Protection. - Patent Filing Procedure and Prosecution - Infringement of Patents –Acquisition and Transfer of Patent Rights - Patents for improvements.

UNIT III PROTECTING INDUSTRIAL DESIGN OF A PRODUCT 9

Industrial Design - Subject matter of Industrial Designs - Requirements for obtaining protection for industrial Design – Differences between Patent protection and Industrial design Protection – benefits of Industrial Design protection – National and International Procedure for filing – Rights granted to ‘Design’ holders.

UNIT IV PROTECTING SOFTWARE CODES, DESIGN MANUALS AND BUSINESS BRANDS 9

Software codes, Design drawings and technical manuals – Protection through Copyright - Works in which Copy Right subsists – Meaning of the word ‘Original’ – Fair dealing - Rights of Owners of Copy Rights – Procedures - Authorities and Institutions under the Copy Right Act – Infringement and remedies. Creation and protection of Business brands - Trademarks (T.M.) – Different types of Trademarks – Service Mark – Classification Mark – Collective Mark - Importance of T.M. – Difference between registered T.M. and T.M. in use – Basic requirements for the registration of T.M. – Procedure for registration – Rights of registered T.M. owners – Infringement and remedies

UNIT V INTELLECTUAL PROPERTY MANAGEMENT AS APPLIED TO PRODUCT DESIGN 9

Introduction to Intellectual Property Management (IPM) – Need for I.P. management - Interrelationships between legal advocacy and IPM – Role of Legal Practitioners – Role of Managers – I.P. Commercialisation – I.P. Audit and its Importance

TOTAL: 45

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

- CO1** Apply the importance of IPR in Product Design & Development.
- CO2** Apply the protection principles behind patents in Product Design & Development.
- CO3** Apply the protection principles behind industrial design in Product Design & Development.
- CO4** Apply the protection principles behind software codes, design manuals, business brands in Product Design & Development.
- CO5** Apply the IPR management principles in Product Design and Development.

REFERENCES:

1. N.S.Gopalakrishnan & T.G.Agitha, ‘Principles of Intellectual Property’, Eastern Book Company, 2014.
2. Mathew Thomas, “Understanding Intellectual Property”, Eastern Book Company, 2016.
3. G.B.Reddy, “Intellectual Property Rights and The Law” Intellectual Property Rights and the Law”, Gogia Law Agency, 2020.
4. N.R.Subbaram, “Patent law – Practices and Procedures”, Wadhwa, Second Edition, 2007.

5. N.R.Subbaram, "Demystifying Intellectual Property Rights", Lexis Nexis Butterworths Wadhwa, 2009.

CO	PO					
	1	2	3	4	5	6
1	2	3	3	2	1	3
2	2	3	3	2	1	3
3	2	3	3	2	1	3
4	2	3	3	2	1	3
5	2	3	3	2	1	3
Avg.	2	3	3	2	1	3



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COURSE OBJECTIVES: To understand and apply the principles and concepts in Metals & Non-Metals for Product Design and Development.

UNIT I METALS AND NON-METALS 9

Ferrous metals – Non ferrous metals – Alloys – Plastics – Reinforced plastics - Composites – Rubbers – Elastomeric materials – Ceramics - Glasses – Design limiting properties - Properties - Manufacturing process – Process trees – Interaction of process and properties.

UNIT II MATCHING MATERIAL TO DESIGN 9

Design process – Material and process information for design – Selection, Screening, ranking – Stiffness and weight – Manipulating the modulus and density – Stiffness limited design – Plasticity, yielding and ductility – Elastic and plastic problems.

UNIT III FRACTURE, FRICTION AND WEAR LIMITED DESIGN 9

Strength and toughness – Vibration and resonance – Fatigue – Solutions to fracture problems – Tribological properties – Materials to manage friction and wear.

UNIT IV ADVANCED APPLICATIONS 9

Materials for high temperature – Conductors, insulators and dielectrics – Magnetic materials – Material for optical devices – Materials for durability – Oxidation, Corrosion, and degradation – Joining processes.

UNIT V SUSTAINABLE MATERIAL MANAGEMENT 9

Global material foot print – Sustainable Development Goals - SDG 12 - sustainable consumption and production patterns - Importance of circular economy – Materials recycling – Processes – Impacts on environment - Recycling Ferrous, Aluminum, other Non-ferrous metals, Plastics, Rubber, other materials.

TOTAL: 45

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

- CO1** Applying the metals and non-metals in product design and development
- CO2** Matching the materials in product design and development
- CO3** Applying the principles of fracture, friction and wear in product design and development.
- CO4** Applying the advanced application of materials in product design and development
- CO5** Applying the principles of sustainable materials management in product design and development.

REFERENCES:

1. Michael Ashby, Hugh Shercliff, David Cebon, “Materials – Engineering, Science, Processing and Design”, Elsevier, 2018.
2. Charles A Harper, “Handbook of Materials for Product Design”, Mc Graw Hill, 2207.
3. Mangonan P L, The Principles of Materials Selection for Engineering Design, Prentice Hall, 1999.
4. ASM Handbook: Materials Selection and Design, Volume 20, Taylor & Francis, 1997.
5. Mahmoud M Farag, Materials and Process Selection for Engineering Design, CRC Press, 2013.

CO	PO					
	1	2	3	4	5	6
1	3	2	3	3	3	3
2	3	2	3	3	3	3
3	3	2	3	3	3	3
4	3	2	3	3	3	3
5	3	2	3	3	3	3
Avg.	3	2	3	3	3	3

PD3005	QUALITY AND FINANCIAL CONCEPTS IN PRODUCT DEVELOPMENT	L T P C 3 0 0 3
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COURSE OBJECTIVES: To understand and apply the principles and concepts of Quality and finance in Product Design and Development.

UNIT I TRADITIONAL QUALITY TOOLS & RELIABILITY 9

Seven Statistical Tools of Quality – Problems in Box Plot and Pareto Chart – Multivariable Charts and 3D Plot – Statistical Process Control: Problems in Mean and Range Chart; p, np, u and c chart – Reliability: Hazard / Failure Rate; Mean Time Between Failure; Simple problems in Series; Parallel; Combination; Standby Systems.

UNIT II NEW MANAGEMENT TOOLS 9

New Seven Management Tools – Benchmarking: Types; Process; Benefits – Quality Function Deployment (QFD): Concept; Benefits; Process; House of Quality: Structure and Methodology – FMEA Procedure; benefits.

UNIT III LEAN TOOLS 9

Key Tools in Lean Production / Manufacturing – 4R Total Improvement – PDSA Cycle: Phases; Benefits – Kaizen and Kairyo – 5S House Keeping – TPM: Definition; Objective; Pillars; Step – Six Sigma: Definition; Concept; Process (DMAIC Methodology) – Project selection for Six Sigma (Types of Quality Problems).

UNIT IV EMBODIMENT AND ROBUST DESIGN 9

Embodiment Design: Basic methods: Refining geometry and layout – General process of product embodiment – Embodiment checklist – Advanced methods: Systems modeling – Mechanical embodiment principles – Robust Design: Definition; Process Steps.

UNIT V FINANCIAL CONCEPTS 9

Financial Planning: Definition; Need; Sources; Capital Structure; Capitalization; Term Loans; Short term Finance; Venture Capital; Export Finance – Working Capital Management: Definition; Significance; Assessment; Factors; Sources; Management.

TOTAL: 45

COURSE OUTCOMES:

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

- CO1** Apply the traditional quality tools and reliability concepts product design and development
- CO2** Apply the new management tools in product design and development
- CO3** Apply the lean tools in product design and development.
- CO4** Apply the principles of embodiment and robust in product design and development
- CO5** Apply the principles of financial concepts in product design and development.

REFERENCES:

1. AmitavaMitra, “Fundamentals of Quality control and improvement”, 2nd Edition, Pearson Education Asia, 2002.
2. Besterfiled, “Total Quality Management”, Pearson India, 2006.
3. James R. Evens, William M Lindsay, “The Management and control of Quality”, 6th Edition, South – Western
4. Karl T. Ulrich, Steven D. Eppinger, “Product Design and Development”, TATA McGraw Hill, 3rd Edition, 2003.
5. Kevin Otto & Kristin Wood, “Product Design Techniques in Reverse Engineering and New Product Development”, Pearson Education, 2001.
6. Khanka.S.S, “Entrepreneurial Development”, S.Chand Publishers, 2015.
7. Vijayakumar and Raju, “Total Quality Management”, Lakshmi Publication, 2015.

CO	PO					
	1	2	3	4	5	6
1	2	2	3	2	1	3
2	2	2	3	2	1	3
3	2	2	3	2	1	3
4	2	2	3	2	1	3
5	2	2	3	2	1	3
Avg.	2	2	3	2	1	3



Attested


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 Centre for Academic Courses
 Anna University, Chennai-600 025

COURSE OBJECTIVES: To understand and apply the principles and concepts in Tool Design for Product Design and Development.

UNIT I IMPORTANCE OF TOOLING AND ITS LIMITATIONS ON PRODUCT DESIGN 9

Introduction – Toolings – Press tools, Moulds and Dies – Limitations on Product design - Plastics, Rubber, Composites - Aluminum - Zinc alloys – Cast/mold in place part designs – Post Insert part designs – Handling undercuts in part design.

UNIT II TOOL DESIGN FOR NEAR NET SHAPE PRODUCTS 9

Near net-shape part design – Different kinds of near net-shape processes – Tooling for Plastics, Aluminium, Zinc alloys – Injection, compression, transfer mould design – Essential features of moulds – Die casting die designs - Essential features of dies – Rotational moulds – Blow moulds – Dip coating mandrels.

UNIT III TOOL DESIGN FOR SHEET METAL PRODUCTS 9

Sheet metal part design – Different kinds of sheet metal operations and its application in product design – Die design for Blanking, Fine blanking, Piercing, Bending, Drawing, Forming.

UNIT IV POST PROCESSING JIGS AND FIXTURES 9

Need for post processing and its importance on reduction of complexity in product design - Design of Jigs and Fixtures in general - Jigs and Fixtures for Post Operations of Mouldings, Castings, Sheet metal parts.

UNIT V INTERSECTION OF TOOL DESIGN AND PRODUCT DESIGN 9

Case studies – Auto motive components – Parts for home appliances – consumer products etc.

TOTAL: 45

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

CO1 Apply the fundamental concepts and principles behind tooling and its limitations in Product Design & Development.

CO2 Apply the tool design principles in near net shape products.

CO3 Apply the tool design principles in near net shape products.

CO4 Apply the tool design principles in the post processing of jigs & fixtures.

CO5 Apply the intersection of tool design principles in product design using various case studies.

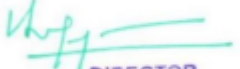
REFERENCES:

1. ASTME, “Fundamentals of Tool Design”, Wilson, Frank W., Ed.-in-Chief; American Society of Tool and Manufacturing Engineers, 1962.
2. Donaldson et al, “Tool Design”, Tata Mc Graw Hill, 1976.
3. Chitale and Gupta, “Product Design and Manufacturing”, Prentice Hall of India Pvt. Ltd. House Publishers, 2003.
4. Charles A Harper, “Handbook of Materials for Product Design”, Mc Graw Hill, 2007.
5. Robert A. Malloy, “Plastic Part Design for Injection Molding: An Introduction”, Hanser Pub., 2010.

CO	PO					
	1	2	3	4	5	6
1	3	1	3	3	2	2
2	3	1	3	3	2	2
3	3	1	3	3	2	2
4	3	1	3	3	2	2
5	3	1	3	3	2	2
Avg.	3	1	3	3	2	2



Attested


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