

**ANNA UNIVERSITY, CHENNAI**  
**UNIVERSITY DEPARTMENTS**  
**REGULATIONS - 2019**  
**CHOICE BASED CREDIT SYSTEM**  
**M.E. PRODUCT DESIGN AND DEVELOPMENT**

**THE VISION OF THE DEPARTMENT OF MECHANICAL ENGINEERING**

We, at the Department of Mechanical Engineering, Anna University shall strive hard to impart knowledge and state-of-the-art training to our students and expose them to broad areas of Mechanical Engineering, namely Design, Manufacturing, Energy, Thermal Sciences and currently related interdisciplinary areas, so that they can later practice their profession at home or abroad keeping in mind the needs and concern of the society they represent, safeguarding values, ethics and be instrumental in bringing about an overall technological development.

**THE MISSION OF THE DEPARTMENT OF MECHANICAL ENGINEERING**

1. To deliver knowledge in Mechanical Engineering and Materials Science and Engineering with high educational standards so that the outgoing students are employable and globally competitive.
2. To produce graduate and post graduate engineers with core competency as well as relevant software skills and social responsibility.
3. To be dynamic in imparting knowledge to students depending upon the changing national and International needs

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**M.E. PRODUCT DESIGN AND DEVELOPMENT (PART - TIME)**

**PROGRAMME EDUCATIONAL OBJECTIVES (PEOs):**

1. To prepare students to excel in new product design and development through application of knowledge and practical skills.
2. To provide students with a solid foundation in mathematical modeling of engineering problems required for bringing new products fast into the market.
3. To provide students with required scientific and engineering knowledge so as to comprehend, analyze, design and create innovative products and solutions for real life problems.
4. To inculcate professional and ethical values in students and enable them to work in multidisciplinary teams.
5. To provide students an academic environment which can facilitate life-long learning needed for a successful career in new product development

**PROGRAMME OUTCOMES (POs):**

After going through the four years of study, our Industrial Engineering Graduates will exhibitability to:

<b>PO#</b>	<b>Graduate Attribute</b>	<b>Programme Outcome</b>
1	Engineering knowledge	Apply knowledge of mathematics, basic science and engineering science.
2	Problem analysis	Identify, formulate and solve engineering problems.
3	Design/development of solutions	Design a system or process to improve its performance, satisfying its constraints.
4	Conduct in investigations of complex problems	Conduct experiments & collect, analyze and interpret the data.
5	Modern tool usage	Apply various tools and techniques to improve the efficiency of the system.
6	The Engineer and society	Conduct themselves to uphold the professional and social obligations.
7	Environment and sustainability	Design the system with environment consciousness and sustainable development.
8	Ethics	Interact in industry, business and society in a professional and ethical manner.
9	Individual and team work	Function in a multi-disciplinary team.
10	Communication	Proficiency in oral and written Communication.
11	Project management and	Implement cost effective and improved system.
12	Life-long learning	Continue professional development and learning as a life-long activity.



<b>YEAR 3</b>	SEM 4	Solid Freeform Manufacturing	√	√	√	√	√							
		Program Elective III												
		Program Elective V												
		Product Design Laboratory	√	√	√	√								√
	SEM 5	Program Elective V												
		Open Elective												
		Dissertation I	√	√	√	√	√			√	√	√	√	√
SEM 6	Dissertation II	√	√	√	√	√			√	√	√	√	√	

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**M.E. PRODUCT DESIGN AND DEVELOPMENT**

**SEMESTER I**

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
<b>THEORY</b>								
1.	ED5253	Integrated Product Design and Process Development	PCC	3	0	0	3	3
2.	ED5251	Designing with Advanced Materials	PCC	3	0	0	3	3
3.	PD5151	Creativity and Innovation	PCC	3	0	0	3	3
4.	RM5151	Research Methodology and IPR	RMC	2	0	0	2	2
<b>PRACTICALS</b>								
5.	PD5111	CAD Laboratory	PCC	0	0	4	4	2
<b>TOTAL</b>				<b>11</b>	<b>0</b>	<b>4</b>	<b>15</b>	<b>13</b>

**SEMESTER II**

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
<b>THEORY</b>								
1.	ED5153	Computer Applications in Design	PCC	3	0	0	3	3
2.	PD5201	Reverse Engineering	PCC	3	0	0	3	3
3.		Program Elective I	PEC	3	0	0	3	3
<b>PRACTICALS</b>								
4.	PD5211	Multibody Dynamics Laboratory	PCC	0	0	4	4	2
<b>TOTAL</b>				<b>9</b>	<b>0</b>	<b>4</b>	<b>13</b>	<b>11</b>

**SEMESTER III**

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
<b>THEORY</b>								
1	PD5351	Product Lifecycle Management	PCC	3	0	0	3	3
2	ED5252	Finite element Methods in Mechanical Design	PCC	3	1	0	4	4
3		Program Elective II	PEC	3	0	0	3	3
4.		Audit course – I*	AC	3	0	0	3	0
<b>PRACTICALS</b>								
5	ED5261	Simulation and Analysis Laboratory	PCC	0	0	4	4	2
<b>TOTAL</b>				<b>12</b>	<b>1</b>	<b>4</b>	<b>17</b>	<b>12</b>

\* Audit Course is optional.

**SEMESTER IV**

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
<b>THEORY</b>								
1.	CI5151	Solid Freeform Manufacturing	PCC	3	0	0	3	3
2.		Program Elective III	PEC	3	0	0	3	3
3.		Program Elective IV	PEC	3	0	0	3	3
4.		Audit course – II*	AC	2	0	0	2	0
<b>PRACTICALS</b>								
5.	PD5461	Product Design Laboratory	PCC	0	0	4	4	2
<b>TOTAL</b>				<b>11</b>	<b>0</b>	<b>4</b>	<b>15</b>	<b>11</b>

\* Audit Course is optional.

**SEMESTER V**

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
<b>THEORY</b>								
1.		Program Elective V	PEC	3	0	0	3	3
2.		Open Elective	OEC	3	0	0	3	3
<b>PRACTICALS</b>								
3.	PD5511	Dissertation I	EEC	0	0	12	12	6
<b>TOTAL</b>				<b>6</b>	<b>0</b>	<b>12</b>	<b>18</b>	<b>12</b>

**SEMESTER VI**

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
<b>PRACTICALS</b>								
1	PD5611	Dissertation II	EEC	0	0	24	24	12
<b>TOTAL</b>				<b>0</b>	<b>0</b>	<b>24</b>	<b>24</b>	<b>12</b>

**TOTAL NO. OF CREDITS : 71**

**PROGRAM CORE COURSE (PCC)**

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	ED5253	Integrated Product Design and Process Development	PCC	3	0	0	3	3
2.	ED5251	Designing with Advanced Materials	PCC	3	0	0	3	3
3.	PD5111	CAD Laboratory	PCC	0	0	4	4	2
4.	ED5153	Computer Applications in Design	PCC	3	0	0	3	3
5.	PD5201	Reverse Engineering	PCC	3	0	0	3	3
6.	PD5211	Multibody Dynamics Laboratory	PCC	0	0	4	4	2
7.	PD5351	Product Lifecycle Management	PCC	3	0	0	3	3
8.	ED5252	Finite Element Methods in Mechanical Design	PCC	3	1	0	4	4
9.	ED5261	Simulation and Analysis Laboratory	PCC	0	0	4	4	2
10.	CI5151	Solid Freeform Manufacturing	PCC	3	0	0	3	3
11.	PD5461	Product Design Laboratory	PCC	0	0	4	4	2

**PROGRAM ELECTIVE COURSES**

**SEMESTER II, ELECTIVE – I**

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	PD5001	Quality and Financial Concepts in Product Development.	PEC	3	0	0	3	3
2.	ED5081	Optimization Techniques in Design	PEC	3	0	0	3	3
3.	PD5002	Human Factors Engineering in Product Design	PEC	3	0	0	3	3

**SEMESTER III, ELECTIVE II**

SL. NO.	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CI5071	Design for Manufacturing and Assembly	PEC	3	0	0	3	3
2.	ED5083	Tribology in Design	PEC	3	0	0	3	3
3.	ED5073	Bearing Design and Rotor Dynamics	PEC	3	0	0	3	3

**SEMESTER IV, ELECTIVE III**

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	PD5071	Automated Product Manufacturing Systems	PEC	3	0	0	3	3
2.	IC5251	Computational Fluid Dynamics	PEC	3	0	0	3	3
3.	ED5154	Vibration Analysis and Control	PEC	3	0	0	3	3

**SEMESTER IV, ELECTIVE IV**

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	ED5084	Vehicle Dynamics	PEC	3	0	0	3	3
2.	ED5074	Composite Materials and Mechanics	PEC	3	0	0	3	3
3.	ED5077	Design of Hydraulic and Pneumatic Systems	PEC	3	0	0	3	3

**SEMESTER V, ELECTIVE V**

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	ED5072	Advanced Machine Tool Design	PEC	3	0	0	3	3
2.	ED5076	Design of Hybrid And Electric Vehicles	PEC	3	0	0	3	3
3.	ED5071	Advanced Finite Element Analysis	PEC	3	0	0	3	3

**RESEARCH METHODOLOGY AND IPR COURSES (RMC)**

SL. NO.	COURSE CODE	COURSE TITLE	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
			L	T	P		
1.	RM5151	Research Methodology and IPR	2	0	0	2	2

**OPEN ELECTIVE COURSES [OEC]**  
(Out of 6 Courses one Course must be selected)

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	OE5091	Business Data Analytics	OEC	3	0	0	3	3
2.	OE5092	Industrial Safety	OEC	3	0	0	3	3
3.	OE5093	Operations Research	OEC	3	0	0	3	3
4.	OE5094	Cost Management of Engineering Projects	OEC	3	0	0	3	3
5.	OE5095	Composite Materials	OEC	3	0	0	3	3
6.	OE5096	Waste to Energy	OEC	3	0	0	3	3

**AUDIT COURSES (AC)**

Registration for any of these courses is optional to students

SL. NO	COURSE CODE	COURSE TITLE	PERIODS PER			CREDITS
			L	T	P	
1.	AX5091	English for Research Paper Writing	2	0	0	0
2.	AX5092	Disaster Management	2	0	0	0
3.	AX5093	Sanskrit for Technical Knowledge	2	0	0	0
4.	AX5094	Value Education	2	0	0	0
5.	AX5095	Constitution of India	2	0	0	0
6.	AX5096	Pedagogy Studies	2	0	0	0
7.	AX5097	Stress Management by Yoga	2	0	0	0
8.	AX5098	Personality Development Through Life Enlightenment Skills	2	0	0	0
9.	AX5099	Unnat Bharat Abhiyan	2	0	0	0

**EMPLOYABILITY ENHANCEMENT COURSES (EEC)**

SL. NO	COURSE CODE	COURSE TITLE	CATEGORY	PERIODS PER WEEK			CREDITS	SEM
				L	T	P		
1	PD5511	Dissertation I	EEC	0	0	12	6	V
2	PD5611	Dissertation II	EEC	0	0	24	12	VI

<b>ED5253</b>	<b>INTEGRATED PRODUCT DESIGN AND PROCESS DEVELOPMENT</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
		<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**COURSE OBJECTIVES:**

1. To Understand the principles of generic development process; product planning; customer need analysis for new product design and development.
2. To enhance the understanding of setting product specifications and generate, select, screen, and test concepts for new product design and development.
3. To apply the principles of product architecture and the importance of industrial design principles and DFM principles for new product development.
4. To expose the different Prototyping techniques, Design of Experiment principles to develop a robust design and importance to patent a developed new product.
5. Applying the concepts of economics principles; project management practices in development of new product.

**UNIT – I INTRODUCTION TO PRODUCT DESIGN AND IDENTIFICATION OF CUSTOMER NEED 9**

Need for IPPD - Strategic importance of Product development –Duration and Cost of Product Development – Challenges in Product Development – Product Development Processes and Organizations – Activities in Identifying Customer Needs

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

Plan and establish Target and Final product specifications – Activities of Concept Generation - Task - Concept Selection methodology – Concept Screening and Scoring - Concept Testing Methodologies.

**UNIT – III PRODUCT ARCHITECTURE , INDUSTRIAL DESIGN AND DESIGN FOR MANUFACTURE 9**

Product Architecture – Implications and establishing the architecture – Delayed Differentiation – Platform Planning - Need and impact of industrial design - Industrial design process - management of the industrial design process - assessing the quality of industrial design – DFM Definition - Estimation of Manufacturing cost- Reducing the component costs, costs of supporting function and assembly costs – Impact of DFM decision on other factors.

**UNIT – IV PROTOTYPING, ROBUST DESIGN AND INTELLECTUAL PROPERTY 9**

Prototype basics - Principles of prototyping - Planning for prototypes - Robust design – Seven step process of Robust Design through Design of Experiments- Need and Importance of Intellectual Property – Seven step process of preparing a patent document.

**UNIT – V PRODUCT DEVELOPMENT ECONOMICS AND MANAGING PROJECTS 9**

Economic Analysis – Elements of Economic Analysis - Understanding and representing tasks-baseline project planning - accelerating the project - project execution – postmortem project evaluation.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

1. Apply the principles of generic development process; product planning; customer need analysis for new product design and development.
2. Set product specifications and generate, select, screen, test concepts for new product design and development.
3. Apply the principles of product architecture, industrial design and design for manufacturing principles in new product development.
4. Apply the adopt Prototyping techniques and Design of Experiment principles to develop a robust design and document a new product for patent.
5. Apply of the concepts of economics principles; project management practices in accelerating the new product development activity.

**REFERENCES:**

1. Karl T.Ulrich, Steven D.Eppinger, Anita Goyal, "Product Design and Development", McGraw –Hill Education (India) Pvt. Ltd, 4<sup>th</sup> Edition, 2012.
2. Kenneth Crow, "Concurrent Engineering/Integrated Product Development". DRM Associates, 6/3, Via Olivera, Palos Verdes, CA 90274(310) 377-569, Workshop Book
3. Kevin N Otto, Kristin L Wood, "Product Design – Techniques in Reverse Engineering and New Product Development", Pearson Education, Inc, 2016
4. Stephen Rosenthal, "Effective Product Design and Development", Business One Orwin, Homewood, 1992
5. Stuart Pugh, "Total Design – Integrated Methods for successful Product Engineering", Addison Wesley Publishing, Neyourk, NY, 1991.

0.3- Low

0.6- Medium

0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.9	0.9	0.9	0.9							0.9	0.9	0.9	0.6
2	0.9	0.6	0.9	0.9	0.9					0.6		0.6	0.9	0.6	0.9
3	0.9	0.6	0.6	0.9	0.6								0.6	0.6	0.3
4	0.9	0.9	0.9	0.9	0.9					0.6		0.9	0.9	0.9	0.9
5	0.9	0.6	0.6	0.9	0.9					0.6		0.9	0.9	0.9	0.9

**ED5251****DESIGNING WITH ADVANCED MATERIALS**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**OBJECTIVES:**

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

1. analyzing the different strengthening and failure mechanism of the metals
2. applying the effects of metallurgical parameters in the materials design
3. analyzing the relationship between the selection of materials and processing
4. developing the novel material through understanding the properties of the existing metallic materials
5. analyzing the different materials used in the engineering applications

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

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



**OBJECTIVES:**

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

1. Applying the principles of essential theory of creativity in new product design and development.
2. Applying the principles of various methods and tools for creativity in new product design and development.
3. Applying the design principles of creativity in new product design and development.
4. Applying the various innovation principles and practices in new product design and development.
5. Applying the principles of innovation management in new product design and development.

**UNIT – I INTRODUCTION TO ESSENTIAL THEORY OF CREATIVITY 9**

Directed creativity: The Need for Creative Thinking in the Pursuit of Quality - Essential Theory for Directed Creativity: Definitions and the Theory of the Mechanics of Mind; Heuristics and Models: Attitudes, Approaches, and Actions That Support Creative Thinking

**UNIT – II METHODS AND TOOLS FOR CREATIVITY 9**

Three basic principles behind the tools of directed creativity – Tools that prepare the mind for creative thought – Tools that stimulate the imagination for new idea – Development and action: the bridge between mere creativity and the rewards of innovation - ICEDIP: Inspiration, Clarification, Distillation, Perspiration, Evaluation and Incubation – Creativity and Motivation.

**UNIT – III DESIGN AND APPLICATION OF CREATIVITY 9**

Three levels of emotional design: Visceral, Behavioral and Reflective – Process design, reengineering, and creativity – Creativity and customer needs analysis – Innovative product and service design – Creative problem solving and incremental improvement

**UNIT – IV INNOVATION PRINCIPLES & PRACTICES 9**

Methods of Creativity Activation: Morphological Box – Requirements for Inventive Problem Solving – Altshuller's Engineering Parameters – Altshuller's Inventive Principles – Altshuller's Contradiction Matrix Algorithm.

**UNIT – IV INNOVATION MANAGEMENT 9**

Disruptive Innovation Model – Two Types of Disruption – 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: The Disruptive Growth Engine.

**TOTAL :45 PERIODS****OUTCOMES:**

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

1. Apply the principles of essential theory of creativity in new product design and development.
2. Apply the principles of various methods and tools for creativity in new product design and development.
3. Apply the design principles of creativity in new product design and development.
4. Apply the various innovation principles and practices in new product design and development.
5. Apply the principles of innovation management in new product design and development.

**REFERENCES:**

1. Clayton M. Christensen and Michael E. Raynor, "The Innovator's Solution", Harvard Business School Press, Boston, USA, 2003.
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. Paul E. Plsek, "Creativity, Innovation and Quality", ASQ Quality Press, Milwaukee, Wisconsin, 2000.
5. Semyon D. Savransky, "Engineering of Creativity – TRIZ", CRC Press, New York, USA, 2000.

0.3- Low

0.6- Medium

0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.3	0.3	0.6	0.3		0.3						0.3	0.6	0.3	
2	0.3	0.6	0.9	0.9		0.3						0.3	0.6	0.3	
3	0.3	0.6	0.9	0.6		0.3	0.6	0.3				0.3	0.6	0.3	0.3
4	0.3	0.3	0.9	0.6		0.3	0.3	0.3			0.6	0.3	0.6	0.3	
5	0.3	0.3	0.3	0.3		0.3	0.3				0.6	0.3	0.6	0.3	0.3

RM5151

RESEARCH METHODOLOGY AND IPR

L T P C  
2 0 0 2

**COURSE OBJECTIVES:**

To impart knowledge and skills required for research and IPR:

- Problem formulation, analysis and solutions.
- Technical paper writing / presentation without violating professional ethics
- Patent drafting and filing patents.

**UNIT I RESEARCH PROBLEM FORMULATION 6**

Meaning of research problem- Sources of research problem, criteria characteristics of a good research problem, errors in selecting a research problem, scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations

**UNIT II LITERATURE REVIEW 6**

Effective literature studies approaches, analysis, plagiarism, and research ethics.

**UNIT III TECHNICAL WRITING /PRESENTATION 6**

Effective technical writing, how to write report, paper, developing a research proposal, format of research proposal, a presentation and assessment by a review committee.

**UNIT IV INTRODUCTION TO INTELLECTUAL PROPERTY RIGHTS (IPR) 6**

Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.

**UNIT V INTELLECTUAL PROPERTY RIGHTS (IPR)****6**

Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc.

Traditional knowledge Case Studies, IPR and IITs.

**TOTAL: 30 PERIODS****COURSE OUTCOMES:**

1. Ability to formulate research problem
2. Ability to carry out research analysis
3. Ability to follow research ethics
4. Ability to understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity
5. Ability to understand about IPR and filing patents in R & D.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
<b>CO1</b>	✓	✓										
<b>CO2</b>	✓											
<b>CO3</b>	✓							✓				
<b>CO4</b>	✓				✓							
<b>CO5</b>	✓					✓						✓

**REFERENCES:**

1. Asimov, "Introduction to Design", Prentice Hall, 1962.
2. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd, 2007.
3. Mayall, "Industrial Design", McGraw Hill, 1992.
4. Niebel, "Product Design", McGraw Hill, 1974.
5. Ranjit Kumar, 2nd Edition, "Research Methodology: A Step by Step Guide for beginners" 2010

**PD5111****CAD LABORATORY****L T P C****0 0 4 2**

1. **CAD Introduction.** **30**
2. **Sketcher**
3. **Solid modeling** – Extrude, Revolve, Sweep, etc and Variational sweep, Loft ,etc
4. **Surface modeling** –Extrude, Sweep, Trim, etc and Mesh of curves, Free form etc
5. **Feature manipulation** – Copy, Edit, Pattern, Suppress, History operations etc.
6. **Assembly** - Constraints, Exploded Views, Interference check
7. **Drafting** - Layouts, Standard & Sectional Views, Detailing & Plotting.

Exercises in modeling and drafting of mechanical components - assembly using parametric and feature based packages. 2D TO 3D CONVERSION.

**30****TOTAL: 60 PERIODS**

**OUTCOMES:**

On Completion of the course the student will be able to

1. Use the modern engineering tools necessary for engineering practice
2. Draw 2D part drawings, sectional views and assembly drawings as per standards.
3. Create 3D Model on any CAD software.
4. Convert 3D solid models into 2D drawing and prepare different views, sections and dimensioning of part models.

0.3- Low

0.6- Medium

0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.3	0.6	0.3	0.3									0.6	0.6	0.3
2	0.3	0.6	0.3	0.3									0.6	0.6	0.3
3	0.3	0.6	0.3	0.3									0.6	0.6	0.3
4	0.3	0.6	0.3	0.3									0.6	0.6	0.3
5	0.3	0.6	0.3	0.3									0.6	0.6	0.3

**ED5153****COMPUTER APPLICATIONS IN DESIGN**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**COURSE OBJECTIVES:**

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

**UNIT – I INTRODUCTION TO COMPUTER GRAPHICS  
FUNDAMENTALS**
**9**

Overview of Graphics systems: Video Display Devices, Raster-Scan System, Random-Scan Systems, Graphics Monitors and Workstations, Input Devices, Hard-Copy Devices, Graphics Software.

Output primitives: Line Drawing Algorithm - DDA, Bresenham's and Parallel Line Algorithm. Circle generating algorithm – Midpoint Circle Algorithm.

Geometric Transformations: Coordinate Transformations, Windowing and Clipping, 2D Geometric transformations-Translation, Scaling, Shearing, Rotation and Reflection, Composite transformation, 3D transformations.

**UNIT – II CURVES AND SURFACES MODELLING**
**9**

Introduction to curves - Analytical curves: line, circle and conics – synthetic curves: Hermite cubic spline- Bezier curve and B-Spline curve – curve manipulations.

Introduction to surfaces - Analytical surfaces: Plane surface, ruled surface, surface of revolution and tabulated cylinder – synthetic surfaces: Hermitebicubic surface- Bezier surface and B-Spline surface-surface manipulations.

**UNIT – III NURBS AND SOLID MODELING**
**9**

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

**UNIT – IV VISUAL REALISM 9**  
 Hidden Line removal, Hidden Surface removal, – Hidden Solid Removal algorithms - Shading – Coloring.  
 Animation - Conventional, Computer animation, Engineering animation - types and techniques.

**UNIT – V ASSEMBLY OF PARTS AND PRODUCT LIFE CYCLE MANAGEMENT 9**  
 Assembly modeling – Design for manufacture – Design for assembly – computer aided DFMA - inferences of positions and orientation - tolerances analysis –Center of Gravity and mass property calculations - mechanism simulation. Graphics and computing standards - Data Exchange standards. Product development and management – new product development –models utilized in various phases of new product development – managing product life cycle.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

1. Solve 2D and 3D transformations for the basic entities like line and circle.
2. Formulate the basic mathematics fundamental to CAD system.
3. Use the different geometric modeling techniques like feature based modeling, surface modeling and solid modeling.
4. Create geometric models through animation and transform them into real world systems
5. 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, 6<sup>th</sup> Edition, 2015.
3. David Rogers, James Alan Adams “Mathematical Elements for Computer Graphics” 2<sup>nd</sup> Edition, Tata McGraw-Hill edition.2002
4. Donald D Hearn and M. Pauline Baker “Computer Graphics C Version”, Prentice Hall, Inc., 2<sup>nd</sup> Edition, 1996.
5. Ibrahim Zeid, "Mastering CAD/CAM", McGraw Hill, 2<sup>nd</sup> Edition, 2006
6. William M Newman and Robert F.Sproull “Principles of Interactive Computer Graphics”, Mc Graw Hill Book Co. 1<sup>st</sup>Edition, 2001.

0.3- Low

0.6- Medium

0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.6	0.9	0.6		0.9					0.6			0.9		0.6
2	0.6	0.9	0.6		0.9					0.6			0.9		0.6
3	0.6	0.9	0.6		0.9					0.6			0.9		0.6
4	0.6	0.9	0.6		0.9					0.6			0.9		0.6
5	0.6	0.9	0.6		0.9					0.6			0.9		0.6

**OBJECTIVES:**

The main learning objective of this course is to prepare students for:

1. Applying the fundamental concepts and principles of reverse engineering in product design and development.
2. Applying the concept and principles material characteristics, part durability and life limitation in reverse engineering of product design and development.
3. Applying the concept and principles of material identification and process verification in reverse engineering of product design and development.
4. Applying the concept and principles of data processing, part performance and system compatibility in reverse engineering of product design and development.
5. Analyzing the various legal aspect and applications of reverse engineering in product design and development.

**UNIT- I                    INTRODUCTION TO REVERSE ENGINEERING & GEOMETRIC                    9**  
**FORM**

Definition – Uses – The Generic Process – Phases – Computer Aided Reverse Engineering - Surface and Solid Model Reconstruction – Dimensional Measurement – Prototyping.

**UNIT – II                    MATERIAL CHARACTERISTICS, PART DURABILITY AND LIFE                    9**  
**LIMITATION**

Alloy Structure Equivalency – Phase Formation and Identification – Mechanical Strength – Hardness –Part Failure Analysis – Fatigue – Creep and Stress Rupture – Environmentally Induced Failure.

**UNIT – III                    MATERIAL IDENTIFICATION AND PROCESS VERIFICATION                    9**

Material Specification - Composition Determination - Microstructure Analysis - Manufacturing Process Verification.

**UNIT – IV                    DATA PROCESSING, PART PERFORMANCE AND SYSTEM                    9**  
**COMPATIBILITY**

Statistical Analysis – Data Analysis – Reliability and the Theory of Interference – Weibull Analysis – Data Conformity and Acceptance – Data Report – Performance Criteria – Methodology of Performance Evaluation – System Compatibility.

**UNIT – V                    ACCEPTANCE, LEGALITY AND INDUSTRIAL APPLICATIONS OF RE                    9**

Legality of Reverse Engineering – Patent – Copyrights –Trade Secret – Third-Party Materials – Reverse Engineering in the Automotive Industry; Aerospace Industry; Medical Device Industry.

**TOTAL : 45 PERIODS**

**OUTCOMES:**

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

1. Apply the fundamental concepts and principles of reverse engineering in product design and development.
2. Apply the concept and principles material characteristics, part durability and life limitation in reverse engineering of product design and development.
3. Apply the concept and principles of material identification and process verification in reverse engineering of product design and development.
4. Apply the concept and principles of data processing, part performance and system compatibility in reverse engineering of product design and development.
5. Analyze the various legal aspect and applications of reverse engineering in product design and development.

**REFERENCE BOOKS:**

1. Wego Wang, Reverse Engineering Technology of Reinvention, CRC Press, 2011.
2. Vinesh Raj and Kiran Fernandes, “Reverse Engineering: An Industrial Perspective”, Springer-Verlag London Limited 2008.
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

0.3- Low

0.6- Medium

0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.6	0.3	0.3								0.3	0.6	0.3	
2	0.9	0.9	0.3	0.6								0.3	0.6	0.3	
3	0.9	0.9	0.3	0.6		0.3	0.3	0.3				0.3	0.6	0.3	
4	0.9	0.9	0.3	0.6		0.3	0.3	0.3				0.3	0.6	0.3	
5	0.3	0.6	0.3	0.3		0.3	0.3	0.3				0.3	0.6	0.3	

PD5211

MULTIBODY DYNAMICS LABORATORY

L T P C  
0 0 4 2

**OBJECTIVE:**

- To expose the students to understand the forces and torques that come into action in various kinds of mechanical systems

**Exercise for this lab**

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

**TOTAL: 30 PERIODS**

**OUTCOMES:**

- The students get familiarized with modeling different systems and importing them into the multi body dynamic software.
- The students will be trained to obtain required dynamic properties by conducting multi body dynamic tests.
- The students will learn how to use this data in additional stress analysis software.

0.3- Low

0.6- Medium

0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.9	0.9	0.6								0.3	0.6	0.3	
2	0.9	0.9	0.9	0.6								0.3	0.6	0.3	
3	0.9	0.9	0.9	0.6								0.3	0.6	0.3	
4	0.9	0.9	0.9	0.6								0.3	0.6	0.3	
5	0.9	0.9	0.9	0.6								0.3	0.6	0.3	

**COURSE OBJECTIVES**

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

<b>UNIT-I</b>	<b>HISTORY, CONCEPTS AND TERMINOLOGY OF PLM</b>	<b>9</b>
Introduction to PLM, Need for PLM, opportunities of PLM, Different views of PLM - Engineering Data Management (EDM), Product Data Management (PDM), Collaborative Product Definition Management (cPDM), Collaborative Product Commerce (CPC), Product Lifecycle Management (PLM). PLM/PDM Infrastructure – Network and Communications, Data Management, Heterogeneous data sources and applications		
<b>UNIT-II</b>	<b>PLM/PDM FUNCTIONS AND FEATURES</b>	<b>9</b>
User Functions – Data Vault and Document Management, Workflow and Process Management, Product Structure Management, Product Classification and Programme Management. Utility Functions – Communication and Notification, data transport, data translation, image services, system administration and application integration		
<b>UNIT-III</b>	<b>DETAILS OF MODULES IN A PDM/PLM SOFTWARE</b>	<b>9</b>
Case studies based on top few commercial PLM/PDM tools – Teamcenter, Windchill, ENOVIA, Aras PLM, SAP PLM, Arena, Oracle Agile PLM and Autodesk Vault.		
<b>UNIT-IV</b>	<b>ROLE OF PLM IN INDUSTRIES</b>	<b>9</b>
Case studies on PLM selection and implementation (like auto, aero, electronic) - other possible sectors, PLM visioning, PLM strategy, PLM feasibility study, change management for PLM, financial justification of PLM, barriers to PLM implementation, ten step approach to PLM, benefits of PLM for–business, organisation, users, product or service, process performance		
<b>UNIT-V</b>	<b>BASICS ON CUSTOMISATION/INTEGRATION OF PDM/PLM SOFTWARE</b>	<b>9</b>
PLM Customization, use of EAI technology (Middleware), Integration with legacy data base, CAD, SLM and ERP		

**Total =45 Periods****OUTCOMES:**

On Completion of the course the student will be able to

1. Summarize the history, concepts and terminology of PLM
2. Use the functions and features of PLM/PDM
3. Use different modules offered in commercial PLM/PDM tools.
4. Implement PLM/PDM approaches for industrial applications.
5. Integrate PLM/PDM with legacy data bases, CAx& ERP systems

**REFERENCES:**

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

0.3- Low

0.6- Medium

0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.3	0.6	0.6	0.3								0.3	0.6	0.3	
2	0.6	0.6	0.6	0.3								0.3	0.6	0.3	
3	0.6	0.3	0.6	0.3								0.3	0.6	0.3	0.3
4	0.3	0.3	0.9	0.3								0.3	0.6	0.3	
5	0.3	0.3	0.3	0.3								0.3	0.6	0.3	0.3

**ED5252**

**FINITE ELEMENT METHODS IN MECHANICAL DESIGN**

**L T P C**

**3 1 0 4**

**OBJECTIVES**

- To learn mathematical models for one dimensional problems and their numerical solutions
- To learn two dimensional scalar and vector variable problems to determine field variables
- To learn Isoparametric transformation and numerical integration for evaluation of element matrices
- To study various solution techniques to solve Eigen value problems
- To learn solution techniques to solve non-linear problems

**UNIT-I**

**FINITE ELEMENT ANALYSIS OF ONE DIMENSIONAL PROBLEMS**

**9+3**

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+3**

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+3**  
 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+3**  
 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+3**  
 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 = 60 PERIODS**

**OUTCOMES:**

On Completion of the course the student will be able to

1. Develop mathematical models for one dimensional problems and their numerical solutions
2. Determine field variables for two dimensional scalar and vector variable problems
3. Apply Isoparametric transformation and numerical integration for evaluation of element matrices
4. Apply various solution techniques to solve Eigen value problems
5. 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 McGrawHill, 2005
3. Rao, S.S., “The Finite Element Method in Engineering”, 6<sup>th</sup> Edition, Butterworth-Heinemann,2018.
4. Reddy,J.N. “Introduction to the Finite Element Method”, 4<sup>th</sup> Edition, Tata McGrawHill,2018
5. Seshu.P, “Text Book of Finite Element Analysis”, PHI Learning Pvt. Ltd., NewDelhi, 2012.
6. TirupathiR.Chandrupatla and Ashok D.Belegundu, “Introduction to Finite Elements in Engineering”, International Edition, Pearson Education Limited, 2014.

0.3- Low                      0.6- Medium                      0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.6	0.6	0.6	0.9								0.9	0.3	0.6
2	0.9	0.6	0.6	0.6	0.9								0.9	0.3	0.6
3	0.9	0.6	0.6	0.6	0.9								0.9	0.3	0.6
4	0.9	0.6	0.6	0.6	0.9								0.9	0.3	0.6
5	0.9	0.6	0.6	0.6	0.9								0.9	0.3	0.6

**OBJECTIVES:**

- To give exposure to software tools needed to analyze engineering 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 PERIODS****List of Equipments / Software:**

Finite Element Analysis packages

**COURSE OUTCOMES:**

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

1. Solve engineering problems numerically using Computer Aided Finite Element Analysis packages

0.3- Low

0.6- Medium

0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.9	0.9	0.6								0.3	0.6	0.3	
2	0.9	0.9	0.9	0.6								0.3	0.6	0.3	
3	0.9	0.9	0.9	0.6								0.3	0.6	0.3	
4	0.9	0.9	0.9	0.6								0.3	0.6	0.3	
5	0.9	0.9	0.9	0.6								0.3	0.6	0.3	

**OBJECTIVES:**

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

**UNIT I INTRODUCTION****9**

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

**UNIT II DESIGN FOR ADDITIVE MANUFACTURING****9**

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

**UNIT III VAT POLYMERIZATION AND SHEET LAMINATION PROCESSES****9**

Stereolithography Apparatus (SLA): Principles – Photo Polymerization of SL Resins - Pre Build Process – Part-Building and Post-Build Processes - Part Quality and Process Planning, Recoating Issues - Materials - Advantages - Limitations and Applications. Digital Light Processing (DLP) - Materials - Process - Advantages and Applications.

Laminated Object Manufacturing (LOM): Working Principles - Process - Materials, Advantages, Limitations and Applications. Ultrasonic Additive Manufacturing (UAM) - Process - Parameters - Applications. Case Studies.

**UNIT IV MATERIAL EXTRUSION AND POWDER BED FUSION PROCESSES****9**

Fused deposition Modeling (FDM): Working Principles - Process - Materials and Applications. Design Rules for FDM.

Selective Laser Sintering (SLS): Principles - Process - Indirect and Direct SLS - Powder Structure – Materials - Surface Deviation and Accuracy - Applications. Multijet Fusion.

Selective Laser Melting (SLM) and Electron Beam Melting (EBM): Principles – Processes – Materials – Advantages - Limitations and Applications. Case Studies.

**UNIT V JETTING AND DIRECT ENERGY DEPOSITION PROCESSES****9**

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

Material Jetting: Multi Jet Modelling (MJM) - Principles - Process - Materials - Advantages and Limitations.

Laser Engineered Net Shaping (LENS): Processes- Materials- Advantages - Limitations and Applications. Case Studies.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

At the end of this course, the students shall be able to:

CO1: Recognize the importance in the evolution of SFM/AM, proliferation into the various fields and its effects on supply chain.

CO2: Evaluate the design for AM and its importance in the quality of fabricated parts.

CO3: Acquire knowledge on principles and applications of polymerization and sheet lamination processes with case studies.

CO4: Acquire knowledge on principles of material extrusion and powder bed fusion processes and design guidelines.

CO5: Perceive jetting and direct energy deposition processes and their applications.

	PO						PSO			
	1	2	3	4	5	6	1	2	3	4
<b>CO1</b>	0.6	0.9	0.3	0.9	0.9	0.6	0.9	0.9	0.9	0.9
<b>CO2</b>	0.9	0.6	0.9	0.9	0.9	0.6	0.9	0.9	0.9	0.6
<b>CO3</b>	0.9	0.9	0.6	0.9	0.6	0.3	0.6	0.9	0.9	0.9
<b>CO4</b>	0.9	0.9	0.6	0.9	0.6	0.3	0.6	0.9	0.9	0.9
<b>CO5</b>	0.9	0.9	0.6	0.9	0.6	0.3	0.6	0.9	0.9	0.9

**REFERENCES:**

1. Andreas Gebhardt and Jan-Steffen Hotter, "Additive Manufacturing:3D Printing for Prototyping and Manufacturing", Hanser publications Munchen, Germany, 2015. ISBN: 978-1-56990-582-1.
2. Ben Redwood, Brian Garret, Filemon Schöffner, and Tony Fadel, "The 3D Printing Handbook: Technologies, Design and Applications", 3D Hubs B.V., Netherland, 2017. ISBN-13: 978-9082748505.
3. Ian Gibson, David W. Rosen and Brent Stucker, "Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing" Springer - New York, USA, 2<sup>nd</sup> Edition, 2015. ISBN-13: 978-1493921126.
4. Liou, L.W. and Liou, F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 1<sup>st</sup> Edition, 2007 FL, USA. ISBN- 9780849334092.
5. Milan Brandt., "Laser Additive Manufacturing 1st Edition Materials, Design, Technologies, and Applications", Woodhead Publishing, UK, 2016. ISBN- 9780081004333.

**PD5461****PRODUCT DESIGN LABORATORY**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>0</b>	<b>0</b>	<b>4</b>	<b>2</b>

**OBJECTIVES:**

- To give exposure to develop digital and physical prototype models using RP machine / clay models of a new product/ existing product

The students in a group have to develop digital and physical prototype models using RP machine / clay 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 demonstration of the new product developed and oral examination on the same by internal examiners.

**TOTAL : 60 PERIODS**

**OUTCOMES:**

1. Appreciate the use of physical prototype models for evaluating product concept
2. Apply theoretical knowledge to design and development of physical products using clay, wood, sheet metal and RP techniques

0.3- Low

0.6- Medium

0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.9	0.9	0.9	0.9			0.9				0.9	0.9	0.9	0.9
2	0.9	0.9	0.6	0.9	0.6	0.6			0.6	0.6		0.6	0.9	0.6	0.9
3															
4															
5															

**PD5001**

**QUALITY AND FINANCIAL CONCEPTS IN PRODUCT DEVELOPMENT**

**L T P C**  
**3 0 0 3**

**OBJECTIVES:**

The main learning objective of this course is to prepare students for:

1. Applying the concept and principles of quality tools such as seven old and new tools of quality, SPC, multivariate charts, box plots, Pareto charts in product development.
2. Applying the concept and principles of quality tools such as benchmarking, QFD, HoQ, and reliability in product development.
3. Applying the concept and principles of Six Sigma and Lean manufacturing in product development.
4. Applying the concept and principles of robust design and embodiment design in product development.
5. Applying the concept and principles of finance and working capital management in product development.

**UNIT – I**

**QUALITY TOOLS I**

**9**

Seven Statistical Tools of Quality – New Seven Management Tools – Multivariable Charts and 3D Plot – Statistical Process Control: Problems in Mean and Range Chart; p, np, u and c chart; Problems in Box Plot and Pareto Chart.

**UNIT – II**

**QUALITY TOOLS II**

**9**

Benchmarking: Types; Process; Benefits – Quality Function Deployment (QFD): Concept; Benefits; Process; House of Quality: Structure and Methodology – Reliability: Hazard / Failure Rate; Mean Time Between Failure; Simple problems in Series; Parallel; Combination; Standby Systems.

**UNIT – III**

**DESIGN FOR SIX SIGMA AND LEAN PRINCIPLES**

**9**

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

**UNIT – IV ROBUST DESIGN AND EMBODIMENT DESIGN 9**

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

**UNIT – V FINANCE AND WORKING CAPITAL MANAGEMENT 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 PERIODS**

**OUTCOMES:**

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

1. Apply the concept and principles of quality tools such as seven old and new tools of quality, SPC, multivariate charts, box plots, Pareto charts in product development.
2. Apply the concept and principles of quality tools such as benchmarking, QFD, HoQ, and reliability in product development.
3. Apply the concept and principles of Six Sigma and Lean manufacturing in product development.
4. Apply the concept and principles of robust design and embodiment design in product development.
5. Apply the concept and principles of finance and working capital management in product 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.

0.3- Low

0.6- Medium

0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.6	0.9		0.6								0.3	0.6	0.3	
2	0.6	0.9		0.6								0.3	0.6	• 0.3	
3	0.6	0.9	0.6	0.3								0.3	0.6	0.3	
4	0.6	0.9	0.9	0.6								0.3	0.6	0.3	
5	0.3	0.3		0.3							0.6	0.3	0.6	0.3	

**COURSE OBJECTIVES:**

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

**UNIT – I UNCONSTRAINED OPTIMIZATION TECHNIQUES 9**

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

**UNIT – II CONSTRAINED OPTIMIZATION TECHNIQUES 9**

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

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

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

**UNIT – IV ADVANCED OPTIMIZATION TECHNIQUES 9**

Multi stage 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.

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:

1. Formulate unconstrained optimization techniques in engineering design application.
2. Formulate constrained optimization techniques for various application.
3. Implement neural network technique to real world design problems.
4. Apply genetic algorithms to combinatorial optimization problems.
5. 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.T and Mizutani E., "Neuro-Fuzzy and Soft Computing", Pearson Education.2015,
3. Johnson Ray, C., "Optimum design of mechanical elements", Wiley, 2nd Edition 1980.
4. Kalyanmoy Deb, "Optimization for Engineering Design: Algorithms and Examples", PHI Learning Private Limited, 2<sup>nd</sup> Edition, 2012.
5. Rao Singiresu S., "Engineering Optimization – Theory and Practice", New Age International Limited, New Delhi, 3rd Edition, 2013.
6. Rajasekaran S and VijayalakshmiPai, G.A, "Neural Networks, Fuzzy Logic and Genetic Algorithms", PHI, 2011

0.3- Low

0.6- Medium

0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.9	0.6	0.6	0.6								0.9	0.6	0.9
2	0.9	0.9	0.6	0.6	0.6								0.9	0.6	0.9
3	0.9	0.9	0.6	0.6	0.6								0.9	0.6	0.9
4	0.9	0.9	0.6	0.6	0.6								0.9	0.6	0.9
5	0.9	0.9	0.6	0.6	0.6								0.9	0.6	0.9

**PD5002****HUMAN FACTORS ENGINEERING IN PRODUCT DESIGN**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**OBJECTIVES:**

The main learning objective of this course is to prepare students for

1. Applying the fundamental concepts and principles of ergonomics in product design and development.
2. Applying the concept and principles of work place design in product design and development.
3. Applying the concept and principles of equipment design in product design and development.
4. Applying the concept and principles of environmental design in product design and development.
5. Applying the concept and principles of cognitive ergonomics & human factor application in product design and development.

**UNIT I FUNDAMENTALS OF ANTHROPOMETRY IN ERGONOMICS 9**

Anthropometry and its uses in ergonomics – Principles of applied anthropometry in ergonomics – Application of anthropometry in design – Design for everyone.

**UNIT II ERGONOMICS IN WORK PLACE DESIGN 9**

Design for standing workers – Design for seated workers – Design for repetitive task – Design for manual handling activity task – Design for work capacity, stress, and fatigue.

**UNIT III ERGONOMICS IN EQUIPMENT DESIGN 9**

Design for visual displays – Design for auditory displays – Design for controls – Design for virtual environments.

**UNIT IV ERGONOMICS IN ENVIRONMENTAL DESIGN 9**

Heat, cold and the design of the physical environment – Vision, light and lighting – Hearing, sound, noise and vibration

**UNIT V COGNITIVE ERGONOMICS & HUMAN FACTOR APPLICATION 9**

Human information processing, skill and performance – Human–computer interaction, memory and language – Human–machine interaction, human error and safety.

**TOTAL: 45 PERIODS**

**OUTCOMES:**

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

1. Apply the fundamental concepts and principles of ergonomics in product design and development.
2. Apply the concept and principles of work place design in product design and development.
3. Apply the concept and principles of equipment design in product design and development.
4. Apply the concept and principles of environmental design in product design and development.
5. Apply the concept and principles of cognitive ergonomics & human factor application in product design and development.

**REFERENCES:**

1. Bridger R S, "Introduction to Ergonomics", Taylor and Francis, London, 2003.
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.

0.3- Low

0.6- Medium

0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.9	0.9	0.9	0.6			0.3				0.3	0.3	0.6	0.3
2	0.9	0.9	0.9	0.9	0.6			0.3				0.3	0.3	0.6	0.3
3	0.9	0.9	0.9	0.9	0.9			0.3				0.3		0.6	0.3
4	0.9	0.9	0.9	0.6	0.9			0.3				0.3		0.6	0.3
5	0.9	0.9	0.9	0.6	0.9			0.3				0.3		0.3	0.3

**CI5071****DESIGN FOR MANUFACTURING AND ASSEMBLY**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**OBJECTIVES:**

- To impart the knowledge in design for manufacturing and assembly (DFM/A) principles.
- To be acquainted with the use of DFM/A tools.
- To elaborate DFM/A system architecture.
- To outline product model and interfacing.
- To discuss system implementation by considering various manufacturing constraints.

**UNIT I INTRODUCTION****9**

Implementation of concurrent engineering- Issues involved in introducing design for manufacturing and assembly (DFM/A)-DFM/A principles and techniques - Current state of commercial DFM/A packages- Requirements for a new generation of DFM/A Systems -Knowledge-based approaches to DFM/A-Interfacing design (CAD) and DFM/A Systems, Case studies.

**UNIT II DFM/A METHODOLOGIES****9**

Total design Environment-Tools: Quality function deployment, Failure modes and effects analysis (FMEA)- Design for manufacturing and assembly principles: Mechanical Assembly-General DFA principles- DFA guidelines: General mechanical, General electro-mechanical - Design for manual assembly- Design for electronics Assembly-Design for Testability-Machining-Currently available manufacturability analysis tools- Integrating DFM/ A into different design regimes - Case studies

**UNIT III DFM/A SYSTEM ARCHITECTURE****9**

System of system design Scenario --Manufacturing Aspects- Design - Analysis-Methods of data representation- Object-oriented Approach-Databases- Design for Manufacturing-Design for Assembly-Conceptual architecture- Analysis and integration and inference- Interfaces-Analysis engine concepts- Process model- Control and system operation- Control issues.

**UNIT IV PRODUCT MODEL AND CAD INTERFACING****9**

Product Model - Structure and object - Oriented Approach-Classes and objects - Polymorphism and inheritance - Modelling concepts- Product model structure overview- Detailed product model- Storage of object-Oriented product models - Features in CAD-DFM integration - Feature representation methodologies- Classification of features -Hierarchical structure of the features - Interfacing with different CAD systems - Interface mechanisms for applications-knowledge engineering and inferencing

**UNIT V SYSTEM IMPLEMENTATION****9**

System for design for PCB assembly, small parts assembly, mechanical assembly, machining Generic architecture operational aspects- Architecture realization- Control module

**TOTAL: 45 PERIODS****COURSE OUTCOMES:**

At the End of the Course, the students will be able to

CO1: Describe the design for manufacturing principles.

CO2: Implement DFM/A principles in the required applications.

CO3: Use DFM/A tools.

CO4: Select appropriate DFM/A system architecture with the given manufacturing aspects.

CO5: Create Product model.

	PO						PSO			
	1	2	3	4	5	6	1	2	3	4
<b>CO1</b>	0.9			0.9		0.6	0.9	0.6	0.6	0.3
<b>CO2</b>	0.9			0.9		0.6	0.9	0.6	0.6	0.6
<b>CO3</b>	0.9			0.9		0.6	0.9	0.6	0.6	0.6
<b>CO4</b>	0.9	0.6		0.9		0.6	0.9	0.6	0.6	0.6
<b>CO5</b>	0.9	0.9		0.9		0.6	0.9	0.6	0.9	0.6

**REFERENCES:**

1. David M. Anderson, "Design for manufacturability ", CRC Press.,United States, 2014,ISBN 9781482204926.
2. Geoffrey Boothroyd, Peter Dewhurst, and Winston A. Knight, "Product Design, for Manufacture, and Assembly", 3<sup>rd</sup> Edition, CRC Press., United States,2011, ISBN 9781420089271.
3. James G. Bralla, "Design for manufacturability handbook", McGraw Hill., United States, 1999, ISBN-13: 978-0070071391.
4. Molloy O., Tilley S., and Warman E., "Design for Manufacturing and Assembly Concepts, architectures and implementation", Springer., United Kingdom, 1998, Reprint 2012, ISBN: 978-1461376507.
5. Peck H., "Designing for manufacture", Sir Isaac Pitman & Sons Ltd., United States 1973.

**COURSE OBJECTIVES:**

- To study and measure the different types of surface features associated with the friction of metals and non-metals.
- To study the different types of wear mechanism and surface modification techniques.
- To analyze the various types of lubricants and lubrication system in the tribology.
- To develop the methodology for deciding lubricants and lubrication regimes for different operating conditions.
- To study the different types of high pressure contacts and rolling bearings.

**UNIT-I SURFACE INTERACTION AND FRICTION 9**

Surface Topography – Surface features-Properties and measurement – Surface interaction – Laws of friction- Adhesive Theory of Sliding Friction – Static friction -Rolling Friction – Friction in extreme conditions –Thermal considerations in sliding contact

**UNIT-II WEAR AND SURFACE TREATMENT 9**

Types of wear mechanism – Laws of wear –Theoretical wear models- Abrasive wear – Adhesive wear – Fatigue wear – fretting wear – Cavitation wear - Wear of Metals and Nonmetals – Surface treatments – Surface modifications –Laser processing – instrumentation – International standards in friction and wear measurements

**UNIT-III LUBRICANTS AND LUBRICATION REGIMES 9**

Lubricants and their physical properties- Viscosity and other properties of oils –Additives-and selection of Lubricants- Lubricants standards ISO,SAE,AGMA, BIS standards – Lubrication Regimes –Solid Lubrication-Dry and marginally lubricated contacts- Boundary Lubrication- Hydrodynamic lubrication-Elasto and plasto hydrodynamic - Magneto hydrodynamic lubrication – Hydro static lubrication – Gas lubrication

**UNIT-IV THEORY OF HYDRODYNAMIC AND HYDROSTATIC LUBRICATION 9**

Reynolds Equation,-Assumptions and limitations-One and two dimensional Reynolds Equation Reynolds and Sommerfeld boundary conditions- Pressure wave, flow, load capacity and friction calculations in Hydrodynamic bearings-Long and short bearings-Pad bearings and Journal bearings-Squeeze film effects-Thermal considerations-Hydrostatic lubrication of Pad bearing Pressure , flow , load and friction calculations-Stiffness considerations- Various types of flow restrictors in hydrostatic bearings

**UNIT-V HIGH PRESSURE CONTACTS AND ELASTO HYDRODYNAMIC LUBRICATION 9**

Rolling contacts of Elastic solids- contact stresses – Hertzian stress equation- Spherical and cylindrical contacts-Contact Fatigue life- Oil film effects- Elasto Hydrodynamic lubrication Theory Soft and hard EHL Reynolds equation for elasto hydrodynamic lubrication- - Film shape within and outside contact zones-Film thickness and friction calculation- Rolling bearings- Stresses and deflections-Traction drives

**TOTAL = 45 PERIODS**

**OUTCOMES:**

On Completion of the course the student will be able to

- Develop the knowledge on the surface features and its role on the friction behaviour of metals and nonmetals
- Understand the various types of wear mechanism and surface modification techniques
- Familiarize the different types of lubricants and lubrication systems in the tribology
- Methodology for deciding lubricants and lubrication regimes for different operating conditions
- Ability to understand the different types of high pressure contacts and rolling bearings

**REFERENCES:**

1. Rabinowicz.E, “Friction and Wear of materials”, John Willey & Sons ,UK,1995
2. Cameron, A. “Basic Lubrication Theory”, Ellis Herward Ltd., UK, 1981
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 G.W.Stachowiak& A.W .Batchelor , Engineering Tribology, Butterworth - Heinemann, UK, 2005

0.3- Low                      0.6- Medium                      0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.6	0.3	0.3		0.6							0.3	0.3	0.6	0.9
2	0.6	0.3	0.3		0.6							0.3	0.3	0.6	0.9
3	0.6	0.3	0.3		0.6							0.3	0.3	0.6	0.9
4	0.6	0.3	0.3		0.6							0.3	0.3	0.6	0.9
5	0.6	0.3	0.3		0.6							0.3	0.3	0.6	0.9

**ED5073**

**BEARING DESIGN AND ROTOR DYNAMICS**

**L T P C**  
**3 0 0 3**

The main learning objective of this course is to prepare students for:

- Apply and develop mathematical model of a system
- Applying the design and suggest bearings for specific applications
- Applying a fatigue life calculations for various types of bearings
- Apply and analyze bearing behaviour
- Study the dynamics of rotors mounted on Hydrodynamic Bearings

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

**6**

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

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

**10**

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

**UNIT-III                      ROLLING CONTACTS SELECTION OF ROLLING                      10**  
**BEARINGS**

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

**UNIT-IV                      ROTOR DYNAMICS                      9**

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

**UNIT-V                      DYNAMICS OF ROTORMOUNTED ON HYDRODYNAMIC                      10**  
**BEARINGS**

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

**TOTAL =45 PERIODS**

**OUTCOMES:**

On Completion of the course the student will be able to

- understand application of various types of bearings and their operating principles
- design and suggest bearings for specific applications
- perform fatigue life calculations for various types of bearings,
- understand and analyze bearing behavior
- study the dynamics of rotors mounted on Hydrodynamic Bearings

**REFERENCES:**

1. Neale, M.J. “Tribology Hand Book”, Butterworth Heinemann, United Kingdom 2001
2. Cameron, A. “Basic Lubrication Theory”, Ellis Herward Ltd., UK, 1981
3. 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 G.W.Stachowiak & A.W .Batchelor , Engineering Tribology, Butterworth-Heinemann, UK, 2005

0.3- Low                      0.6- Medium                      0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.9	0.6			0.3							0.6	0.6	0.9
2	0.9	0.6	0.6		0.6			0.3					0.6	0.6	0.9
3	0.9	0.6	0.6		0.6			0.3					0.6	0.6	0.9
4	0.9	0.9	0.6		0.6			0.3					0.6	0.6	0.9
5	0.6	0.6	0.9	0.9	0.6			0.3					0.6	0.6	0.9

**OBJECTIVES:**

The main learning objective of this course is to prepare students for:

1. Applying the principles of automation and control techniques toward new product design and development.
2. Applying the principles of numerical control and industrial robotics toward new product design and development.
3. Applying the principles of manufacturing systems; manual and automated assembly systems; and material handling systems toward new product design and development.
4. Applying the principles of cellular manufacturing systems and flexible manufacturing systems toward new product design and development..
5. Applying the principles of manufacturing support systems toward new product design and development.

**UNIT – I AUTOMATION & CONTROL TECHNOLOGIES 8**

Introduction to CAD, CAM, CAD/CAM and CIM – Introduction to Manufacturing Systems – Automation in manufacturing Systems – Types of Automation – Reasons for Automation – Automation Strategies – Manufacturing Models and Metrics – Basic elements of an Automated System – Levels of Automation – Continuous versus Discrete Control – Computer Process Control

**UNIT – II NUMERICAL CONTROL & INDUSTRIAL ROBOTICS 10**

Elements of NC Manufacturing Systems – Computer Numerical Control – Axes and Co-ordinate Systems – Features, Advantages, Disadvantages and Limitations – Manual Part Programming – Robot Anatomy – Robot Control Systems – End Effectors – Sensors – Applications – Robot programming.

**UNIT – III MANUFACTURING SYSTEMS – MANUAL & AUTOMATED ASSEMBLY SYSTEMS – MATERIAL HANDLING SYSTEMS 9**

Components of Manufacturing Systems – Classification of Manufacturing Systems – Single Station Manufacturing cell and analysis – Manual Assembly line – Line Balancing – Automated Assembly System – Material Handling Equipment – Storage Systems.

**UNIT – IV CELLULAR MANUFACTURING & FLEXIBLE MANUFACTURING SYSTEMS 8**

Part Families – Classification and Coding – Production Flow analysis – Cellular Manufacturing Applications of Group Technology – Flexible Manufacturing Systems – Components – Applications and benefits – FMS planning – Quantitative analysis in FMS.

**UNIT – V MANUFACTURING SUPPORT SYSTEMS 10**

Process Planning – Computer Aided Process Planning – Production planning and Control Systems – Aggregate Planning and Master Production schedule – Material Requirement Planning – Capacity Planning – Shop Floor Control – Overview of Automatic Identification and Data capture – Bar Code Technology and Radio Frequency Identification.

**TOTAL:45 PERIODS****OUTCOMES:**

On successful completion of this course the students will be able:

1. Apply the principles of automation and control techniques toward new product design and development.
2. Apply the principles of numerical control and industrial robotics toward new product design and development.
3. Apply the principles of manufacturing systems; manual and automated assembly systems; and material handling systems toward new product design and development.
4. Apply the principles of cellular manufacturing systems and flexible manufacturing systems toward new product design and development..
5. Apply the principles of manufacturing support systems toward new product design and development.

**REFERENCES:**

1. Mikell P. Groover, "Automation, Production Systems, and Computer – Integrated Manufacturing", 3rd Ed., PHI Learning Pvt. Ltd., New Delhi, 2009.
2. Chris McMahon and Jimmie Browne, "CAD/CAM – Principles, Practice and Manufacturing Management", 2nd Ed., Pearson Education, Asia, 2001.
3. FarazdakHaideri, "CAD / CAM and Automation", 6th Edition, NiraliPrakashan, 2009.
4. Ibrahim Zeid and R. Sivasubramanian, "CAD / CAM – Theory and Practice", 2nd Ed., Tata McGraw Hill, 2010.
5. P. N. Rao, "CAD /CAM – Principles and Applications", 2nd Ed., Tata McGraw Hill, 20044.
- 4.Mikell P. Groover and Emory W. Zimmers, Jr., "CAD / CAM – Computer – Aided Design and Manufacturing", Pearson Education, 2003.
6. P. Radhakrishnan, S. Subramanyan and V. Raju, "CAD / CAM / CIM", 2nd Edition, New Age International (Pvt.) Ltd. Publishers, 2003.

0.3- Low

0.6- Medium

0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.9	0.9	0.9								0.3	0.6	0.3	
2	0.9	0.9	0.9	0.9								0.3	0.6	0.3	
3	0.9	0.9	0.9	0.9								0.3	0.6	0.3	
4	0.9	0.9	0.9	0.9								0.3	0.6	0.3	
5	0.9	0.9	0.9	0.9								0.3	0.6	0.3	

IC5251

**COMPUTATIONAL FLUID DYNAMICS**

**L T P C**  
**3 0 0 3**

**COURSE OBJECTIVES:**

- This course aims to introduce numerical modeling and its role in the field of heat, fluid flow and combustion it will enable the students to understand the various discretisation methods and solving methodologies and to create confidence to solve complex problems in the field of heat transfer and fluid dynamics.
- To develop finite volume discretised forms of the governing equations for diffusion processes.
- To develop finite volume discretised forms of the convection-diffusion processes.
- To develop pressure based algorithms for flow processes.
- To introduce various turbulence models, Large Eddy Simulation and Direct Numerical Simulation.

**UNIT – I GOVERNING DIFFERENTIAL EQUATIONS AND DISCRETISATION TECHNIQUES 8**

Basics of Heat Transfer, Fluid flow – Mathematical description of fluid flow and heat transfer – Conservation of mass, momentum, energy and chemical species - Classification of partial differential equations – Initial and Boundary Conditions – Discretisation techniques using finite difference methods – Taylor’s Series - Uniform and non-uniform Grids, Numerical Errors, Grid Independence Test.

**UNIT – II DIFFUSION PROCESSES : FINITE VOLUME METHOD 10**

Steady one-dimensional diffusion, Two and three dimensional steady state diffusion problems, Discretisation of unsteady diffusion problems – Explicit, Implicit and Crank-Nicholson’s schemes, Stability of schemes.

**UNIT – III CONVECTION-DIFFUSION PROCESSES : FINITE VOLUME METHOD 9**

One dimensional convection – diffusion problem, Central difference scheme, upwind scheme – Hybrid and power law discretization techniques – QUICK scheme.

**UNIT – IV FLOW PROCESSES : FINITE VOLUME METHOD 8**

Discretisation of incompressible flow equations – Pressure based algorithms, SIMPLE, SIMPLER & PISO algorithms.

**UNIT – V TURBULENCE MODELS 10**

Turbulence – RANS equation - Algebraic Models, One equation model, Two equation models –  $k-\epsilon$  & standard  $k-\epsilon$  model, Low Reynold number models of  $k-\epsilon$ , Large Eddy Simulation (LES), Direct Numerical Simulation (DNS) - Introduction. Solving simple cases using standard CFD codes.

**TOTAL:45 PERIODS****OUTCOME:**

On successful completion of this course the students will be able to:

- Analyse the governing equations and boundary conditions.
- Analyse various discretization techniques for both steady and unsteady diffusion problems.
- Analyse the various convection-diffusion problems by Finite-Volume method.
- Analyse the flow processes by using different pressure bound algorithms.
- Select and use the different turbulence models according to the type of flows.

**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.

0.3- Low

0.6- Medium

0.9- High

C O	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	-	-	-	-	-	0.6	-	-	-	-	0.3	0.9	0.6	0.3
2	0.9	0.6	0.6	0.6	0.3	0.3	0.6	-	-	-	0.6	0.6	0.6	0.9	-
3	0.3	0.3	0.3	0.3	0.6	-	-	0.3	0.6	-	0.9	-	-	-	0.9
4	0.3	0.3	-	0.3	0.3	-	-	0.3	0.3	-	0.9	0.6	-	0.6	-
5	0.3	-	-	-	-	0.6	0.9	0.3	-	-	0.6	0.3	0.9	-	-

**OBJECTIVES**

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

**UNIT-I FUNDAMENTALS OF VIBRATION 9+3**

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 9+3**

Introduction-Free Vibration Of Undamped And Damped - Forced Vibration With Harmonic Excitation System –Coordinate Couplings And Principal Coordinates.

**UNIT-III MULTI-DEGREE FREEDOM SYSTEM AND CONTINUOUS SYSTEM 9+3**

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

**UNIT-IV VIBRATION AND NOISE CONTROL 9+3**

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 9+3**

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

**TOTAL = 60 PERIODS**

**OUTCOMES:**

On Completion of the course the student will be able to

1. apply the basic concepts of vibration in damped and undamped systems
2. determine the natural frequencies and mode shapes of the two degree freedom systems.
3. calculate the natural frequencies and mode shapes of the multi degree freedom and continuous systems
4. control the vibration and noise levels in a body
5. measure and analyze the vibration levels in a body

**REFERENCES:**

1. Graham Kelly. Sand Shashidhar K. Kudari, "Mechanical Vibrations", Tata McGraw –Hill Publishing Com. Ltd., 2007
2. Singiresu S. Rao," Mechanical Vibrations," Pearson Education Incorporated, 2017
3. Ramamurti. V, "Mechanical Vibration Practice with Basic Theory", Narosa Publishing House, 2000
4. William T. Thomson, "Theory of Vibration with Applications", Taylor & Francis, 2003

0.3- Low                      0.6- Medium                      0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.9	0.6			0.3							0.3	0.6	0.3
2	0.9	0.6	0.6		0.6			0.3					0.3	0.6	0.3
3	0.9	0.6	0.6		0.6			0.3					0.3	0.6	
4	0.9	0.9	0.9		0.6			0.3					0.3	0.6	0.3
5	0.6	0.9	0.9	0.9	0.6			0.3					0.3	0.6	0.3

**ED5084**

**VEHICLE DYNAMICS**

**L T P C**  
**3 0 0 3**

**COURSE OBJECTIVES:**

The main learning objective of this course is to prepare students for:

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

**UNIT-I BASIS OF VIBRATION 9**

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

**UNIT-II TYRES 9**

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

**UNIT-III VERTICAL DYNAMICS 9**

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

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

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

**UNIT-V LATERAL DYNAMICS****9**

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

**TOTAL = 45 PERIODS****OUTCOMES:**

On Completion of the course the student will be able to

- Formulate and develop mathematical model of a system
- Apply vehicular vibrations and response of vehicle
- Create a tire model based on required performance
- Predict vehicle performance, control methodologies to ensure stability and ride comfort
- 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 EngineersInc, 1992
5. G. NakhaieJazar, Vehicle Dynamics: Theory and Application, 1st edition, Springer, 2008

0.3- Low

0.6- Medium

0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.9	0.6			0.3							0.6	0.9	0.6
2	0.9	0.6	0.6		0.6			0.3					0.6	0.9	0.6
3	0.9	0.6	0.6		0.6			0.3					0.6	0.6	0.6
4	0.9	0.9	0.6		0.6			0.3					0.6	0.9	0.6
5	0.6	0.9	0.9	0.9	0.6			0.3					0.6	0.9	0.6

**ED5074****COMPOSITE MATERIALS AND MECHANICS**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**COURSE OBJECTIVES:**

1. Study of different composite materials and finding its mechanical strength
2. Fabrication of FRP and other composites by different manufacturing methods
3. Stress analysis of fiber reinforced Laminates for different combinations of plies with different orientations of the fiber.
4. Calculation of stresses in the lamina of the laminate using different failure theories
5. Calculation of residual stresses in different types of laminates under thermo-mechanical load using the Classical Laminate Theory.

**UNIT-I INTRODUCTION TO COMPOSITE MATERIALS****9**

Definition-Matrix materials-polymers-metals-ceramics - Reinforcements: Particles, whiskers, inorganic fibers, metal filaments- ceramic fibers- fiber fabrication- natural composite wood, Jute - Advantages and drawbacks of composites over monolithic materials. Mechanical properties and applications of composites, Particulate-Reinforced composite Materials, Dispersion-Strengthened composite, Fiber-reinforced composites Rule of mixtures-Characteristics of fiber-Reinforced composites, Manufacturing fiber and composites

**UNIT-II MANUFACTURING OF COMPOSITES 9**  
Manufacturing of Polymer Matrix Composites (PMCs)-handlay-up, spray technique, filament winding, Pultrusion, Resin Transfer Moulding (RTM)-, bag moulding, injection moulding, Sandwich Mould Composites (SMC) - Manufacturing of Metal Matrix Composites (MMCs) - Solid state, liquid state, vapour state processing, Manufacturing of Ceramic Matrix Composites (CMCs) –hot pressing-reaction bonding process-infiltration technique, direct oxidation- interfaces

**UNIT-III LAMINA CONSTITUTIVE EQUATIONS 9**  
Lamina Constitutive Equations: Lamina Assumptions – Macroscopic Viewpoint. Generalized Hooke's Law. Reduction to Homogeneous Orthotropic Lamina – Isotropic limit case, Orthotropic Stiffness matrix ( $Q_{ij}$ ), Definition of stress and Moment Resultants. Strain Displacement relations. Basic Assumptions of Laminated anisotropic plates. Laminate Constitutive Equations – Coupling Interactions, Balanced Laminates, Symmetric Laminates, Angle Ply Laminates, Cross Ply Laminates. Laminate Structural Moduli. Evaluation of Lamina Properties from Laminate Tests. Quasi-Isotropic Laminates. Determination of Lamina stresses within Laminates.

**UNIT-IV LAMINA STRENGTH ANALYSIS AND ANALYSIS OF LAMINATED FLAT PLATES 9**  
Introduction - Maximum Stress and Strain Criteria. Von-Misses Yield criterion for Isotropic Materials. Generalized Hill's Criterion for Anisotropic materials. Tsai-Hill's Failure Criterion for Composites. Tensor Polynomial (Tsai-Wu) Failure criterion. Prediction of laminate Failure Equilibrium Equations of Motion. Energy Formulations. Static Bending Analysis. Buckling Analysis. Free Vibrations – Natural Frequencies

**UNIT-V THERMO-STRUCTURAL ANALYSIS 9**  
Fabrication stresses/Residual stresses in FRP laminated composites- Co-efficient of Thermal Expansion (C.T.E.) - Modification of Hooke's Law. Modification of Laminate Constitutive Equations. Orthotropic Lamina C.T.E's -Stress and Moment Resultants due cooling of the laminates during fabrication-Calculations for thermo-mechanical stresses in FRP laminates  
**Case studies:** Implementation of CLT for evaluating residual stresses in the components made with different isotropic layers such as electronic packages etc.

**TOTAL (L: 45 )=45 PERIODS**

**COURSE OUTCOMES:**

On Completion of the course the student will be able to

1. Calculate for mechanical strength of the composite material
2. fabricate the FRP and other composites by different manufacturing methods
3. analyze fiber reinforced Laminates for different combinations of plies with different orientations of the fiber.
4. Evaluate the stresses in the lamina of the laminate using different failure theories
5. analyze thermo-mechanical behavior and evaluate residual stresses in different types of laminates using the Classical Laminate Theory.

**REFERENCES:**

1. Agarwal BD and Broutman LJ, "Analysis and Performance of Fiber Composites", John Wiley and Sons, New York, 1990.
2. Gibson R F, Principles of Composite Material Mechanics, McGraw-Hill, 1994,
3. CRC press, 4th Edition, 2015.
4. Hyer MW and Scott R White, "Stress Analysis of Fiber – Reinforced Composite Materials", McGraw-Hill, 1998
5. Issac M Daniel and Orilshai, "Engineering Mechanics of Composite Materials", Oxford University Press-2006, First Indian Edition - 2007
6. MadhujitMukhopadhyay, "Mechanics of Composite Materials and Structures", University Press (India) Pvt. Ltd., Hyderabad, 2004 (Reprinted 2008)
7. Mallick PK, Fiber – Reinforced Composites: Materials, Manufacturing and Design, CRC Press, 3<sup>rd</sup> Edition,2007.

0.3- Low

0.6- Medium

0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.6	0.6	0.9	0.9		0.6	0.6					0.6	0.3		0.3
2	0.6	0.6		0.6		0.6	0.6	0.6				0.6	0.3		
3	0.6	0.6	0.6	0.6		0.6	0.6					0.6	0.3	0.3	0.3
4	0.6	0.6	0.6	0.6		0.6	0.6					0.6	0.3		
5	0.6	0.6	0.6	0.6		0.6	0.6					0.6	0.3	0.3	

**ED5077****DESIGN OF HYDRAULIC AND PNEUMATIC SYSTEMS****L T P C****3 0 0 3****COURSE OBJECTIVES:**

1. To introduce the different components of hydraulic systems and its design and selection procedures.
2. To formulate a thorough understanding on the need and use of various control and regulating elements in hydraulic systems.
3. To enable them to independently design hydraulic circuits for industrial applications
4. To expose them to the different components of pneumatic systems and enable them to design simple pneumatic systems.
5. To make them understand the need to integrate electronics and develop low cost systems and provide solution to simple industrial applications

**UNIT – I OIL HYDRAULIC SYSTEMS AND HYDRAULIC ACTUATORS 9**

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

**UNIT – II CONTROL AND REGULATION ELEMENTS 9**

Pressure - direction and flow control valves - relief valves, non-return and safety valves - actuation systems, Proportional Electro hydraulic servo valves

**UNIT – III HYDRAULIC CIRCUITS 9**

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

**UNIT – IV PNEUMATIC SYSTEMS AND CIRCUITS 9**

Pneumatic fundamentals - control elements, position and pressure sensing, Pneumatic equipments - selection of components - design calculations - logic circuits - switching circuits - fringe conditions modules and these integration - sequential circuits - cascade methods - mapping methods - step counter method - compound circuit design - combination circuit design- Karnaugh - Veitch map

**UNIT – V ELECTROMAGNETIC & ELECTRONIC CONTROL OF HYDRAULICS & PNEUMATIC CIRCUIT 9**

Electrical control of pneumatic circuits – use of relays, counters, timers, ladder diagrams, use of microprocessor in circuit design – use of PLC in hydraulic and pneumatic circuits – Fault finding– application -fault finding - hydro pneumatic circuits - use of microprocessors for sequencing - PLC, Low cost automation - Robotic circuits.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

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

1. Design and select appropriate pumps in industries based on need.
2. Select correct sizing and rating of control elements in hydraulics.
3. Design basic circuits (hydraulic) for industrial applications.
4. Design basic pneumatic circuits for industrial applications.
5. Identify and provide solution for troubleshooting and design low cost automation for industrial application.

**REFERENCES:**

1. Anthony Esposito, "Fluid Power with Applications", Prentice Hall, 2009.
2. Jagadeesha T, "Pneumatics Concepts, Design and Applications ", Universities Press, 2015
3. James A. Sullivan, "Fluid Power Theory and Applications", Fourth Edition, Prentice Hall, 1997
4. Majumdar, S.R., "Oil Hydraulics Systems – Principles and Maintenance", Tata McGraw Hill, 2001
5. Shanmuga Sundaram.K, "Hydraulic and Pneumatic Controls". Chand & Co, 2006

0.3- Low                      0.6- Medium                      0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.9	0.9	0.9	0.9			0.6		0.6		0.6	0.9	0.6	0.9
2	0.9	0.9	0.6	0.9	0.9			0.6		0.6		0.6	0.9	0.6	0.9
3	0.9	0.9	0.9	0.6	0.9			0.6		0.6		0.6	0.9	0.6	0.6
4	0.9	0.9	0.9	0.9	0.9			0.6		0.6		0.6	0.9	0.6	0.6
5	0.9	0.6	0.9	0.6	0.9			0.6		0.6		0.6	0.9	0.6	0.6

**ED5072****ADVANCED MACHINE TOOL DESIGN**

**L    T    P    C**  
**3    0    0    3**

**OBJECTIVES**

**The main learning objective of this course is to prepare the students for:**

1. Selecting the different machine tool mechanisms.
2. Designing the Multi speed Gear Box and feed drives.
3. Designing the machine tool structures.
4. Designing the guideways and power screws.
5. Designing the spindles and bearings.

**UNIT-I                      INTRODUCTION TO MACHINE TOOL DESIGN****9**

Introduction to Machine Tool Drives and Mechanisms, Auxiliary Motions in Machine Tools, Kinematics of Machine Tools, Motion Transmission

**UNIT-II                      REGULATION OF SPEEDS AND FEEDS****9**

Aim of Speed and Feed Regulation, Stepped Regulation of Speeds, Multiple Speed Motors, Ray Diagrams and Design Considerations, Design of Speed Gear Boxes, Feed Drives, Feed Box Design

**UNIT-III                      DESIGN OF MACHINE TOOL STRUCTURES****9**

Functions of Machine Tool Structures and their Requirements, Design for Strength, Design for Rigidity, Materials for Machine Tool Structures, Machine Tool Constructional Features, Beds and Housings, Columns and Tables, Saddles and Carriage

**UNIT-IV DESIGN OF GUIDEWAYS AND POWER SCREWS 9**  
 Functions and Types of Guideways, Design of Guideways, Design of Aerostatic Slide ways, Design of Anti-Friction Guideways, Combination Guideways, Design of Power Screws

**UNIT-V DESIGN OF SPINDLES AND SPINDLE SUPPORT 9**  
 Functions of Spindles and Requirements, Effect of Machine Tool Compliance on Machining Accuracy, Design of Spindles, Antifriction Bearings. Dynamics of Machine Tools: Machine Tool Elastic System, Static and Dynamic Stiffness

**TOTAL = 45 PERIODS**

**OUTCOMES:**

On Completion of the course the student will be able to

1. Select the different machine tool mechanisms.
2. Design the Multi speed Gear Box and feed drives.
3. Design the machine tool structures.
4. Design the guideways and power screws.
5. Design the spindles and bearings.

**REFERENCES:**

1. N.K. Mehta, Machine Tool Design and Numerical Control, TMH, New Delhi, 2010
2. G.C. Sen and A. Bhattacharya, Principles of Machine Tools, New Central Book Agency, 2009
3. D. K Pal, S. K. Basu, "Design of Machine Tools", 5th Edition. Oxford IBH, 2008
4. N. S. Acherkhan, "Machine Tool Design", Vol. I, II, III and IV, MIR publications, 1968
5. F. Koenigsberger, Design Principles of Metal-Cutting Machine Tools, Pergamon Press, 1964
6. F. Koenigsberger, Machine Tool Structures, Pergamon Press, 1970

0.3- Low

0.6- Medium

0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.9	0.9	0.6		0.3	0.6	0.3					0.3	0.6	0.6
2	0.9	0.9	0.9	0.6		0.3	0.6	0.3					0.3	0.6	0.6
3	0.9	0.9	0.9	0.6		0.3	0.6	0.3					0.3	0.6	0.6
4	0.9	0.9	0.9	0.6		0.3	0.6	0.3					0.3	0.6	0.6
5	0.9	0.9	0.9	0.6		0.3	0.6	0.3					0.3	0.6	0.6

**ED5076**

**DESIGN OF HYBRID AND ELECTRIC VEHICLES**

**L T P C**  
**3 0 0 3**

**COURSE OBJECTIVES:**

1. Fundamental concepts of electric and hybrid vehicle operation and architectures.
2. Understand the properties of batteries and its types.
3. Provide knowledge about design of series hybrid electric vehicles.
4. Provide knowledge about design of parallel hybrid electric vehicles.
5. Understand of electric vehicle drive train.

**UNIT – I INTRODUCTION TO ELECTRIC VEHICLES 9**

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

**UNIT – II ENERGY SOURCE 9**  
 Battery basics- lead acid battery – alternative batteries – battery parameters- technical characteristics – battery power – alternative energy sources: Fuel cells - Fuel Cell characteristics- Fuel cell types.

**UNIT – III SERIES HYBRID ELECTRIC DRIVE TRAIN DESIGN 9**  
 Operation Patterns- Control Strategies-Sizing of the Major Components -Design of peaking power source - Traction Motor Size - Design of the Gear Ratio-Verification of Acceleration Performance-.Verification of gradeability-- 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 DRIVETRAIN 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 PERIODS**

**COURSE OUTCOMES:**

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

1. Explain how a hybrid vehicle works and describe its main components and their function.
2. Choose proper energy storage systems for vehicle applications
3. Design series hybrid electric vehicles.
4. Design parallel hybrid electric vehicles.
5. 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/>

0.3- Low                      0.6- Medium                      0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.3		0.9		0.6	0.6	0.9						0.9	0.6	0.3
2	0.3		0.9		0.6	0.6	0.9						0.9	0.6	0.3
3	0.3		0.9		0.6	0.6	0.9						0.9	0.6	0.3
4	0.3		0.9		0.6	0.6	0.9						0.9	0.6	0.3
5	0.3		0.9		0.6	0.6	0.9						0.9	0.6	0.3

**OBJECTIVES**

1. To study concept of Finite Element Analysis to solve problems involving plate and shell elements
2. To learn concept of Finite Element Analysis to solve problems involving geometric and material non linearity
3. To study solution techniques to solve dynamic problems
4. To study the concepts of Finite Element Analysis to solve fluid mechanics and heat transfer problems
5. To study error norms, convergence rates and refinement.

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

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

**UNIT-II NON-LINEAR PROBLEMS 9**

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

**UNIT-III DYNAMIC PROBLEM 9**

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

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

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

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

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

**TOTAL = 45 PERIODS**

**OUTCOMES:**

On Completion of the course the student will be able to

1. Apply concept of Finite Element Analysis to solve problems involving plate and shell elements
2. Apply concept of Finite Element Analysis to solve problems involving geometric and material non linearity
3. Formulate solution techniques to solve dynamic problems
4. Apply concepts of Finite Element Analysis to solve fluid mechanics and heat transfer problems
5. Investigate error norms, convergence rates and refinement.

**REFERENCES:**

1. Bathe K.J., "Finite Element Procedures in Engineering Analysis", Prentice Hall, 1990
2. Logan.D.L., "A first course in Finite Element Method", Cengage Learning, 2012
3. Reddy,J.N. "An Introduction to Nonlinear Finite Element Analysis ", 2<sup>nd</sup>Edition, Oxford,2015
4. Robert D. Cook, David S. Malkus, Michael E. Plesha, Robert J. Witt, "Concepts and Applications of Finite Element Analysis", 4th Edition, Wiley Student Edition, 2004.
5. TirupathiR.Chandrupatla and Ashok D.Belegundu, "Introduction to Finite Elements in Engineering", International Edition, Pearson Education Limited, 2014.
6. Zienkiewicz, O.C., Taylor, R.L. and Zhu.J.Z., "The Finite Element Method : Its Basis and Fundamentals", 7th Edition, Butterworth-Heinemann,2013.

0.3- Low

0.6- Medium

0.9- High

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	0.9	0.9	0.6	0.9	0.9								0.9	0.3	0.6
2	0.9	0.9	0.6	0.9	0.9								0.9	0.3	0.6
3	0.9	0.9	0.6	0.9	0.9								0.9	0.3	0.6
4	0.9	0.9	0.6	0.9	0.9								0.9	0.3	0.6
5	0.9	0.9	0.6	0.9	0.9								0.9	0.3	0.6

## OPEN ELECTIVE COURSES (OEC)

OE5091

**BUSINESS DATA ANALYTICS**

**L T P C**  
**3 0 0 3**

### **COURSE OBJECTIVES:**

- To understand the basics of business analytics and its life cycle.
- To gain knowledge about fundamental business analytics.
- To learn modeling for uncertainty and statistical inference.
- To understand analytics using Hadoop and Map Reduce frameworks.
- To acquire insight on other analytical frameworks.

### **UNIT I OVERVIEW OF BUSINESS ANALYTICS**

**9**

Introduction – Drivers for Business Analytics – Applications of Business Analytics: Marketing and Sales, Human Resource, Healthcare, Product Design, Service Design, Customer Service and Support – Skills Required for a Business Analyst – Framework for Business Analytics Life Cycle for Business Analytics Process.

#### **Suggested Activities:**

- Case studies on applications involving business analytics.
- Converting real time decision making problems into hypothesis.
- Group discussion on entrepreneurial opportunities in Business Analytics.

#### **Suggested Evaluation Methods:**

- Assignment on business scenario and business analytical life cycle process.
- Group presentation on big data applications with societal need.
- Quiz on case studies.

### **UNIT II ESSENTIALS OF BUSINESS ANALYTICS**

**9**

Descriptive Statistics – Using Data – Types of Data – Data Distribution Metrics: Frequency, Mean, Median, Mode, Range, Variance, Standard Deviation, Percentile, Quartile, z-Score, Covariance, Correlation – Data Visualization: Tables, Charts, Line Charts, Bar and Column Chart, Bubble Chart, Heat Map – Data Dashboards.

#### **Suggested Activities:**

- Solve numerical problems on basic statistics.
- Explore chart wizard in MS Excel Case using sample real time data for data visualization.
- Use R tool for data visualization.

#### **Suggested Evaluation Methods:**

- Assignment on descriptive analytics using benchmark data.
- Quiz on data visualization for univariate, bivariate data.

### **UNIT III MODELING UNCERTAINTY AND STATISTICAL INFERENCE**

**9**

Modeling Uncertainty: Events and Probabilities – Conditional Probability – Random Variables – Discrete Probability Distributions – Continuous Probability Distribution – Statistical Inference: Data Sampling – Selecting a Sample – Point Estimation – Sampling Distributions – Interval Estimation – Hypothesis Testing.

#### **Suggested Activities:**

- Solving numerical problems in sampling, probability, probability distributions and hypothesis testing.
- Converting real time decision making problems into hypothesis.

#### **Suggested Evaluation Methods:**

- Assignments on hypothesis testing.
- Group presentation on real time applications involving data sampling and hypothesis testing.
- Quizzes on topics like sampling and probability.

## **UNIT IV ANALYTICS USING HADOOP AND MAPREDUCE FRAMEWORK**

**9**

Introducing Hadoop – RDBMS versus Hadoop – Hadoop Overview – HDFS (Hadoop Distributed File System) – Processing Data with Hadoop – Introduction to MapReduce – Features of MapReduce – Algorithms Using Map-Reduce: Matrix-Vector Multiplication, Relational Algebra Operations, Grouping and Aggregation – Extensions to MapReduce.

### **Suggested Activities:**

- Practical – Install and configure Hadoop.
- Practical – Use web based tools to monitor Hadoop setup.
- Practical – Design and develop MapReduce tasks for word count, searching involving text corpus etc.

### **Suggested Evaluation Methods:**

- Evaluation of the practical implementations.
- Quizzes on topics like HDFS and extensions to MapReduce.

## **UNIT V OTHER DATA ANALYTICAL FRAMEWORKS**

**9**

Overview of Application development Languages for Hadoop – PigLatin – Hive – Hive Query Language (HQL) – Introduction to Pentaho, JAQL – Introduction to Apache: Sqoop, Drill and Spark, Cloudera Impala – Introduction to NoSQL Databases – Hbase and MongoDB.

### **Suggested Activities:**

- Practical – Installation of NoSQL database like MongoDB.
- Practical – Demonstration on Sharding in MongoDB.
- Practical – Install and run Pig
- Practical – Write PigLatin scripts to sort, group, join, project, and filter data.
- Design and develop algorithms to be executed in MapReduce involving numerical methods for analytics.

### **Suggested Evaluation Methods:**

- Mini Project (Group) – Real time data collection, saving in NoSQL, implement analytical techniques using Map-Reduce Tasks and Result Projection.

**TOTAL: 45 PERIODS**

### **COURSE OUTCOMES:**

On completion of the course, the student will be able to:

- Identify the real world business problems and model with analytical solutions.
- Solve analytical problem with relevant mathematics background knowledge.
- Convert any real world decision making problem to hypothesis and apply suitable statistical testing.
- Write and Demonstrate simple applications involving analytics using Hadoop and MapReduce
- Use open source frameworks for modeling and storing data.
- Apply suitable visualization technique using R for visualizing voluminous data.

### **REFERENCES:**

1. Vignesh Prajapati, "Big Data Analytics with R and Hadoop", Packt Publishing, 2013.
2. Umesh R Hodeghatta, Umesha Nayak, "Business Analytics Using R – A Practical Approach", Apress, 2017.
3. Anand Rajaraman, Jeffrey David Ullman, "Mining of Massive Datasets", Cambridge University Press, 2012.
4. Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W. Ohlmann, David R. Anderson, "Essentials of Business Analytics", Cengage Learning, second Edition, 2016.
5. U. Dinesh Kumar, "Business Analytics: The Science of Data-Driven Decision Making", Wiley, 2017.
6. A. Ohri, "R for Business Analytics", Springer, 2012
7. Rui Miguel Forte, "Mastering Predictive Analytics with R", Packt Publication, 2015.

**COURSE OBJECTIVES:**

- Summarize basics of industrial safety
- Describe fundamentals of maintenance engineering
- Explain wear and corrosion
- Illustrate fault tracing
- Identify preventive and periodic maintenance

**UNIT I INTRODUCTION****9**

Accident, causes, types, results and control, mechanical and electrical hazards, types, causes and preventive steps/procedure, describe salient points of factories act 1948 for health and safety, wash rooms, drinking water layouts, light, cleanliness, fire, guarding, pressure vessels, etc, Safety color codes. Fire prevention and firefighting, equipment and methods.

**UNIT II FUNDAMENTALS OF MAINTENANCE ENGINEERING****9**

Definition and aim of maintenance engineering, Primary and secondary functions and responsibility of maintenance department, Types of maintenance, Types and applications of tools used for maintenance, Maintenance cost & its relation with replacement economy, Service life of equipment.

**UNIT III WEAR AND CORROSION AND THEIR PREVENTION****9**

Wear- types, causes, effects, wear reduction methods, lubricants-types and applications, Lubrication methods, general sketch, working and applications, i. Screw down grease cup, ii. Pressure grease gun, iii. Splash lubrication, iv. Gravity lubrication, v. Wick feed lubrication vi. Side feed lubrication, vii. Ring lubrication, Definition, principle and factors affecting the corrosion. Types of corrosion, corrosion prevention methods.

**UNIT IV FAULT TRACING****9**

Fault tracing-concept and importance, decision tree concept, need and applications, sequence of fault finding activities, show as decision tree, draw decision tree for problems in machine tools, hydraulic, pneumatic, automotive, thermal and electrical equipment's like, i. Any one machine tool, ii. Pump iii. Air compressor, iv. Internal combustion engine, v. Boiler, vi. Electrical motors, Types of faults in machine tools and their general causes.

**UNIT V PERIODIC AND PREVENTIVE MAINTENANCE****9**

Periodic inspection-concept and need, degreasing, cleaning and repairing schemes, overhauling of mechanical components, overhauling of electrical motor, common troubles and remedies of electric motor, repair complexities and its use, definition, need, steps and advantages of preventive maintenance. Steps/procedure for periodic and preventive maintenance of: I. Machine tools, ii. Pumps, iii. Air compressors, iv. Diesel generating (DG) sets, Program and schedule of preventive maintenance of mechanical and electrical equipment, advantages of preventive maintenance. Repair cycle concept and importance

**TOTAL: 45 PERIODS****COURSE OUTCOMES:**

- CO1: Ability to summarize basics of industrial safety
- CO2: Ability to describe fundamentals of maintenance engineering
- CO3: Ability to explain wear and corrosion
- CO4: Ability to illustrate fault tracing
- CO5: Ability to identify preventive and periodic maintenance

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

#### REFERENCES:

1. Audels, Pump-hydraulic Compressors, Mcgrew Hill Publication, 1978.
2. Garg H P, Maintenance Engineering, S. Chand and Company, 1987.
3. Hans F. Winterkorn, Foundation Engineering Handbook, Chapman & Hall London, 2013.
4. Higgins & Morrow, Maintenance Engineering Handbook, Eighth Edition, 2008

OE5093

OPERATIONS RESEARCH

L T P C

3 0 0 3

#### COURSE OBJECTIVES:

- Solve linear programming problem and solve using graphical method.
- Solve LPP using simplex method
- Solve transportation, assignment problems
- Solve project management problems
- Solve scheduling problems

#### UNIT I LINEAR PROGRAMMING

9

Introduction to Operations Research – assumptions of linear programming problems - Formulations of linear programming problem – Graphical method

#### UNIT II ADVANCES IN LINEAR PROGRAMMING

9

Solutions to LPP using simplex algorithm- Revised simplex method - primal dual relationships – Dual simplex algorithm - Sensitivity analysis

#### UNIT III NETWORK ANALYSIS – I

9

Transportation problems -Northwest corner rule, least cost method, Voges's approximation method - Assignment problem -Hungarian algorithm

#### UNIT IV NETWORK ANALYSIS – II

9

Shortest path problem: Dijkstra's algorithms, Floyds algorithm, systematic method -CPM/PERT

#### UNIT V NETWORK ANALYSIS – III

9

Scheduling and sequencing - single server and multiple server models - deterministic inventory models - Probabilistic inventory control models

**TOTAL : 45 PERIODS**

#### COURSE OUTCOMES:

- CO1: To formulate linear programming problem and solve using graphical method.  
CO2: To solve LPP using simplex method  
CO3: To formulate and solve transportation, assignment problems  
CO4: To solve project management problems  
CO5: To solve scheduling problems

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓											
CO2	✓											
CO3	✓	✓	✓									
CO4	✓	✓	✓									
CO5	✓	✓	✓									

#### REFERENCES:

1. Harvey M Wagner, Principles of Operations Research: Prentice Hall of India 2010
2. Hitler Libermann, Operations Research: McGraw Hill Pub. 2009
3. Pant J C, Introduction to Optimisation: Operations Research, Jain Brothers, Delhi, 2008
4. Pannerseivam, Operations Research: Prentice Hall of India 2010
5. Taha H A, Operations Research, An Introduction, PHI, 2008

**OE5094**

**COST MANAGEMENT OF ENGINEERING PROJECTS**

**L T P C**  
**3 0 0 3**

#### OBJECTIVES:

- Summarize the costing concepts and their role in decision making
- Infer the project management concepts and their various aspects in selection
- Interpret costing concepts with project execution
- Develop knowledge of costing techniques in service sector and various budgetary control techniques
- Illustrate with quantitative techniques in cost management

#### **UNIT I INTRODUCTION TO COSTING CONCEPTS 9**

Objectives of a Costing System; Cost concepts in decision-making; Relevant cost, Differential cost, Incremental cost and Opportunity cost; Creation of a Database for operational control.

#### **UNIT II INTRODUCTION TO PROJECT MANAGEMENT 9**

Project: meaning, Different types, why to manage, cost overruns centres, various stages of project execution: conception to commissioning. Project execution as conglomeration of technical and nontechnical activities, Detailed Engineering activities, Pre project execution main clearances and documents, Project team: Role of each member, Importance Project site: Data required with significance, Project contracts.

#### **UNIT III PROJECT EXECUTION AND COSTING CONCEPTS 9**

Project execution Project cost control, Bar charts and Network diagram, Project commissioning: mechanical and process, Cost Behavior and Profit Planning Marginal Costing; Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis, Various decision-making problems, Pricing strategies: Pareto Analysis, Target costing, Life Cycle Costing.

#### **UNIT IV COSTING OF SERVICE SECTOR AND BUDGETERY CONTROL 9**

Just-in-time approach, Material Requirement Planning, Enterprise Resource Planning, Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis, Budgetary Control: Flexible Budgets; Performance budgets; Zero-based budgets.

#### **UNIT V QUANTITATIVE TECHNIQUES FOR COST MANAGEMENT 9**

Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Learning Curve Theory.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

- CO1 – Understand the costing concepts and their role in decision making  
 CO2–Understand the project management concepts and their various aspects in selection  
 CO3–Interpret costing concepts with project execution  
 CO4–Gain knowledge of costing techniques in service sector and various budgetary control techniques  
 CO5 - Become familiar with quantitative techniques in cost management

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓	✓	✓		✓			✓	✓		✓	✓
CO2	✓	✓	✓		✓				✓		✓	✓
CO3	✓	✓	✓		✓	✓					✓	✓
CO4	✓	✓	✓		✓		✓				✓	✓
CO5	✓	✓	✓		✓	✓	✓				✓	✓

**REFERENCES:**

1. Ashish K. Bhattacharya, Principles & Practices of Cost Accounting A. H. Wheeler publisher, 1991
2. Charles T. Horngren and George Foster, Advanced Management Accounting, 1988
3. Charles T. Horngren et al Cost Accounting A Managerial Emphasis, Prentice Hall of India, New Delhi, 2011
4. Robert S Kaplan Anthony A. Alkinson, Management & Cost Accounting, 2003
5. Vohra N.D., Quantitative Techniques in Management, Tata McGraw Hill Book Co. Ltd, 2007

**OE5095****COMPOSITE MATERIALS****L T P C  
3 0 0 3****COURSE OBJECTIVES:**

- Summarize the characteristics of composite materials and effect of reinforcement in composite materials.
- Identify the various reinforcements used in composite materials.
- Compare the manufacturing process of metal matrix composites.
- Understand the manufacturing processes of polymer matrix composites.
- Analyze the strength of composite materials.

**UNIT I INTRODUCTION****9**

Definition – Classification and characteristics of Composite materials - Advantages and application of composites - Functional requirements of reinforcement and matrix - Effect of reinforcement (size, shape, distribution, volume fraction) on overall composite performance.

**UNIT II REINFORCEMENTS****9**

Preparation-layup, curing, properties and applications of glass fibers, carbon fibers, Kevlar fibers and Boron fibers - Properties and applications of whiskers, particle reinforcements - Mechanical Behavior of composites: Rule of mixtures, Inverse rule of mixtures - Isostrain and Isostress conditions.

**UNIT III MANUFACTURING OF METAL MATRIX COMPOSITES****9**

Casting – Solid State diffusion technique - Cladding – Hot isostatic pressing - Properties and applications. Manufacturing of Ceramic Matrix Composites: Liquid Metal Infiltration – Liquid phase sintering. Manufacturing of Carbon – Carbon composites: Knitting, Braiding, Weaving - Properties and applications.

**UNIT IV MANUFACTURING OF POLYMER MATRIX COMPOSITES 9**

Preparation of Moulding compounds and prepregs – hand layup method – Autoclave method – Filament winding method – Compression moulding – Reaction injection moulding - Properties and applications.

**UNIT V STRENGTH 9**

Laminar Failure Criteria-strength ratio, maximum stress criteria, maximum strain criteria, interacting failure criteria, hygrothermal failure. Laminate first ply failure-insight strength; Laminate strength-ply discount truncated maximum strain criterion; strength design using caplet plots; stress concentrations.

**TOTAL: 45 PERIODS**

**COURSE OUTCOMES:**

- CO1 - Know the characteristics of composite materials and effect of reinforcement in composite materials.
- CO2 – Know the various reinforcements used in composite materials.
- CO3 – Understand the manufacturing processes of metal matrix composites.
- CO4 – Understand the manufacturing processes of polymer matrix composites.
- CO5 – Analyze the strength of composite materials.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1		✓	✓	✓								
CO2		✓	✓	✓	✓						✓	
CO3			✓	✓	✓		✓				✓	
CO4			✓	✓	✓		✓				✓	
CO5				✓	✓		✓					

**REFERENCES:**

1. Cahn R.W. - Material Science and Technology – Vol 13 – Composites, VCH, West Germany.
2. Callister, W.D Jr., Adapted by Balasubramaniam R, Materials Science and Engineering, An introduction, John Wiley & Sons, NY, Indian edition, 2007.
3. Chawla K.K., Composite Materials, 2013.
4. Lubin.G, Hand Book of Composite Materials, 2013.

**OE5096**

**WASTE TO ENERGY**

**L T P C  
3 0 0 3**

**OBJECTIVES:**

- Interpret the various types of wastes from which energy can be generated
- Develop knowledge on biomass pyrolysis process and its applications
- Develop knowledge on various types of biomass gasifiers and their operations
- Invent knowledge on biomass combustors and its applications on generating energy
- Summarize the principles of bio-energy systems and their features

**UNIT I INTRODUCTION TO EXTRACTION OF ENERGY FROM WASTE 9**

Classification of waste as fuel – Agro based, Forest residue, Industrial waste - MSW – Conversion devices – Incinerators, gasifiers, digestors

**UNIT II BIOMASS PYROLYSIS 9**

Pyrolysis – Types, slow fast – Manufacture of charcoal – Methods - Yields and application – Manufacture of pyrolytic oils and gases, yields and applications.

**UNIT III BIOMASS GASIFICATION****9**

Gasifiers – Fixed bed system – Downdraft and updraft gasifiers – Fluidized bed gasifiers – Design, construction and operation – Gasifier burner arrangement for thermal heating – Gasifier engine arrangement and electrical power – Equilibrium and kinetic consideration in gasifier operation.

**UNIT IV BIOMASS COMBUSTION****9**

Biomass stoves – Improved chullahs, types, some exotic designs, Fixed bed combustors, Types, inclined grate combustors, Fluidized bed combustors, Design, construction and operation - Operation of all the above biomass combustors.

**UNIT V BIO ENERGY****9**

Properties of biogas (Calorific value and composition), Biogas plant technology and status - Bio energy system - Design and constructional features - Biomass resources and their classification - Biomass conversion processes - Thermo chemical conversion - Direct combustion - biomass gasification - pyrolysis and liquefaction - biochemical conversion - anaerobic digestion - Types of biogas Plants – Applications - Alcohol production from biomass - Bio diesel production -Urban waste to energy conversion - Biomass energy programme in India.

**TOTAL: 45 PERIODS****COURSE OUTCOMES:**

- CO1 – Understand the various types of wastes from which energy can be generated
- CO2 – Gain knowledge on biomass pyrolysis process and its applications
- CO3 – Develop knowledge on various types of biomass gasifiers and their operations
- CO4 – Gain knowledge on biomass combustors and its applications on generating energy
- CO5 – Understand the principles of bio-energy systems and their features

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	✓		✓									✓
CO2	✓		✓									✓
CO3	✓	✓	✓		✓							✓
CO4	✓	✓	✓		✓		✓					✓
CO5	✓	✓	✓		✓							✓

**REFERENCES:**

1. Biogas Technology - A Practical Hand Book - Khandelwal, K. C. and Mahdi, S. S., Vol. I & II, Tata McGraw Hill Publishing Co. Ltd., 1983.
2. Biomass Conversion and Technology, C. Y. WereKo-Brobby and E. B. Hagan, John Wiley & Sons, 1996.
3. Food, Feed and Fuel from Biomass, Challal, D. S., IBH Publishing Co. Pvt. Ltd., 1991.
4. Non Conventional Energy, Desai, Ashok V., Wiley Eastern Ltd., 1990.

## AUDIT COURSES (AC)

AX5091

**ENGLISH FOR RESEARCH PAPER WRITING**

**L T P C**  
**2 0 0 0**

### **COURSE OBJECTIVES**

- Teach how to improve writing skills and level of readability
- Tell about what to write in each section
- Summarize the skills needed when writing a Title
- Infer the skills needed when writing the Conclusion
- Ensure the quality of paper at very first-time submission

### **UNIT I INTRODUCTION TO RESEARCH PAPER WRITING**

**6**

Planning and Preparation, Word Order, Breaking up long sentences, Structuring Paragraphs and Sentences, Being Concise and Removing Redundancy, Avoiding Ambiguity and Vagueness

### **UNIT II PRESENTATION SKILLS**

**6**

Clarifying Who Did What, Highlighting Your Findings, Hedging and Criticizing, Paraphrasing and Plagiarism, Sections of a Paper, Abstracts, Introduction

### **UNIT III TITLE WRITING SKILLS**

**6**

Key skills are needed when writing a Title, key skills are needed when writing an Abstract, key skills are needed when writing an Introduction, skills needed when writing a Review of the Literature, Methods, Results, Discussion, Conclusions, The Final Check

### **UNIT IV RESULT WRITING SKILLS**

**6**

Skills are needed when writing the Methods, skills needed when writing the Results, skills are needed when writing the Discussion, skills are needed when writing the Conclusions

### **UNIT V VERIFICATION SKILLS**

**6**

Useful phrases, checking Plagiarism, how to ensure paper is as good as it could possibly be the first- time submission

**TOTAL: 30 PERIODS**

### **COURSE OUTCOMES**

CO1 –Understand that how to improve your writing skills and level of readability

CO2 – Learn about what to write in each section

CO3 – Understand the skills needed when writing a Title

CO4 – Understand the skills needed when writing the Conclusion

CO5 – Ensure the good quality of paper at very first-time submission

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3										✓		✓
CO4										✓		✓
CO5										✓		✓

### **REFERENCES**

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



## REFERENCES

1. Goel S. L., Disaster Administration And Management Text And Case Studies”,Deep & Deep Publication Pvt. Ltd., New Delhi,2009.
2. NishithaRai, Singh AK, “Disaster Management in India: Perspectives, issues and strategies “NewRoyal book Company,2007.
3. Sahni, PardeepEt.Al. ,” Disaster Mitigation Experiences And Reflections”, Prentice Hall OfIndia, New Delhi,2001.

**AX5093**

**SANSKRIT FOR TECHNICAL KNOWLEDGE**

**L T P C**  
**2 0 0 0**

## COURSE OBJECTIVES

- Illustrate the basic sanskrit language.
- Recognize sanskrit, the scientific language in the world.
- Appraise learning of sanskrit to improve brain functioning.
- Relate sanskrit to develop the logic in mathematics, science & other subjects enhancing the memory power.
- Extract huge knowledge from ancient literature.

### UNIT I          ALPHABETS

Alphabets in Sanskrit

**6**

### UNIT II          TENSES AND SENTENCES

Past/Present/Future Tense - Simple Sentences

**6**

### UNIT III          ORDER AND ROOTS

Order - Introduction of roots

**6**

### UNIT IV          SANSKRIT LITERATURE

Technical information about Sanskrit Literature

**6**

### UNIT V          TECHNICAL CONCEPTS OF ENGINEERING

Technical concepts of Engineering-Electrical, Mechanical, Architecture, Mathematics

**6**

**TOTAL: 30 PERIODS**

## COURSE OUTCOMES

- CO1 - Understanding basic Sanskrit language.
- CO2 - Write sentences.
- CO3 - Know the order and roots of Sanskrit.
- CO4 - Know about technical information about Sanskrit literature.
- CO5 - Understand the technical concepts of Engineering.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1										✓		✓
CO2										✓		✓
CO3												✓
CO4												✓
CO5												✓

## REFERENCES

1. “Abhyaspustakam” – Dr. Vishwas, Samskrita-Bharti Publication, New Delhi
2. “Teach Yourself Sanskrit” Prathama Deeksha-Vempati Kutumbshastri, Rashtriya Sanskrit Sansthanam, New Delhi Publication
3. “India’s Glorious Scientific Tradition” Suresh Soni, Ocean books (P) Ltd., New Delhi, 2017.

**AX5094**

**VALUE EDUCATION**

**L T P C**  
**2 0 0 0**

**COURSE OBJECTIVES**

Students will be able to

- Understand value of education and self-development
- Imbibe good values in students
- Let the should know about the importance of character

**UNIT I**

Values and self-development–Social values and individual attitudes. Work ethics, Indian vision of humanism. Moral and non-moral valuation. Standards and principles. Value judgements

**UNIT II**

Importance of cultivation of values. Sense of duty. Devotion, Self-reliance. Confidence, Concentration. Truthfulness, Cleanliness. Honesty, Humanity. Power of faith, National Unity. Patriotism. Love for nature, Discipline

**UNIT III**

Personality and Behavior Development–Soul and Scientific attitude. Positive Thinking. Integrity and discipline. Punctuality, Love and Kindness. Avoid fault Thinking. Free from anger, Dignity of labour.

Universal brother hood and religious tolerance. True friendship. Happiness Vs suffering, love for truth. Aware of self-destructive habits. Association and Cooperation. Doing best for saving nature

**UNIT IV**

Character and Competence–Holy books vs Blind faith. Self-management and Good health. Science of reincarnation. Equality, Nonviolence, Humility, Role of Women. All religions and same message. Mind your Mind, Self-control. Honesty, Studying effectively.

**TOTAL: 30 PERIODS**

**COURSE OUTCOMES**

Students will be able to

- Knowledge of self-development.
- Learn the importance of Human values.
- Developing the overall personality.

**SUGGESTED READING**

1. Chakroborty, S.K.“Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi

**AX5095**

**CONSTITUTION OF INDIA**

**L T P C**  
**2 0 0 0**

**COURSE OBJECTIVES**

Students will be able to:

- Understand the premises informing the twin themes of liberty and freedom from a civil rights perspective.
- To address the growth of Indian opinion regarding modern Indian intellectuals’ constitutional
- Role and entitlement to civil and economic rights as well as the emergence nation hood in the early years of Indian nationalism.
- To address the role of socialism in India after the commencement of the Bolshevik Revolutionin1917and its impact on the initial drafting of the Indian Constitution.

**UNIT I HISTORY OF MAKING OF THE INDIAN CONSTITUTION:**

History, Drafting Committee, (Composition & Working)

**UNIT II PHILOSOPHY OF THE INDIAN CONSTITUTION:**

Preamble, Salient Features

**UNIT III CONTOURS OF CONSTITUTIONAL RIGHTS AND DUTIES:**

Fundamental Rights, Right to Equality, Right to Freedom, Right against Exploitation, Right to Freedom of Religion, Cultural and Educational Rights, Right to Constitutional Remedies, Directive Principles of State Policy, Fundamental Duties.

**UNIT IV ORGANS OF GOVERNANCE:**

Parliament, Composition, Qualifications and Disqualifications, Powers and Functions, Executive, President, Governor, Council of Ministers, Judiciary, Appointment and Transfer of Judges, Qualifications, Powers and Functions.

**UNIT V LOCAL ADMINISTRATION:**

District's Administration head: Role and Importance, □Municipalities: Introduction, Mayor and role of Elected Representative, CEO, Municipal Corporation. Pachayati raj: Introduction, PRI: Zila Pachayat. Elected officials and their roles, CEO Zila Pachayat: Position and role. Block level: Organizational Hierarchy (Different departments), Village level:Role of Elected and Appointed officials, Importance of grass root democracy.

**UNIT VI ELECTION COMMISSION:**

Election Commission: Role and Functioning. Chief Election Commissioner and Election Commissioners - Institute and Bodies for the welfare of SC/ST/OBC and women.

**TOTAL: 30 PERIODS**

**COURSE OUTCOMES**

Students will be able to:

- Discuss the growth of the demand for civil rights in India for the bulk of Indians before the arrival of Gandhi in Indian politics.
- Discuss the intellectual origins of the framework of argument that informed the conceptualization
- of social reforms leading to revolution in India.
- Discuss the circumstances surrounding the foundation of the Congress Socialist Party[CSP] under the leadership of Jawaharlal Nehru and the eventual failure of the proposal of direct elections through adult suffrage in the Indian Constitution.
- Discuss the passage of the Hindu Code Bill of 1956.

**SUGGESTED READING**

1. The Constitution of India,1950 (Bare Act),Government Publication.
2. Dr.S.N.Busi, Dr.B. R.Ambedkar framing of Indian Constitution,1<sup>st</sup> Edition, 2015.
3. M.P. Jain, Indian Constitution Law, 7<sup>th</sup> Edn., Lexis Nexis,2014.
4. D.D. Basu, Introduction to the Constitution of India, Lexis Nexis, 2015.

**COURSE OBJECTIVES**

Students will be able to:

- Review existing evidence on their view topic to inform programme design and policy
- Making under taken by the DfID, other agencies and researchers.
- Identify critical evidence gaps to guide the development.

**UNIT I INTRODUCTION AND METHODOLOGY:**

Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions - Overview of methodology and Searching.

**UNIT II INTRODUCTION AND METHODOLOGY:**

Aims and rationale, Policy background, Conceptual framework and terminology - Theories of learning, Curriculum, Teacher education - Conceptual framework, Research questions - Overview of methodology and Searching.

**UNIT III THEMATIC OVERVIEW**

Pedagogical practices are being used by teachers in formal and informal classrooms in developing countries - Curriculum, Teacher education.

**UNIT IV EVIDENCE ON THE EFFECTIVENESS OF PEDAGOGICAL PRACTICES**

Methodology for the in depth stage: quality assessment of included studies - How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy? - Theory of change - Strength and nature of the body of evidence for effective pedagogical practices - Pedagogic theory and pedagogical approaches - Teachers' attitudes and beliefs and Pedagogic strategies.

**UNIT V PROFESSIONAL DEVELOPMENT**

Professional development: alignment with classroom practices and follow up support - Peer support - Support from the head teacher and the community - Curriculum and assessment - Barriers to learning: limited resources and large class sizes

**UNIT VI RESEARCH GAPS AND FUTURE DIRECTIONS**

Research design – Contexts – Pedagogy - Teacher education - Curriculum and assessment - Dissemination and research impact.

**TOTAL: 30 PERIODS**

**COURSE OUTCOMES**

Students will be able to understand:

- What pedagogical practices are being used by teachers informal and informal classrooms in developing countries?
- What is the evidence on the effectiveness of these pedagogical practices, in what conditions, and with what population of learners?
- How can teacher education (curriculum and practicum) and the school curriculum and guidance materials best support effective pedagogy?

**SUGGESTED READING**

1. Ackers J, Hardman F (2001) Classroom interaction in Kenyan primary schools, Compare, 31(2): 245-261.
2. Agrawal M (2004) Curricular reform in schools: The importance of evaluation, Journal of Curriculum Studies, 36(3):361-379.
3. Akyeampong K (2003) Teacher training in Ghana-does it count? Multi-site teacher education research project (MUSTER) country report 1. London: DFID.
4. Akyeampong K, Lussier K, Pryor J, Westbrook J (2013) Improving teaching and learning of

basic maths and reading in Africa: Does teacher preparation count? International Journal Educational Development, 33(3): 272–282.

5. Alexander RJ(2001) Culture and pedagogy: International comparisons in primary education. Oxford and Boston: Blackwell.
6. Chavan M(2003) Read India: Amass scale, rapid, 'learning to read' campaign.
7. [www.pratham.org/images/resource%20working%20paper%202.pdf](http://www.pratham.org/images/resource%20working%20paper%202.pdf)

**AX5097**

**STRESS MANAGEMENT BY YOGA**

**L T P C**  
**2 0 0 0**

**COURSE OBJECTIVES**

- To achieve overall health of body and mind
- To overcome stress

**UNIT I**

Definitions of Eight parts of yoga.(Ashtanga)

**UNIT II**

Yam and Niyam - Do`s and Don't`s in life - i) Ahinsa, satya, astheya, bramhacharya and aparigraha, ii) Ahinsa, satya, astheya, bramhacharya and aparigraha.

**UNIT III**

Asan and Pranayam - Various yog poses and their benefits for mind & body - Regularization of breathing techniques and its effects-Types of pranayam

**TOTAL: 30 PERIODS**

**COURSE OUTCOMES**

Students will be able to:

- Develop healthy mind in a healthy body thus improving social health also
- Improve efficiency

**SUGGESTED READING**

1. 'Yogic Asanas for Group Training-Part-I':Janardan Swami Yoga bhyasi Mandal, Nagpur
2. "Rajayoga or conquering the Internal Nature" by Swami Vivekananda, Advaita Ashrama (Publication Department), Kolkata

**AX5098**

**PERSONALITY DEVELOPMENT THROUGH  
LIFE ENLIGHTENMENT SKILLS**

**L T P C**  
**2 0 0 0**

**COURSE OBJECTIVES**

- To learn to achieve the highest goal happily
- To become a person with stable mind, pleasing personality and determination
- To awaken wisdom in students

**UNIT I**

Neetisatakam-holistic development of personality - Verses- 19,20,21,22 (wisdom) - Verses- 29,31,32 (pride & heroism) – Verses- 26,28,63,65 (virtue) - Verses- 52,53,59 (dont's) - Verses- 71,73,75,78 (do's)

**UNIT II**

Approach to day to day work and duties - Shrimad Bhagwad Geeta: Chapter 2-Verses 41, 47,48 - Chapter 3-Verses 13, 21, 27, 35 Chapter 6-Verses 5,13,17,23, 35 - Chapter 18-Verses 45, 46, 48.

### **UNIT III**

Statements of basic knowledge - Shrimad Bhagwad Geeta: Chapter2-Verses 56, 62, 68 Chapter 12 -Verses 13, 14, 15, 16,17, 18 - Personality of role model - shrimad bhagwad geeta - Chapter2-Verses 17, Chapter 3-Verses 36,37,42 - Chapter 4-Verses 18, 38,39 Chapter18 – Verses 37,38,63

**TOTAL: 30 PERIODS**

### **COURSE OUTCOMES**

Students will be able to

- Study of Shrimad-Bhagwad-Geeta will help the student in developing his personality and achieve the highest goal in life
- The person who has studied Geeta will lead the nation and mankind to peace and prosperity
- Study of Neet is hatakam will help in developing versatile personality of students.

### **SUGGESTED READING**

1. Gopinath, Rashtriya Sanskrit Sansthanam P, Bhartrihari's Three Satakam, Niti-sringar-vairagya, New Delhi,2010
2. Swami Swarupananda, Srimad Bhagavad Gita, Advaita Ashram, Publication Department, Kolkata, 2016.