R-20 3rd Year Course Structure

III-YEAR-I-SEMESTER												
Course Code	**Title of the course**	**Category**	**Periods**						**Sessionals Marks**	**Semester end Exam marks**	**Total Marks**	**Credits**
			L	**T**	**P**	**E**	**O**	**Total**				
MEC 311	***Open Elective-I	OE	3	0	0	1	2	6	40	60	100	3
MEC 312	Humanities Elective	HS	3	0	0	1	2	6	40	60	100	3
MEC 313	Design Thinking	ES	3	0	0	1	2	6	40	60	100	3
MEC 314	Dynamics of Machinery	PC	2	1	0	2	4	9	40	60	100	3
MEC 315	Applied Thermal Engineering-II	PC	2	1	0	2	4	9	40	60	100	3
MEC 316	Design of Machine Elements-I	PC	2	1	0	2	4	9	40	60	100	3
MEC 317	Kinematics and Dynamics of Machinery Lab	PC	0	0	3	0	1	4	50	50	100	1.5
MEC 318	Thermal Engineering Lab	PC	0	0	3	0	1	4	50	50	100	1.5
MEC 319	Quantitative Aptitude-I & Verbal Aptitude	HS	0	0	3	1	3	7	100	0	100	1.5
MEC 320	Industrial Training- I	PR	0	0	0	0	0	0	--	100	100	2
Total			**15**	**3**	**9**	**10**	**23**	**60**	**440**	**560**	**1000**	**24.5**

III-YEAR-II-SEMESTER												
Course Code	**Title of the course**	**Category**	**Periods**						**Sessionals Marks**	**Semester end Exam marks**	**Total Marks**	**Credits**
			L	**T**	**P**	**E**	**O**	**Total**				
MEC 321	***Open Elective- II	OE	3	0	0	0	2	5	50	50	100	3
MEC 322	Professional Elective-I	PE	3	0	0	1	2	6	40	60	100	3
MEC 323	Professional Elective-II	PE	3	0	0	1	3	7	40	60	100	3
MEC 324	Finite Element Analysis	SC	1	0	2	2	4	10	40	60	100	2
MEC 325	Fluid Mechanics & Hydraulic Machinery	PC	2	1	0	2	3	8	40	60	100	3
MEC 326	Design of Machine Elements-II	PC	2	1	0	2	4	9	40	60	100	3
MEC 327	Fluid Mechanics & Hydraulic Machinery -Lab	PC	0	0	3	0	1	4	50	50	100	1.5
MEC 328	Computer Aided Design & Manufacturing Lab	SC	1	0	3	0	2	5	50	50	100	2.5
MEC 329	Quantitative Aptitude-II & Soft Skills	HS	0	0	3	2	3	8	100	0	100	1.5
Total			**15**	**2**	**11**	**10**	**24**	**62**	**450**	**450**	**900**	**22.5**

Professional Elective-I	Production Planning & Control	Gas Turbines & Jet Proplusions	Automation in manufacturing	Non-Destructive Testing
Professional Elective-II	Refrigeration & Air- conditioning	Power plant Engineering	Nano Technology	Quality & Reliability engineering
Professional Elective-III	Mechanical Measurements	Computatinal Fluid dynamics	Condition monitoring	Industrial tribology
Professional Elective-IV	Non-Conventional Energy Sources	Managerial Economics & Financial Accountancy	Unconventiona l machine process	Artificial intelligence
Professional Elective-V	Operations Research	Alternate fuels	Advanced mechanics of materials	Product Design& Manufacturing
Humanities Electives	Industrial Engineering Management	Stastical Quality Control	Enterprenuersh ip development	Suppy chain management
***Open Elective-III/Emerging subject	Mechatronics			
***Open Elective-IV/Emerging subject	Robotics			

Note: Open electives-I & II are offered by other departments. The CSE/IT departments are requested to offer PYTHON-programming & Data structures as open electives.

Note: In Open electives-III & IV/Emerging subjects -only emerging subjects will be offered by the parent department. The subjects could be Mechatronics, Robotics, Additive manufacturing,Condition monitoring etc. (will be decided by the department)

INDUSTRIAL ENGINEERING AND MANAGEMENT (HUMANITIES ELECTIVE)											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC312(A)	HS	3	-	-	48	-	-	40	60	100	3

Prerequisite: Machine Tools Lab

Course Objectives: The course is indented to impart knowledge on the basics of management functions and principles, fundamentals of production planning and control, work study, selection of material handling equipment, various dispute acts and quality assessment techniques.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Apply functions and principles of management to private/public sectors.
CO-2	Employ the techniques of production planning and control to manage production operations.
CO-3	Apply work measurement techniques and method study procedures for productivity improvement.
CO-4	Employ the principles of material handling, procurement and further understand the significance of acts pertaining to industrial relations
CO-5	Evaluate quality of product using statistical process control charts and acceptance sampling plans.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	1	-	-	-	-	2	-	2	-	-	2	2
CO-2	2	1	-	-	-	2	-	-	-	-	2	2
CO-3	2	2	-	-	-	1	-	-	-	-	2	2
CO-4	1	-	-	-	-	2	-	2	-	-	2	2
CO-5	2	2	1	-	-	2	-	-	-	-	2	2

Course Outcomes	PSO1	PSO2
CO-1	-	2
CO-2	-	2
CO-3	-	2
CO-4	-	2
CO-5	-	2

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS

UNIT – I	**Periods: 10L+0T=10**

CONCEPTS OF INDUSTRIAL MANAGEMENT & INTRODUCTION TO PERSONNEL MANAGEMENT

Concepts of Industrial Management: Principles of management- Growth of management thought, Functions of management, Principles of organization, Types of organization and committees.

Introduction to Personnel Management: Functions, Motivation, Theories of motivation, Hawthrone studies, Discipline in industry, Promotion, Transfer, lay off and discharge, Labour turnover.

UNIT - II	**Periods: 10L+0T=10**

PRODUCTION PLANNING AND CONTROL & PLANT LAYOUT

Production Planning and Control: Types of productions, Production cycle, Product design and development - Process planning, Forecasting, Loading, Scheduling, Dispatching, Routing- Simple problems. Materials Planning – ABC analysis – Incoming materials control – Kanban system – Just in time. MRP systems- Master Production Schedule – Bill of Materials –MRP II.

Plant Layout: Plant location - Factors - Plant layout - Types - Process Layout, Product layout, Combined Layout, Project Layout - Layout design process.

UNIT – III	**Periods: 10L+0T=10**

WORK STUDY

Introduction to work study – Method study – Recording Techniques – charts & Diagrams Time study – stopwatch time study – Standard data - Method Time Measurement (M-T-M) – simple problems – Ergonomics.

UNIT – IV	**Periods: 12L+0T=12**

MATERIALS HANDLING AND MANAGEMENT & INDUSTRIAL RELATIONS

Materials Handling and Management: Principles, Concept of unit load, Containerization, Pelletization, Selection of material handling equipment, Applications of belt conveyors, Cranes, Forklift trucks in industry. Purchasing, Objectives of purchasing department, Buying techniques, Purchase procedure, Stores and material control, Receipt and issue of materials, Store records.

Industrial relations: Trade unions, Industrial disputes, Strikes, Lock-out, Picketing, Gherao, Settlement of industrial disputes, Collective bargaining, Industrial dispute act 1947 and factories act 1948.

UNIT – V	**Periods: 6L+0T=6**

STATISTICAL QUALITY CONTROL

Control charts of variables and attributes (p-chart, x-bar & R-chart, U-chart, KU-chart, C-chart) (Use of formulae only). Single and double sampling plans.

TEXT BOOKS:	
1.	Dr.O.P.Khanna, *Industrial Engineering Management*, 4th edition, Dhanpat Rai publications.
2.	Martand Teslang, *Industrial Engineering and Production Management*, 2 nd Edition, S. Chand & Co.
REFERENCE BOOKS:	
1.	Koontz & Donnel, *Principles of Management*, 3rd edition, Mc-Graw Hill Publishers.
2.	Everette Adam & Ronald Ebert, *Production and Operations Management*, Prentice Hall, 1992.
WEB RESOURCES:	
1.	www.iems.ucf.edu/
2.	www.iise.org/
3.	www.iiie-india.com/

STATISTICAL QUALITY CONTROL
(HUMANITIES ELECTIVE)

Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC312(B)	HS	2	1	-	32	16	-	40	60	100	3

Prerequisites: Engineering Mathematics; Manufacturing Processes; Metal Cutting, Machine Tools & Metrology.

Course Objectives: To acquaint the students with the basic knowledge of statistical quality control**.**

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Apply the concepts of statistical quality control such as off-line and on-line quality control, quality management philosophies, quality costs, Taguchi's loss function and six sigma concept for quality engineering and management.
CO-2	Produce and analyze the control charts for variables to evaluate the process performance.
CO-3	Analyse and make conclusions about the process capability.
CO-4	Prepare and analyse the control charts for attributes to conclude about the process control.
CO-5	Design, apply and analyze the sampling plans to judge the quality of the products.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	2	2	2	-	-	-	2	-	-	-	3	-
CO-2	3	3	3	-	-	-	2	-	-	-	3	-
CO-3	3	3	3	-	-	-	2	-	-	-	3	-
CO-4	3	3	3	-	-	-	2	-	-	-	3	-
CO-5	3	3	3	-	-	-	2	-	-	-	3	-

Course Outcomes	PSO1	PSO2
CO-1	2	-
CO-2	3	-
CO-3	3	-
CO-4	3	-
CO-5	3	-

CO - Course Outcome; PO - Program Outcome; PSO - Program Specific Outcome; Level - 1: Low, 2: Medium, 3: High

SYLLABUS	
UNIT - I	**Periods: 7L+3T=10**
INTRODUCTION TO STATISTICAL QUALITY CONTROL:	
Introduction to quality & its definitions; Off-line and on-line quality control; Quality costs; Deming's, Crosby's & Juran's philosophies; Taguchi's loss function; Introduction to six sigma concept.	
UNIT - II	**Periods: 7L+4T =11**
CONTROL CHARTS FOR VARIABLES:	
Shewhart's normal bowl; Control charts for variables - $\bar{x}$, R and sigma control charts; Theory of runs - ARL and ATS, Type-I and type-II errors.	
UNIT - III	**Periods: 4L+2T =6**
PROCESS CAPABILITY ANALYSIS:	
Process capability analysis using frequency distribution and control charts; Process capability ratios - C_p and C_{pk}; Process capability ratios for nominal the better type, smaller the better type and larger the better type product specifications.	
UNIT - IV	**Periods: 7L+3T =10**
CONTROL CHARTS FOR ATTRIBUTES:	
Control charts for attributes - p chart, standardized p chart, np chart, c chart, u chart, demerit control chart.	
UNIT - V	**Periods: 7L+4T =11**
ACCEPTANCE SAMPLING PLANS:	
Acceptance Sampling plans - single, double, multiple and sequential sampling plans; Design of single and sequential sampling plans; Rectifying inspection - AOQ, AOQL and ATI.	
TEXT BOOKS:	
1.	M. Mahajan, "*Statistical Quality Control",* Dhanpatrai & Co. Pvt. Ltd., 2016 edition.
2.	Amitava Mitra, "*Fundamentals of Quality Control and Improvement",* 3rd edition, John Wiley
REFERENCE BOOKS:	
1.	D. C. Montgomery, "*Introduction to Statistical Quality Control*", 6th edition, John Wiley & sons, 2009.
2.	E.L. Grant, "*Introduction to Statistical Quality Control*", 7th edition, Tata Mc-Graw Hill Co. Ltd., 2000.
WEB RESOURCES:	
1.	https://nptel.ac.in/courses/110105088
2.	https://nptel.ac.in/courses/110101010

ENTREPRENEURSHIP DEVELOPMENT
(HUMANITIES ELECTIVE)

Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC312(C)	HS	3	-	-	48	-	-	40	60	100	3

Prerequisite: Human Values and Professional Ethics

Course Objectives: To develop necessary knowledge and skills required for organizing and carrying out entrepreneurial activities, to develop the ability of analyzing and understanding business situations in which entrepreneurs act.

Course Outcomes: At the end of the course the student will be able to	
CO-1	Demonstrate entrepreneurship qualities and skills.
CO-2	Explain entrepreneurship policies.
CO-3	Develop skills in preparation and evolution of entrepreneurship criteria's.
CO-4	Analyze marketing strategies of entrepreneurship.
CO-5	Demonstrate preventive measures to be followed for effective management of entrepreneurship.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	-	-	-	-	-	2	2	1	2	2	2	2
CO-2	-	-	-	-	-	2	2	1	2	2	2	2
CO-3	-	-	-	-	-	2	2	1	2	2	2	2
CO-4	-	-	-	-	-	2	2	1	2	2	2	2
CO-5	-	-	-	-	-	2	2	1	2	2	2	2

Course Outcomes	PSO1	PSO2
CO-1	-	-
CO-2	-	-
CO-3	-	-
CO-4	-	-
CO-5	-	-

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS	
UNIT - I	**Periods: 9L+0T=9**
ENTREPRENEURAL COMPETENCE	
Entrepreneurship concept – Entrepreneurship as a Career – Entrepreneurial Personality - Characteristics of Successful, Entrepreneur – Knowledge and Skills of Entrepreneur.	
UNIT - II	**Periods: 12L+0T=12**
ENTREPRENEURAL ENVIRONMENT	
Business Environment - Role of Family and Society - Entrepreneurship Development Training and Other Support Organizational Services - Central and State Government Industrial Policies and Regulations - International Business.	
UNIT - III	**Periods: 9L+0T=9**
BUSINESS PLAN PREPARATION	
Sources of Product for Business - Prefeasibility Study - Criteria for Selection of Product - Ownership - Capital - Budgeting Project Profile Preparation - Matching Entrepreneur with the Project - Feasibility Report Preparation and Evaluation Criteria.	
UNIT - IV	**Periods: 9L+0T=9**
LAUNCHING OF SMALL BUSINESS	
Finance and Human Resource Mobilization Operations Planning - Market and Channel Selection - Growth Strategies - Product Launching – Incubation, Venture capital, IT startups.	
UNIT - V	**Periods: 9L+0T=9**
MANAGEMENT OF SMALL BUSINESS	
Monitoring and Evaluation of Business - Preventing Sickness and Rehabilitation of Business Units- Effective Management of small Business.	
TEXT BOOKS:	
1.	NVR Naidu& T. Krishna Rao ,"*Management and Entrepreneurship*", I K International Publishing House; 0 edition (21 August 2008)
2.	Vasant Desai "*Dynamics of Entrepreneurial Development & Management*", Himalaya Publishing House.
3.	Poornima M. Charantimath "*Entrepreneurship Development*", Small Business, Pearson Education; Third edition (31 January 2018)
4.	S. S. Khanka ,"*Entrepreneurship Development*", S Chand & Company; 2011th edition (1 December 2007)
REFERENCE BOOKS:	
1.	David H. Holt ,*Entrepreneurship: New Venture Creation*, PEI. , 1st.Ed. 2016
2.	Brigitte Berger ,*The Culture of Entrepreneurship* , Ics Pr (1 November 1991)
3.	K. Nagarajan ,*Project Management* , New Age International Pvt Ltd , 1st.Ed. 2005
WEB RESOURCES:	
1.	https://onlinecourses.swayam2.ac.in/ntr22_ed08/preview

SUPPLY CHAIN MANAGEMANT (HUMANITIES ELECTIVE)											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC312(D)	HS	3	-	-	48	-	-	40	60	100	3

Prerequisite: Nil

Course Objectives:

1. To provide an overview of role and importance of supply chain management in today's dynamic world.
2. To explore important aspects of supply chain management.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Explain the concepts of SCM and also identify Supply Chain network to bring the product into the market.
CO-2	Describe the various demand forecasting techniques and apply them in forecasting the demand of a particular product.
CO-3	Develop supply chain planning to get the optimum results.
CO-4	Explain location alternatives and apply these methods to find the optimal solution.
CO-5	Develop supply chain in logistics.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	2	-	-	-	-	-	2	1	2	2	2	2
CO-2	2	2	-	-	-	2	2	1	2	2	2	2
CO-3	2	1	2	-	-	-	2	1	2	2	2	2
CO-4	2	1	2	-	-	2	1	1	2	2	2	2
CO-5	2	-	2	-	-	-	1	1	2	2	2	2

Course Outcomes	PSO1	PSO2
CO-1	-	2
CO-2	-	2
CO-3	-	2
CO-4	-	2
CO-5	-	2

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS	
UNIT - I	**Periods: 12L+0T=12**
INTRODUCTION TO SUPPLY CHAIN MANAGEMENT	
Supply Chain -Importance of Supply Chain management (SCM), Overview, Objectives, Nature & Scope of SCM, Managing the supply Chain, Models of SCM, Evolution of SCM. Supply chain networks, integrated supply chain planning, importance of design, role of facility decisions, Distribution channels, design of distribution channel, channel design, locational determinants.	
UNIT - II	**Periods: 9L+0T=9**
DEMAND MANAGEMENT	
Demand management process, the role of forecasting and production, basic approach to forecasting, overview of qualitative and quantitative methods of forecasting, Nature of forecasting, relationship between customer service and demand management.	
UNIT - III	**Periods: 9L+0T=9**
SUPPLY CHAIN PLANNING	
Aggregate planning in a supply chain, aggregate planning strategies, planning supply and demand in a supply chain, planning and managing inventories in a supply chain, planning for optimal level of product availability.	
UNIT - IV	**Periods: 9L+0T=9**
LOCATION ALTERNATIVES	
The need for long range planning, major locational determinants, historical perspectives on location problems, single facility versus multi facility location, methods of evaluating location alternatives.	
UNIT - V	**Periods: 9L+0T=9**
SUPPLY CHAIN - ORGANIZATION	
Need for supply chain organizational structure, importance of supply chain organization, organizational development, organizational structure in integrated logistics, organizational choice and organizational scope, alliances and partnerships. **Case Study:** The purpose of each case is to get you involved in the course material, and to help you to understand the supply chain issues.	
TEXT BOOKS:	
1.	Bowersox, *Supply Chain & Logistics Mgmt.* – Closs & Cooper (TMGH) 2nd Ed.
2.	Chopra, *Supply Chain Management Strategy Planning & Operations* – Meindl (Pearson) 1st Ed.
REFERENCE BOOKS:	
1.	N.Chadrasekaran, *Supply Chain Management Process, System & Practice* – (Oxford) 1st Ed
2.	Levi, Kaminsky et al *Designing & Managing the Supply Chain – Concepts, Strategies &Case studies* – (TMGH) 3rd Ed.
WEB RESOURCES:	
1.	http://www.cscmp.org
2.	http://scm.ncsu.edu/

DESIGN THINKING

Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC 313	ES	2	-	2	24	-	24	40	60	100	3

Prerequisite: Computer Aided Geometrical Modelling

Course Objectives: To familiarize students with design thinking concepts and principles
To ensure students can practice the methods, processes and tools of design thinking.
To ensure students can apply the design thinking approach and have ability to model real world situations. To enable students to analyse primary and secondary research in the introduction to design thinking

Course Outcomes: At the end of the course the student will be able to:	
CO-1	**Explain** the design thinking principles & **Identify** an opportunity and scope of the project and **prepare** the problem statement
CO-2	**Apply** the empathy tools to study the user and **summarize** finding related to problem for define phase.
CO-3	**Describe** and **define** the problem specific to the user group and **apply** Ideation tools to **generate** Ideas to **solve** the problem
CO-4	**Develop** prototypes for test phase.
CO-5	**Test** the ideas and **demonstrate** Storytelling ability to present the Ideas.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	2	2	1	1	-	2	2	2	3	3	3	3
CO-2	3	2	1	1	-	2	2	2	3	3	3	3
CO-3	3	3	2	2	-	2	2	2	3	3	3	3
CO-4	3	3	2	2	3	2	2	2	3	3	3	3
CO-5	3	3	2	2	-	2	2	2	3	3	3	3

Course Outcomes	PSO1	PSO2
CO-1	2	-
CO-2	2	-
CO-3	2	-
CO-4	2	2
CO-5	2	-

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS

UNIT - I	**Periods: 3L+3P=6**

Introduction To Design Thinking

Design Thinking, Need of design thinking, 7 characteristics of design thinking, comparison of design thinking to other ways of thinking, tools and resources, 5 actions phases of Design thinking, 5 characteristics of action plan. Double Diamond Technique for Design thinking. Tools: Problem statement. Design principles.

Activities(Internal Assessment):

a. Case studies of General, engineering and service applications

b. Identify an opportunity and scope of the project and prepare the problem statement.

UNIT - II	**Periods: 5L+5P=10**

Empathize Phases: Design Thinking Tools

Interview for empathy, Ask 5x why, 5W+H questions, Stakeholder map, Emotional response cards, Empathy map, Persona/User profile, Customer journey map.

Activities(Internal Assessment):

a. Study the user using empathy tools and summarize finding related to your problem for define phase.

b. Iterate the process at any stage if required

UNIT - III	**Periods: 5L+5P=10**

Define point of view & Ideate Phase: Design Thinking Tools

Define point of view :"How might we…" question, Storytelling, Context mapping, Vision cone, Critical items diagram.

Ideate: Brainstorming, 2x2 Matrix, Dot voting, 6-3-5 Method, Special brainstorming, Analogies & benchmarking as inspiration

Activities(Internal Assessment):

a. Apply the define tools to your problem: Finalize the problem statement

b. Apply the ideate tools to your problem: Generate lots of Ideas

c. Iterate the process at any stage if required

UNIT - IV	**Periods: 6L+6P=12**

Prototyping Phase: Methods and Tools

Prototypes, Critical Experience Prototype (CEP) & Critical Function Prototype (CFP), Dark horse prototype, Funky prototype, Vision prototype, functional (system) prototype, Solutions in detail - "X is finished", Final prototype, Exploration map, Prototype to test

Activities(Internal Assessment):

a. Create prototype for best idea to your problem using any prototype method.

b. Iterate the process at any stage if required

UNIT - V	**Periods: 5L+5P=10**
Test Phase: Methods and Tools & Implementation	
Test Phase: Methods and Tools Testing sheet, Feedback capture grid, Structured usability testing, A/B Testing **Implementation:** Road map for implementation, Problem to growth & scale innovation funnel **Activities(Internal Assessment):** a. Test the developed prototype by test phase tools and finalize the solution to the problem. b. Iterate the process at any stage if required c. Prepare the complete project report.	

TEXT BOOKS:	
1.	Daniel Ling "*Complete Design Thinking Guide for Successful Professionals*", Emerge Creatives Group LLP, Print ISBN: 978-981-09-5564-9.
2.	Tim Brown, *Change by Design: How Design Thinking Transforms Organizations and Inspires Innovation*, HarperCollins e-books, 2009.
3.	Jeanne Liedtka, Andrew King, And Kevin Bennett, "*Solving Problems with Design Thinking"* , Columbia University Press Publishers, E-ISBN 978-0-231-53605-9
4.	Michael Lewrick, Patrick Link, Larry Leifer, *The Design Thinking Toolbox*, John Wiley & Sons, 2020.

REFERENCE BOOKS:	
1.	Michael G. Luchs, Scott Swan, Abbie Griffin , *"Design Thinking: New Product Development Essentials from the PDMA"*, ISBN-13 : 978-1118971802
2.	Beverly Rudkin Ingle, *"Design Thinking for Entrepreneurs and Small Businesses"*, Apress, ISBN: 9781430261827
3.	Jose Betancur *"The Art of Design Thinking: Make More of Your Design Thinking Workshops",* ISBN: 9781522095378
4.	Michael Lewrick, Patrick Link, Larry Leifer, The Design Thinking Playbook, John Wiley & Sons, 2018

WEB RESOURCES:	
1.	https://dschool.stanford.edu/resources/design-thinking-bootleg
2.	https://www.ideo.com/post/design-thinking-for-educators
3.	https://static1.squarespace.com/static/57c6b79629687fde090a0fdd/t/58890239db29d6cc6c3338f7/1485374014340/METHODCARDS-v3-slim.pdf.
4.	https://www.intel.com/content/dam/www/program/education/us/en/documents/K12/design-and-discovery/student-guide-full-curriculum-session1-18.pdf

DYNAMICS OF MACHINERY

Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC314	PC	2	1	-	32	16	-	40	60	100	3

Prerequisite: Engineering Mathematics, Engineering Mechanics, Kinematics of machinery

Course Objectives: To make the students understand the gyroscopic effect on vehicles, ships and aircrafts and design governors for specific application. The objective is also to enable students to perform dynamic and vibration analysis and solve balancing problems in practical applications.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Apply the knowledge of Gyroscopic principle to airplane, ship, two wheelers and four wheelers and design Governors for a specific application
CO-2	Perform static and dynamic analysis on slider crank mechanism and design flywheel for an IC engine.
CO-3	Solve rotating and reciprocating balancing problems in applications like shafts and Locomotives.
CO-4	Distinguish different classes of vibrations and further analyze longitudinal vibrations of single degree of freedom of un-damped and damped conditions.
CO-5	Analyze free and forced transverse vibrations under different loading conditions and further study free torsional vibrations with single, two rotor, three rotor and geared system

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	3	2	-	-	-	-	-	2	2	-	2
CO-2	3	3	2	-	-	-	-	-	2	2	-	2
CO-3	3	3	2	-	-	-	-	-	2	2	-	2
CO-4	3	3	2	-	-	-	-	-	2	2	-	2
CO-5	3	3	2	-	-	-	-	-	2	2	-	2

Course Outcomes	PSO1	PSO2
CO-1	3	-
CO-2	3	-
CO-3	3	-
CO-4	3	-
CO-5	3	-

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome;Level- 1: Low, 2: Medium, 3: High

SYLLABUS

UNIT - I	**Periods: 6L+3T=9**

GYROSCOPE & GOVERNORS

Gyroscope: Gyroscopic torque, Gyroscopic effect on Aeroplanes, Ships. Stability of four wheeled and two wheeled vehicles.

Governors: Types of governors, Watt, Porter and Proell governors, spring loaded governors – Hartnell. Sensitiveness of a governor, Hunting, Isochronism and Stability. Effort and Power of Governor, Controlling force (Porter and Hartnell governors).

UNIT-II	**Periods: 8L+4T=12**

ENGINE FORCE ANALYSIS & TURNING MOMENT DIAGRAM

Static and dynamic force analysis: Approximate Analytical Method for Velocity and Acceleration of the Piston, angular velocity and angular acceleration of the connecting rod of Slider crank Mechanism. D'Alembert's principle, Equivalent offset inertia force, Static and Dynamic analysis of slider crank mechanism (Analytical/Graphical method), Engine force analysis, Dynamically equivalent system, inertia of connecting rod.

Turning moment diagrams: Turning moment diagrams for I-C engines, fluctuation of energy, flywheels, and dimensions of flywheel rims.

UNIT - III	**Periods: 6L+3T=9**

BALANCING OF ROTATING AND RECIPROCATING MASSES

Balancing of rotating masses: Static and Dynamic Balancing of rotating masses, Balancing of several masses in different planes.

Balancing of reciprocating masses: Primary and secondary unbalanced forces of reciprocating masses, Effects of partial balancing in locomotives- hammer blow, swaying couple, variation of tractive force.

UNIT - IV	**Periods: 6L+3T=9**

LONGITUDINAL VIBRATIONS

Vibrations: Definitions- Types of vibrations- Degrees of freedom.

Longitudinal vibrations: Free longitudinal vibrations of systems having single degree of freedom- Equilibrium method- Energy method and Rayleigh's method, Inertia effect of spring. Damped vibrations, Logarithmic decrement, Forced vibrations with damping- Magnification factor, Vibration isolation and Transmissibility.

UNIT - V	**Periods: 6L+3T=9**

TRANSVERSE AND TORSIONAL VIBRATIONS

Transverse and Torsional vibrations: Free transverse vibrations of shafts due to single concentrated load, uniformly distributed load and carrying several concentrated loads- Dunkerley's method and Energy method. Whirling of shafts. Free torsional vibrations (single, two rotor and three rotor system), Torsionally equivalent shaft.

TEXT BOOKS:

1. S. S. Rattan, *Theory of Machines*, 5th edition, McGraw-Hill, New Delhi, 2019
2. R.S.Khurmi & J.K.Gupta, *Theory of Machines*, 14th edition, S Chand & CO Ltd

REFERENCE BOOKS:

1. Thomas Bevan, *Theory of Machines*, 3rd edition, CBS publishers & distributors, 2005.
2. P.L.Ballaney, *Theory of Machines and mechanisms*, 25th ed., Khanna publishers, , 2016.

WEB RESOURCES:

1.	https://nptel.ac.in/courses/112/101/112101096/
2.	http://nptel.ac.in/courses/112104114/

APPLIED THERMAL ENGINEERING - II

Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC315	PC	2	1	-	32	16	-	40	60	100	3

Prerequisite: Engineering Mathematics, Engineering Mechanics, Basic Thermodynamics

Course Objectives: To impart knowledge on the basics of IC engines, gas turbines and compressors-their construction, working features and performance and further generate interest on combustion phenomena in IC engines.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Distinguish between different classes of IC Engines and further evaluate their performance.
CO-2	Compare & analyze the air standard, fuel-air and actual cycles.
CO-3	Describe the combustion phenomenon in S.I & C.I engines and further analyze the effect of engine parameters on it.
CO-4	Distinguish various classes of compressors, evaluate their performance and interpret their characteristics.
CO-5	Categorize the gas turbine plants and analyze different methods for improving their performance.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	3	-	-	-	-	-	-	-	-	-	-
CO-2	3	3	-	-	-	-	2	-	-	-	-	-
CO-3	3	3	-	-	-	-	2	-	-	-	-	-
CO-4	3	3	-	-	-	-	-	-	-	-	-	-
CO-5	3	3	-	-	-	-	-	-	-	-	-	-

Course Outcomes	PSO1	PSO2
CO-1	2	-
CO-2	2	-
CO-3	2	-
CO-4	2	-
CO-5	2	-

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS

UNIT – I	**Periods: 6L+3T=9**

I.C. ENGINES

Heat engines, engine components & nomenclature, working principle of engines- four stroke & two stroke engines, S.I & C.I engines, classification, carburetion-simple carburetor, Fuel injection systems-classification, fuel injection pump, Testing & performance-frictional power-Willan's line method, Morse test, retardation test, indicated power, brake power-rope brake and hydraulic dynamometer, indicated & brake mean effective pressures, engine efficiencies, engine performance characteristics, heat balance sheet.

UNIT – II	**Periods: 6L+3T=9**

CYCLES AND ANALYSIS

Air standard cycles- Otto, Diesel & Dual cycles-Thermal efficiency, work output and mean effective pressure, comparison of cycles-fuel-air cycles and their significance-composition of cylinder gases-variable specific heats-dissociation, comparison of air standard and fuel-air cycles, actual cycles and their analysis, time loss factor, heat loss factor, exhaust blow down, losses due to gas exchange process.

UNIT – III	**Periods: 6L+3T=9**

COMBUSTION IN IC ENGINES

Combustion in SI Engines: S.I. engines- Normal combustion and abnormal combustion-Importance of flame speed and effect of engine variables-types of abnormal combustion-pre-ignition and knock, knock limited parameters, effect of engine variables on knock, Combustion chamber requirements and Types of combustion chambers.

Combustion in CI Engines: Stages of combustion- Delay period and its importance-effect of engine variables, diesel knock-suction, compression and combustion induced turbulence, Direct & Indirect injection combustion chambers.Fuel requirements, fuel rating and anti-knock additives.

UNIT – IV	**Periods: 8L+4T=12**

AIR COMPRESSORS

Reciprocating Compressors: Classifications, indicated diagram, equation for work, isothermal efficiency-effect of clearance in compressors, free air delivered, volumetric efficiency, actual p-v diagram, single stage and multi stage compressors, effect of inter cooling in multi stage compressors.

Rotary Compressors: classification, steady flow compressors, static and stagnation quantities, centrifugal compressor-construction, working principle, velocity diagrams, Euler's work, Isentropic efficiency, slip factor & pressure co-efficient, compressor characteristics, Axial flow compressors–velocity diagrams – degree of reaction, polytropic efficiency, Surging & chocking.

UNIT – V	**Periods: 6L+3T=9**
GAS TURBINES & JET PROPULSION	
Gas Turbines: Simple gas turbine plant-closed and open cycle gas turbines, Brayton cycle, Efficiency, work ratio and optimum pressure ratio for simple gas turbine cycle, actual cycle, methods for performance improvement- regeneration, Inter-cooling and reheating. **Jet propulsion:** Turbo-jet engines, thrust, thrust power, efficiencies, Turbo-prop engines, Ramjet and pulse jet engines, Rocket engines.	
TEXT BOOKS:	
1.	V. Ganesan, *Internal Combustion Engines* 4th edition, Tata McGraw Hill Education (P) Ltd, 2012.
2.	R. K. Rajput, *Thermal Engineering* 10th edition, Laxmi publication (P) Ltd, 2018.
REFERENCE BOOKS:	
1.	R. Yadav, *Applied Thermodynamics* 6th revised edition, Central Publishing House, Allahabad, 2011.
2.	M.L. Mathur and R.P. Sharma, *Internal Combustion Engines* Danpat Rai , 2016.
3.	V. Ganesan, *Gas Turbines* 3rd edition, Tata McGraw Hill Education (P) Ltd, 2010.
WEB RESOURCES:	
1.	https://nptel.ac.in/courses/112103262

DESIGN OF MACHINE ELEMENTS – I											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC 316	PC	2	1	-	32	16	-	40	60	100	3

Prerequisite: Engineering mathematics, Engineering Mechanics, Mechanics of Solids

Course Objectives: This course enables the student to design a competitive product by following all the design considerations, materials and mechanical properties. The knowledge gained through this course also enables the student to design components subjected to static and fatigue loads useful for automotive aerospace industries.

Course Outcomes: At the end of the course the student will be able to :	
CO-1	**Formulate** a design problem based on design & manufacturing considerations and **identify** appropriate material of construction
CO-2	**Analyze** the various criteria of failure and design a component based on these criteria against static and fluctuating loads
CO-3	**Design** threaded, Riveted and welded joints, subjected to Eccentric & fluctuating loads.
CO-4	**Design** shafts, keys and couplings subjected to static and dynamic loads.
CO-5	**Design** of springs subjected to static and fatigue loads.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	2	1	-	-	-	-	-	2	2	-	2
CO-2	3	3	2	-	-	-	-	-	2	2	-	2
CO-3	3	3	3	-	-	-	-	-	2	2	-	2
CO-4	3	3	3	-	-	-	-	-	2	2	-	2
CO-5	3	3	3	-	-	-	-	-	2	2	-	2

Course Outcomes	PSO1	PSO2
CO-1	2	-
CO-2	3	-
CO-3	3	-
CO-4	3	-
CO-5	3	-

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS

UNIT - I	**Periods: 6L+3T=9**

INTRODUCTION TO MECHANICAL ENGINEERING DESIGN

Traditional design methods, design process, Problem formulation, Design considerations, manufacturing considerations, engineering materials, Mechanical properties, BIS system designation of steels.

UNIT - II	**Periods: 6L+3T=9**

DESIGN AGAINST STATIC AND FLUCTUATING LOADS

Design against static loads: Modes of failure, Factory of safety, Axial, bending and torsional Stresses, Cotter joint, Knuckle joint, Static failure theories.

Design against fluctuating load: Stress concentration, Methods of reducing stress concentration, Fatigue, Endurance limit, S-N Curve for steels, Soderberg, Goodman and modified Goodman diagrams, cumulative damage in fatigue, Fatigue design under combined stresses.

UNIT - III	**Periods: 8L+4T=12**

DESIGN OF THREADED, RIVETED AND WELDED JOINTS

Threaded joints: Forms of threads, ISO metric screw threads, eccentrically loaded bolted joints, Torque requirement for bolt tightening, Fluctuating loads on bolted joints, bolt of uniform strength. Power screws, Force analysis on screw jack, Collar friction.

Riveted Joints: Materials of Rivets, Types of Riveted joints, strength and efficiency of riveted joints. Design of Lap and Butt joints.

Welded joints: Types of weld joints, strength of butt and fillet joints, axially loaded unsymmetrical welded joints, eccentrically loaded welded joints, and welded joints subjected to bending moment, welding inspection.

UNIT - IV	**Periods: 6L+3T=9**

DESIGN OF SHAFTS , KEYS AND COUPLINGS

Shafts & keys: Types of shafts, selection of material, shafts design on strength basis & torsional rigidity basis, Design of hollow shafts, ASME codes for shaft design. Types of keys, Design of square and flat key, Kennedy key, Splines.

Couplings:-

Types of couplings, selection of material, Rigid flange couplings, Flexible couplings, universal coupling.

Case Studies will be given in design of shafts and couplings for transmitting the power between two machine elements.

UNIT - V	**Periods: 6L+3T=9**
Design of Springs	
Classification of springs, spring materials, style of spring end, Design of helical Compression springs, helical extension springs, springs design under fatigue loads, torsion springs. Leaf springs, Equalized stress in spring leaves. Surge in springs, Nipping and shot peening. *Case Studies will be given in design of springs subjected to static and fatigue loads.*	

TEXT BOOKS:	
1.	V.B.Bhandari, *Design of Machine Elements*, TMH Publishing Co. Ltd., New Delhi
2.	Jain, *Machine Design*, Khanna Publications
3.	DesignPandya and Shaw, *Machine Design*, Charotar publication
4.	R S Khurmi and J K Gupta, *Machine Design*, Eurasia Publishing house Pvt Ltd

REFERENCE BOOKS:	
1.	Shigley, *Mechanical Engineering design*, Eighth Edition, McGraw Hill Company
2.	R.L.Norton, *Machine design, an integrated approach* ,2nd edition, Pearson Education
3.	kalaikthir Achchagam, ***Design data book*** , PSG College of technology, Coimbatore, 2011. **Note:** Design data book is allowed in examinations.
WEB RESOURCES:	
1.	https://www.nptelvideos.com/course.php?id=791
2.	https://www.digimat.in/nptel/courses/video/112105124/L01.html
3	https://www.machinedesignonline.com/

KINEMATICS AND DYNAMICS OF MACHINERY LAB

Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC 317	PC	-	-	3	-	-	48	50	50	100	1.5

Prerequisite: Engineering Mechanics, Kinematics of Machinery

Course Objectives: The laboratory serves the purpose of training students to understand the kinematic and dynamic characteristics of machines and their components.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Plot displacement, velocity and acceleration of a slider crank mechanism and determine the coriolis component of acceleration.
CO-2	Analyze the cam follower behaviour for various cam positions
CO-3	Evaluate performance characteristics of various centrifugal governors
CO-4	Observe the gyroscopic effect and calculate the gyroscopic couple
CO-5	Balance rotating masses statically and dynamically for the given system
CO-6	Determine the frequency of vibrations and calculate the whirling speed of a rotating shaft

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	2	-	2	-	-	-	3	-	3	-	2
CO-2	3	2	-	2	-	-	-	3	-	3	-	2
CO-3	3	2	-	2	-	-	-	3	-	3	-	2
CO-4	3	2	-	2	-	-	-	3	-	3	-	2
CO-5	3	2	-	2	-	-	-	3	-	3	-	2
CO-6	3	2	-	2	-	-	-	3	-	3		2

Course Outcomes	PSO1	PSO2
CO-1	2	1
CO-2	2	1
CO-3	2	1
CO-4	2	1
CO-5	2	1
CO-6	2	1

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

Sl. No	NAME OF THE EXPERIMENT	COURSE OUTCOME
1	To plot slider displacement, velocity and acceleration for a slider crank mechanism	CO 1
2	To study the coriolis component of acceleration at various speeds	CO 1
3	To study the cam follower behaviour at different cam positions	CO 2
4	To draw performance characteristic curves and find the stability and sensitivity of Porter and Proell Governor	CO 3
5	To draw performance characteristic curves and find the stability and sensitivity of Hartnell Governor	CO 3
6	To study the Gyroscopic effect and determine the gyroscopic couple on a motorized Gyroscope	CO 4
7	To perform static balancing experiment on the static balancing machine	CO 5
8	To perform Dynamic balancing experiment on the Dynamic balancing machine	CO 5
9	To determine the moment of Inertia of a connecting rod by the compound pendulum method and to study the dynamic equivalent system	CO 5
10	To find the natural frequency of longitudinal and transverse vibrations	CO 6
11	To determine the critical or whirling speed of the rotating shaft	CO 6

REFERENCE BOOKS:

1. S. S. Rattan, Theory of Machines, 5th edition, McGraw-Hill Publications, New Delhi,

THERMAL ENGINEERING LAB

Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC 318	PC	-	-	3	-	-	48	50	50	100	1.5

Prerequisite: Knowledge of Engineering Chemistry and Applied Thermal Engineering-I & II.

Course Objectives: The laboratory serves the purpose of imparting training on the basics of internal combustion engines, Air compressor, Refrigerator & Air conditioner, their construction, operation and performance assessment.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Experiment with I.C Engines to **evaluate** their performance
CO-2	Experiment with two stage Air compressor and **determine** its efficiencies.
CO-3	**Estimate** actual & theoretical COP's of VCR System and Air conditioning System by experimentation.
CO-4	**Estimate** the Dryness Fraction of wet steam by using Separating and Throttling Calorimeter.
CO-5	**Determine** the properties of Fuels like Flash, Fire points & Calorific value.
CO-6	**Calibrate** a Pressure Gauge and Assess the Variation of Viscosity of a Lubricating oil with temperature by Experimentation.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	3	-	2	-	-	-	3	-	3	-	2
CO-2	3	3	-	2	-	-	-	3	-	3	-	2
CO-3	3	3	-	2	-	-	-	3	-	3	-	2
CO-4	3	3	-	2	-	-	-	3	-	3	-	2
CO-5	3	3	-	2	-	-	-	3	-	3	-	2
CO-6	3	3	-	2	-	-	-	3	-	3	-	2

Course Outcomes	PSO1	PSO2
CO-1	2	1
CO-2	2	1
CO-3	2	1
CO-4	2	1
CO-5	2	1
CO-6	2	1

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome;Level- 1: Low, 2: Medium, 3: High

SYLLABUS	
LIST OF EXPERIMENTS (any ten)	**Periods: 3 practicals/week**

1. Load test on a single cylinder Diesel Engine to evaluate its **Performance** Morse test on Multi-cylinder petrol engine to determine **Frictional power.**
2. Prepare a **Heat balance sheet** of a Diesel Engine by experimentation.
3. Retardation test on a slow speed Diesel engine to obtain **Frictional power**
4. Determination of **Various Efficiencies** of a given 2-stage air compressor.
5. Determination of theoretical, actual and relative **COP's** of a vapour compression refrigeration system.
6. Measurement of **Dryness fraction** of steam using separating and throttling calorimeter.
7. Determination of **Calorific value** of Gaseous fuel by using Junker's Gas Calorimeter.
8. Observation and marking of **Valve timings** of a four stroke Engine and **Port timings** of a two stroke Engine and further draw **VTD & PTD** respectively.
9. Determination of Absolute **& Kinematic viscosities** of a given lubricating oil sample using Redwood Viscometer and study their variation with temperature.
10. Determination of **Flash & Fire points** of Fuel oils.
11. **Calibration** of a Pressure Gauge by using Pressure gauge tester
12. Determination of theoretical, actual and relative **COP's** of an Air conditioning system.
13. Demonstration Experiment on a Computerized Variable compression ratio Diesel Engine to obtain **Crank angle Vs Pressure diagram.**

REFERENCE BOOKS:

1.	R.K.Rajput, *Thermal Engineering* 10th edition, Laxmi publications (P) Ltd.
2.	V.Ganesan, *Internal Combustion Engines*, Tata McGraw-Hill Publishing Company Limited.

INDUSTRIAL TRAINING -I

Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC 320	PR	-	-	-	-	-	-	0	100	100	2

Prerequisite: -

Course Objectives: The industrial training/ internship programs are intended to provide an exposure to the student on the industrial ambience, the intricacies involved in the industrial activities and the applications of theoretical concepts to solve problems encountered in industries.

The program is carried out twice in four year course each for a minimum duration of six weeks.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Understand the principles of engineering practice and ethical norms in an industry.
CO-2	Apply engineering knowledge to understand the industrial processes.
CO-3	Develop skills to engage in independent learning in view of the technological changes.

Guidelines:

- The industrial training/internships are done at the end of 2nd year 2nd semester for a minimum duration of six weeks in the summer. The internship can be done by the students at local industries, Govt. Organizations, MNC's, Power plants or any other company of his/her choice.
- Evaluation of the program will be done by a departmental committee. The student has to submit a report and appear for an oral presentation before the departmental committee. The report and the oral presentation shall carry 40% and 60% weightages respectively.

PRODUCTION PLANNING & CONTROL (PROFESSIONAL ELECTIVE-I)											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC322(A)	PE	2	1	-	32	16	-	40	60	100	3

Prerequisites: Manufacturing Processes, Metal Cutting, Machine Tools & Metrology.

Course Objectives: To make the students acquaint with the planning and control of production operations.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Apply the functions of production planning and control in production organizations.
CO-2	Solve forecasting problems using the forecasting techniques to manage production operations.
CO-3	Apply inventory models to plan and control the utilization of various resources.
CO-4	Determine the plans for smooth and efficient running of production operations.
CO-5	Apply the functions of dispatching and progressing in production operations.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	2	2	-	-	-	2	-	-	-	3	-
CO-2	3	2	2	-	-	-	2	-	-	-	3	-
CO-3	3	2	2	-	-	-	2	-	-	-	3	-
CO-4	3	2	2	-	-	-	2	-	-	-	3	-
CO-5	3	2	2	-	-	-	2	-	-	-	3	-

Course Outcomes	PSO1	PSO2
CO-1	2	-
CO-2	2	-
CO-3	2	2
CO-4	2	2
CO-5	2	-

CO - Course Outcome, PO - Program Outcome, PSO - Program Specific Outcome, Level - 1: Low, 2: Medium, 3: High

SYLLABUS	
UNIT - I	**Periods: 6L+0T=6**
INTRODUCTION TO PRODUCTION PLANNING AND CONTROL (PPC)	
Definition, objectives and functions of PPC, Types of production, Organization of PPC.	
UNIT - II	**Periods: 6L+4T=10**
FORECASTING	
Importance of forecasting, Types of forecasting, Forecasting techniques – qualitative and quantitative methods – least square method, moving average method, exponential smoothing method.	
UNIT - III	**Periods: 8L+8T =16**
INVENTORY MANAGEMENT	
Functions of inventory, Inventory costs, ABC analysis, VED analysis, EOQ & EPQ deterministic model without shortages, Inventory control systems – P-system and Q-system, Material Requirement Planning, MRP-II, Aggregate planning strategies, Capacity requirement planning, Enterprise resource planning.	
UNIT - IV	**Periods: 6L+4T =10**
ROUTING & SCHEDULING	
Routing: Definition, Routing procedure, Route sheets, Factors affecting routing procedure, Loading. **Scheduling:** Definition, Forward and backward scheduling, Gantt charts, Flow shop scheduling – n jobs and 2 machines, n jobs and 3 machines, Job shop scheduling – 2 jobs and n machines, Line balancing.	
UNIT - V	**Periods: 6L+0T =6**
DISPATCHING & PROGRESSING	
Dispatching: Definition, Functions of dispatching, Duties of dispatcher. **Progressing:** Definition, Types of progressing.	
TEXT BOOKS:	
1.	R. Panneerselvam, *Production and Operations Management*, 3rd edition, PHI, 2012.
2.	Martand Telsang, *Industrial Engineering and Production Management*, 3rd edition, S. Chand & Co. Ltd., 2018.
REFERENCE BOOKS:	
1.	S.K. Mukhopadhyay, *Production Planning and Control - Text & Cases*, 3rd edition, PHI, 2015.
WEB RESOURCES:	
1.	https://nptel.ac.in/courses/110107141
2.	https://nptel.ac.in/courses/110105095

GAS TURBINES AND JET PROPULSION (PROFESSIONAL ELECTIVE-I)											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC322(B)	PE	2	1	-	32	16	-	40	60	100	3

Prerequisite: Basic Thermodynamics, Applied Thermal Engineering-II

Course Objectives: To provide an insight on the principles of compressible fluid flow, gas turbine power cycles and further to create an understanding of the working principles of axial flow compressors, axial flow gas turbines, combustion chambers and jet propulsion systems.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Analyze compressible fluid flow and its characteristics.
CO-2	Explain the working principles of gas turbine power cycles and evaluate their performance characteristics.
CO-3	Describe the working characteristics of Axial flow compressors, evaluate the effect of blade design on the performance and further analyze operational disturbances.
CO-4	Explain the combustion phenomena in a gas turbine & identify the factors affecting combustion chamber design and performance & further explain the working principles of Axial flow gas turbines.
CO-5	Distinguish the different types of jet propulsion systems, their relative merits, demerits and applications and further analyze parameters affecting flight performance.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	3	-	-	-	-	-	-	-	-	-	-
CO-2	3	3	-	-	-	-	-	-	-	-	-	-
CO-3	3	3	-	-	-	-	-	-	-	-	-	-
CO-4	3	3	-	-	-	-	2	-	-	-	-	-
CO-5	3	3	-	-	-	-	-	-	-	-	-	-

Course Outcomes	PSO1	PSO2
CO-1	2	-
CO-2	2	-
CO-3	2	-
CO-4	2	-
CO-5	2	-

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome;Level- 1: Low, 2: Medium, 3: High

SYLLABUS

UNIT - I	**Periods: 6L+3T=9**

INTRODUCTION TO COMPRESSIBLE FLOW

Introduction- Conservation of Mass - Continuity Equation- Conservation of Energy (First Law of Thermodynamics)- Momentum Equation- Sonic Velocity, Mach Number and Mach Waves- Stagnation Temperature, Pressure and Enthalpy- Isentropic Flow Through a Passage of varying cross sectional Area- choking and isentropic flow, operation of nozzle under varying pressure ratio- converging, converging-diverging nozzle.

UNIT - II	**Periods: 6L+3T=9**

GAS TURBINE POWER CYCLES

Introduction- Brayton Cycle- Brayton Cycle with Regeneration- Complex Cycle- Closed Cycle, Performance of actual gas turbine cycle: Efficiency of the compressor and Turbine Pressure or Flow Losses- Heat Exchanger Effectiveness- Effect of varying mass Flow-Loss due to incomplete combustion- Mechanical Losses- Effect of Variable Specific Heats - Calculation of Fuel consumption and cycle Efficiency- Polytropic Efficiency- Performance of Actual Cycles.

UNIT - III	**Periods: 8L+4T=12**

AXIAL FLOW COMPRESSORS

Introduction- Description- Principle of Operation- Performance Analysis- Momentum, Stage Velocity Diagrams, Symmetric Stage, Non-Symmetric Axial -in flow, Non-Symmetric Axial outflow- Actual Energy Transfer- Airofoil Analysis, One Dimensional Ideal Incompressible Flow, Two Dimensional flow With Friction- Blading Efficiency, Losses in terms of Air Angles and Drag Co efficient- Coefficient of Performance, Flow Coefficient (Φ), Pressure Coefficient(ψp),Work Coefficient(Ω)- Blade Loading- Cascade Characteristics-Blade angles- Reynolds and Mach Number Effects- Three Dimensional flow Analysis, Radial Equilibrium Theory, Free Vortex Blades, Constant Reaction Blades, Forced Vortex of Solid Rotation Blades, The General Design -Three Dimensional Blades, Losses- Compressor Stall, Surge and choke- Overall Performance- Compressor Characteristics.

UNIT - IV	**Periods: 8L+4T=12**

COMBUSTION SYSTEMS & AXIAL FLOW GAS TURBINES

Combustion Systems: Introduction- Combustion theory applied to gas turbine combustion, factors affecting combustion chamber design and performance – Pressure loss, Combustion intensity and Efficiency; Requirements of the Combustion chamber- Process of Combustion Combustion geometry, mixing and dilution, Combustion chamber arrangements. Axial Flow Gas Turbines: Introduction- Description- Turbine and Nozzle efficiencies Degree of Reaction, Ideal Impulse Turbine, Impulse Turbine with Loss, Blades Speed Ratio, Velocity Ratio and Torque, Velocity Compound Turbine (Curtis Stage)- The Reaction Turbine- Three Dimensional Flow Analysis, The Free Vortex Blades.

UNIT – V	**Periods: 4L+2T=6**
JET PROPULSIONS	
Introduction-The Ramjet Engine-The Pulse-jet Engine- The Turbo-jet Engine-Thrust Equation-Specific Thrust of the Turbo Jet Engine- Efficiencies- Inlet Diffuser or Ram Efficiency- thermal Efficiency of the Turbo Jet Engine- Propulsive Efficiency - Overall Efficiency of a Propulsive system-parameters affecting flight performance, Effect of Forward Speed- Effect of Altitude - Overall Turbojet Process- Thrust augmentation- The After burn, Injection of Water-Alcohol Mixtures- Bleed, Burn Cycles.	
TEXT BOOKS:	
1.	V. Ganesan, *Gas Turbines*, 3rd edition, McGraw Hill Education, 2017.
2.	P.R. Khajuria and S.P. Dubey, *Gas Turbines and Propulsive Systems*, Dhanpat Rai Publiations, 2012.
REFERENCE BOOKS:	
1.	Dr. R. Yadav ,*Steam and Gas turbine and Power plant Engineering*,7th edition, Central Publishing House, 2000.
2.	H.I.H. Sarvanamuttoo,G.F.C. Rogers & H. Cohen, *Gas Turbines Theory*, 7th edition, Pearson Publications, 2017
WEB RESOURCES:	
1.	http://www.nptel.ac.in/courses/112106166/

AUTOMATION IN MANUFACTURING (PROFESSIONAL ELECTIVE-I)											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC322(C)	PE	3	-	-	48	-	-	40	60	100	3

Prerequisite: Metal cutting, Machine Tools & Metrology

Course Objectives: To familiarize the students with the concepts of automation, its strategies and various production systems. To introduce the models of automated flow lines, line balancing, material storage, retrieval and inspection.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Explain the basic principles of automation and its components which are implemented in production systems.
CO-2	Differentiate different types of flow lines and elucidate their implementation in production systems.
CO-3	Comprehend cellular manufacturing, forming part families, group technology and their involvement in flexible assembly lines and can solve assembly line balancing problems.
CO-4	Ascertain the importance of material handling and storage and can identify various material handling and storage systems used in production systems.
CO-5	Explain various automated inspection methods, strategies and equipment.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	3	-	-	-	1	1	-	-	-	-	-
CO-2	2	2	-	-	-	2	1	-	-	-	-	-
CO-3	3	3	-	-	-	2	1	-	-	-	-	-
CO-4	2	2	-	-	-	2	1	-	-	-	-	-
CO-5	3	3	-	-	-	2	1	-	-	-	-	-

Course Outcomes	PSO1	PSO2
CO-1	3	-
CO-2	2	-
CO-3	3	-
CO-4	2	-
CO-5	3	-

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS

UNIT - I	**Periods: 10L+0T= 10**
INTRODUCTION TO AUTOMATION	
Production systems, automation in production systems, automation principles and strategies, manufacturing operations, production facilities, levels of automation, basic elements of an automated system, pneumatic and hydraulic components, circuits, automation in machine tools, mechanical feeding and tool changing and machine tool control.	
UNIT - II	**Periods: 8L+0T= 8**
AUTOMATED FLOW LINES	
Methods of part transport, transfer mechanism, buffer storage, control function, design and fabrication considerations. Analysis of automated flow lines – General terminology and analysis of transfer lines without and with buffer storage, partial automation, implementation of automated flow lines.	
UNIT - III	**Periods: 10L+0T= 10**
ASSEMBLY SYSTEM AND LINE BALANCING	
Assembly systems: Fundamentals and analysis, cellular manufacturing, part families, coding and production flow analysis, Assembly process and systems assembly line, **Line balancing**: methods, ways of improving line balance, flexible assembly lines.	
UNIT - IV	**Periods: 10L+0T= 10**
AUTOMATED MATERIAL HANDLING AND STORAGE SYSTEMS	
Automated material handling: Types of equipment, functions, analysis and design of material handling systems conveyor systems, automated guided vehicle systems. **Automated storage systems:** Automated storage and retrieval systems; work in process storage, interfacing handling and storage with manufacturing. automatic identification methods, Barcode technology, RFID	
UNIT - V	**Periods: 10L+0T= 10**
AUTOMATED INSPECTION	
Quality in design and manufacturing, inspection principles and strategies, automated inspection: Methods and Equipment's, contact vs non-contact, Coordinate Measuring Machine, Mission vision.	
TEXT BOOKS:	

1.	Mikell. P. Groover, Automation, *Production Systems, and Computer-integrated Manufacturing,* Pearson Publication, 4th edition, 2016.
2.	P. Radha Krishnan & S. Subrahamanyam and Raju, *CAD/CAM/CIM,* 3rd Edition New Age International Publishers, 4th edition, 2016.
3.	Yorem Koren, *Computer Control of Manufacturing Systems,* McGraw Hill Education; 1st edition, 2017.
4.	Anup Goel, A.Jacob Moses, Dr. Subhash L. Gadhave, Vinayak V. Gaikwad, E. Sathish, *Automation in Manufacturing Technology,* Technical Publications,1st Edition,2021.

REFERENCE BOOKS:	
1.	Tien-Chien Chang, Richard A. Wysk and Hsu-Pin Wang - *Computer Aided Manufacturing,* Pearson Publications, 3rd edition,2005.
2.	Dr. R. Thomas Wright, Mike Berkeihiser, *Manufacturing and Automation Technology*, Goodheart-Willcox Publications, 3rd edition,2011
WEB RESOURCES:	
1.	https://nptel.ac.in/courses/112102011
2.	https://nptel.ac.in/courses/112104288

NON-DESTRUCTIVE TESTING (PROFESSIONAL ELECTIVE - I)											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC322(D)	PE	3	-	-	48	-	-	40	60	100	3

Prerequisite: Engineering Physics, Material science and Metallurgy

Course Objectives: To give an insight to the students on the basic principles of various NDT methods, fundamentals, discontinuities in different product forms, importance of NDT, applications, limitations of NDT methods and techniques.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Explain the importance of NDT in industries and describe the working principle of Liquid Penetrant Testing
CO-2	Analyze the defects of the components by applying the principles of magnetic particle testing.
CO-3	Analyze the welding and casting defects by applying radiography technique
CO-4	Examine the base material by ultrasonic testing technique
CO-5	Examine the leaks corrosion and creep damage using acoustic emission testing.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	2	-	-	-	-	-	2	-	-	-	-
CO-2	3	2	-	-	-	-	-	2	-	-	-	-
CO-3	3	2	-	-	-	-	-	2	-	-	-	-
CO-4	3	2	-	-	-	-	-	2	-	-	-	-
CO-5	3	2	-	-	-	-	-	2	-	-	-	-

Course Outcomes	PSO1	PSO2
CO-1	2	-
CO-2	2	-
CO-3	2	-
CO-4	2	-
CO-5	2	-

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS

UNIT – I	**Periods: 9L+0T=9**

INTRODUCTION TO NON DESTRUCTIVE TEST (NDT) TECHNIQUES

History, Surface NDT methods, Visual Testing – vision, lightning and material attributes, environmental factors, visual perception, direct and indirect methods, light sources and special lightning, inspection objectives, sampling plan, classification of indications for acceptance criteria – codes, standards and specifications with significance to National industries

Liquid Penetrant Test (LPT): Principles – types and properties of liquid penetrants - application of Liquid penetrants to parts – dye penetrant process - different washable systems – removal of excess penetrants – developers – post cleaning - emulsifiers– special lighting for penetrant testing – calibration– interpretation and evaluation of test results – applicable codes and standards of LPT.

UNIT - II	**Periods: 10L+0T=10**

MAGNETIC PARTICLE TEST (MPT)

Theory of magnetism – ferromagnetic, paramagnetic materials, characteristics of magnetic fields, magnetic hysteresis - principle of operation of magnetic particle test, Surface strength characteristics – depth of magnetic field penetration factors – circular and longitudinal magnetization technique - Eddy current inspection, application, advantages and limitations.

Magnetic Particle Testing Equipment: method of magnetization, inspection materials, wet and dry particles, portable, mobile and stationary equipment, calibration, dry continuous method, wet residual method, interpretation and evaluation of test indications – principles and methods of demagnetization– residual magnetism – applicable codes and standards used in national industries

UNIT - III	**Periods: 10L+0T=10**

RADIOGRAPHY TEST (RT)

Principle of Radiography, Radiation isotopes sources – types and characteristics, X-ray source – generation and properties, industrial X-ray tubes – film characteristic exposure charts, contrast study – quality, intensity, operational characteristics of X-ray equipment - X- ray film – structure and types for industrial radiography - Image Quality - sensitivity – Image Quality Indicators – Intensifying screens – intensification factor, control of scattered radiation, filters, diaphragms, masks.

Radiography Interpretation and Safety Precautions: Principle of radiation detectors – Ionization chamber, operational limits of exposures – Radiation hazards evaluation and control - Interpretation of radiographs for welds, castings and Inspection standards - applicable codes, standards and specifications for national industries.

UNIT - IV	**Periods: 10L+0T=10**

ULTRASONIC TEST (UT)

Fundamentals of Ultrasonic Waves - Nature of sound waves, wave propagation in metals– modes of sound wave generation – longitudinal waves, transverse waves, surface waves, lamb waves –Velocity, frequency and wavelength of ultrasonic waves – Ultrasonic pressure, intensity and impedance – Attenuation of ultrasonic waves – Snell's law and critical angles – ultrasonic beam split – wave propagation in other engineering materials.

Ultrasonic Inspection Methods and Equipment and Safety: Principle of pulse echo method, through transmission method, resonance method – Advantages, limitations - Data presentation A, B and C scan displays - Ultrasonic testing and evaluation of base material - Ultrasonic test indications, safety and precautions.

UNIT - V	**Periods: 9L+0T=9**
ACOUSTIC EMISSION TECHNIQUE (AET)	
Principles of acoustic emission technique - sources such as melting, twinning, and phase transformations in metals - detection and interpretation of AE signals - importance of signal conditioning, detection, processing. **Acoustic Emission Test systems and applications:** Instrumentation, sensor, amplifier, filter, display, and storage equipment – applications - leak test, detection of active corrosion, detecting creep damage in high energy piping (HEP) systems, pressure vessel inspection, advantages and disadvantages.	

TEXT BOOKS:	
1	J. B. Hull, Vernon John, *Non Destructive Testing*, Macmillan Education, 1988.
2	J Prasad and C. G. Krishnadas Nair, *Non-Destructive Test and Evaluation of Materials*, 2nd Edition,
REFERENCE BOOKS:	
1	Barkanov, Evgeny N.; Dumitrescu, Andrei; Parinov, Ivan A, *Non-destructive Testing and Repair of Pipelines*, Springer International Publishing AG, 2017.
WEB RESOURCES:	
1	www.ndt-ed.org/recoursecenter

REFRIGERATION & AIR-CONDITIONING (PROFESSIONAL ELECTIVE-II)											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC 323 (A)	PE	2	1	-	48	-	-	40	60	100	3

Prerequisite: Basic Thermodynamics, Applied Thermal Engineering-I

Course Objectives: To acquaint the student with the working of various popular refrigeration systems, their applications and performance evaluation techniques and enable them to apply the basics of psychrometry in calculating air conditioning loads.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Identify the appropriate refrigeration method for the given application and also evaluate the performance of air refrigeration systems.
CO-2	Designate different refrigerants and select suitable refrigerant for the given application. Further, the student will be able to evaluate the performance of vapour compression refrigeration systems and suggest performance improvement methods.
CO-3	Explain the need for multi-pressure systems, flash gas removal, flash intercooling techniques and further explain the functioning of some important evaporators, expansion devices used in vapor compression refrigeration systems.
CO-4	Demonstrate the working principles of vapor absorption, steam-jet and vortex tube refrigeration systems and further evaluate the performance of VARS.
CO-5	Analyze air-conditioning processes using the principles of Psychrometry and explain the concept of comfort air-conditioning and calculate air conditioning loads.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	3	3	-	-	2	2	-	-	-	-	-
CO-2	3	3	3	2	-	3	2	-	-	-	-	-
CO-3	3	2	2	-	-		2	-	-	-	-	-
CO-4	3	2	2	-	-	2	2	-	-	-	-	-
CO-5	3	3	3	2	-	3	2	-	-	-	-	-

Course Outcomes	PSO1	PSO2
CO-1	3	-
CO-2	3	-
CO-3	2	-
CO-4	2	-
CO-5	3	-

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS

UNIT - I	**Periods: 6L+3T=9**

INTRODUCTION AND AIR REFRIGERATION:

Methods of Refrigeration; Joule-Thomson coefficient; liquefaction of gases by Linde's process; Unit of Refrigeration; Applications of Refrigeration.

Reversal Carnot cycle; Bell-Colemann cycle; Air cycle systems for air craft refrigeration; Boot strap system; Regenerative cycle; Reduced ambient type; Comparison of different systems.

UNIT - II	**Periods: 6L+3T=9**

REFRIGERANTS AND SIMPLE VAPOUR COMPRESSION REFRIGERATION:

Classification of Refrigerants; Nomenclature; Properties; Selection of refrigerants.

Wet versus Dry compression; Effect of evaporator and condenser pressures; Liquid subcooling; superheating; Simple vapour compression refrigeration cycle and its analysis; Actual VCRS; Methods of improving C.O.P;

UNIT - III	**Periods: 6L+3T=9**

MULTI-PRESSURE VAPOUR COMPRESSION AND COMPONENTS

Basics of multi pressure systems; Flash gas removal and Flash inter cooling.

Classification of evaporators, working of Once through, Flooded, Shell and tube, Baudelot cooler type evaporators.

Classification of expansion devices, Classification; working of Automatic expansion valve, Capillary expansion device and Thermostatic expansion device.

UNIT - IV	**Periods: 6L+3T=9**

UN-CONVENTIONAL REFRIGERATION SYSTEMS:

Simple Vapour Absorption Refrigeration System; Maximum C.O.P. of absorption refrigeration system; Common refrigerant-absorbent systems; Aqua ammonia absorption system; Li-Br absorption refrigeration system; Electrolux refrigeration; Comparison of vapour compression and vapour absorption system, Steam jet refrigeration system; Thermoelectric refrigeration system; vortex tube refrigeration system.

UNIT - V	**Periods: 8L+4T=12**

AIR-CONDITIONING:

Fundamentals of psychrometry; Basic processes in conditioning of air; Sensible heat factor; By pass factor; Air washer: Water injection, Steam injection; Summer and Winter air-conditioning systems; Different types of air-conditioning loads; RSHF; GSHF; Fresh air quantity; Effective temperature; Comfort chart; Human comfort.

TEXT BOOKS:

1.	S.C. Arora and S. Domkundwar, *A Course in Refrigeration and Air-conditioning*, Dhanpat Rai Publications, 2018.

2.	C.P. Arora, *Refrigeration and Air conditioning*, 3rd Edition, Tata Mc Graw Hill publishers, 2012.
3.	R.K. Rajput, *A Textbook of Refrigeration and Air-Conditioning*, S.K. Kataria & Sons, 2013.
REFERENCE BOOKS:	
1.	P.L. Bellany, *Refrigeration and Air conditioning*, 6th edition, Khanna publishers,1983.
2.	S.S. Thipse, *Refrigeration and Air conditioning* Jaico Publishing House, 2005.
3.	Roy J. Dossat, *Principles of Refrigeration*, Wiley Limited, 1978
4.	Stoecker W.F. and Jones J.W, *Refrigeration and Air-Conditioning*,McGraw-Hill, New Delhi, 1983
DATA BOOKS:	
M. L. Mathur, and F. S. Mehta, *Refrigerant and Psychometric Properties - Tables and Charts [SI Units]*, Jain Brothers, 2020 (Revised Edition).	
WEB RESOURCES:	
1.	http://dte.karnataka.gov.in/Institutes/gptkampli/GenericDocHandler/68-fc177b7d-f5d1-4580-b577-b1118df994f4.pdf
2.	https://nptel.ac.in/courses/112105129
3.	https://mrcet.com/downloads/digital_notes/ME/III%20year/R&AC%20NOTES.pdf
4.	https://gmpua.com/CleanRoom/HVAC/Cooling/Handbook%20of%20Air%20Conditioning%20and%20Refrigeration.pdf
5.	https://nptel.ac.in/courses/112/107/112107208
6.	https://nptel.ac.in/courses/112/105/112105128/

POWER PLANT ENGINEERING (PROFESSIONAL ELECTIVE-II)											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC323(B)	PE	3	-	-	48	-	-	40	60	100	3

Prerequisite: Basic Thermodynamics, Applied Thermal Engineering-II

Course Objectives: The course is intended to provide overall view of all types of power plants, their working principles and further create a clear cut understanding of the economies of power plants and fixation of tariff rates.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Explain the working principle of steam power plant and its accessories
CO-2	Explain the accessory systems working in tandem with internal combustion engine power plant and different configurations of gas turbine power plant
CO-3	Describe different components of hydroelectric power plant and evaluate rainfall and run-off estimation
CO-4	Describe the working principle and construction features of nuclear power plant and further classify reactors.
CO-5	Analyze power plant economics and evaluate power tariff.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	2	-	-	-	2	-	-	-	-	-	-
CO-2	3	3	2	-	-	2	-	-	-	-	-	-
CO-3	3	2	2	-	-	2	-	-	-	-	-	-
CO-4	3	2	-	-	-	2	2	-	-	-	-	-
CO-5	3	3	2	-	-	2	-	-	-	-	-	-

Course Outcomes	PSO1	PSO2
CO-1	2	-
CO-2	3	-
CO-3	2	-
CO-4	2	-
CO-5	3	-

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS

UNIT - I	**Periods: 9L+0T=9**

STEAM POWER PLANTS

General layout, fuel handling, burning of coal - stoker firing -classification and principle, pulverised fuel firing -advantages and types of systems, draught systems- definition and types, boilers - fire tube boilers - Cochran boiler, Lancashire boiler, water tube boilers- Babcock and Wilcox boiler, Stirling boiler, high pressure and forced circulation boilers - Lamont boiler,

UNIT - II	**Periods: 11L+0T=11**

DIESEL ENGINE POWER PLANTS

Introduction, general layout of plant, applications, different systems of diesel power plant, supercharging.

GAS TURBINE POWER PLANTS

Introduction, classification - open cycle and closed cycle gas turbine power plant, components -compressor, intercoolers, heat exchangers, combustion chamber, gas turbines, different arrangements of gas turbine power plant, gas turbine fuels, simple Brayton cycle, combined gas turbine and steam power plants -basics.

UNIT - III	**Periods: 10L+0T=10**

HYDROELECTRIC POWER PLANTS

Introduction, hydrology, hydrologic cycle, rainfall, runoff and their measurement, hydrograph, flow duration curve, mass curve, classification of hydroelectric power plants, plant layout and its operation, elements of hydroelectric power plant - dam, surge tanks, spillways, draft tubes, conduits, power house, water hammer effect.

UNIT - IV	**Periods: 9L+0T=9**

NUCLEAR POWERP PLANTS

introduction, isotopes, nuclear fission, reproduction factor, moderation, fertile and fissile materials, nuclear reactors, components, classification - PWR, BWR, CANDU, gas cooled reactor, liquid cooled reactor, properties of fuels, moderator, coolant, control rods, reflector, cladding material, types of nuclear wastes and radioactive waste disposal systems.

UNIT - V	**Periods: 9L+0T=9**

POWER PLANT ECONOMICS

load curves, load duration curves, different terms and definitions- connected load, max demand, demand factor, average load, load factor, diversity factor, plant capacity factor, plant use factor - simple problems, cost analysis, selection of type of generation, economics in plant selection, base load plants, peak load plants, tariff methods for electrical energy- simple problems.

TEXT BOOKS:	
1.	S.C.Arora & S. Domkundawar, *A Course in Power Plant Engineering*, Dhanpat Rai & co (P) Ltd, New Delhi.
2.	R.K.Rajput, *A Textbook of Power Plant Engineering* , 5th edition, Laxmi publications (P) Ltd, New Delhi 2007.
REFERENCE BOOKS:	
1.	Dr P.C.Sharma, *A textbook of power plant engineering*, S.K.Kataria & Sons, New Delhi 2016.
2.	P.K.Nag *Power Plant Engineering* 4th edition, Tata McGraw Hill publishers, 2014.
3.	A.K.Raja, Amit Prakash Srivastava , Manish Dwivedi *Power Plant Engineering* , 1st edition.
WEB RESOURCES:	
1.	http://nptel.ac.in/courses/108105058/9
2.	http://www.powermag.com

NANOTECHNOLOGY (PROFESSIONAL ELECTIVE-II)											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC 323(C)	PE	3	-	-	48	-	-	40	60	100	3

Prerequisite: Engineering physics, Engineering chemistry, Material science & Metallurgy

Course Objectives: To acquaint the student on the basic scientific concepts of nanoscience, properties of nanomaterials, characterization of materials, synthesis, fabrication and also the applications of nanotechnology in various science, engineering and technology fields.

Course Outcomes: The student will be able to:	
CO-1	**Designate** the nano materials based on their properties and crystal lattice.
CO-2	**Analyze** and apply different techniques used in the synthesis and fabrication of nano materials in the form of thin films, nano structures etc.,
CO-3	**Comprehend** and apply various characterization techniques to **evaluate** the structure of nanoparticles.
CO-4	**Characterize** carbon allotropes, **analyze** their morphology and **illustrate** the applications of carbon nano technology.
CO-5	**Demonstrate** the applications of nanotechnology in various steams of engineering, environment and sciences.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	2	1	-	-	-	1	1	-	-	-	-	-
CO-2	2	2	2	-	-	1	1	-	-	-	-	-
CO-3	2	2	2	-	-	1	1	-	-	-	-	-
CO-4	3	2	2	-	-	2	2	-	-	-	-	-
CO-5	3	-	-	-	-	2	2	-	-	-	-	-

Course Outcomes	PSO1	PSO2
CO-1	1	-
CO-2	2	-
CO-3	2	-
CO-4	2	-
CO-5	-	-

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS	
UNIT-I	**Periods: 9L+0T=9**
INTRODUCTION	
History of nano science, definition of nanometer, nano materials, nanotechnology. Classification of nano materials. Crystal symmetries, crystal directions, crystal planes, Band structure. PROPERTIES OF MATERIALS: Mechanical properties, electrical properties, dielectric properties, thermal properties, magnetic properties, opto electronic properties. Effect of size reduction on properties, electronic structure of nanomaterials	
UNIT-II	**Periods: 12L+0T=12**
SYNTHESIS AND FABRICATION	
Synthesis of bulk polycrystalline samples, growth of single crystals. Synthesis techniques for preparation of nano particles – Bottom-Up Approach - sol gel synthesis, hydro thermal growth, thin film growth, PVD and CVD; Top Down Approach - Ball milling, micro fabrication, lithography. Requirements for realizing semiconductor nano structures, growth techniques for nanostructures	
UNIT - III	**Periods: 9L+0T=9**
CHARACTERIZATION TECHNIQUES	
X-Ray diffraction and Scherer method, scanning electron microscopy, transmission electron microscopy, scanning probe microscopy, atomic force microscopy, Raman spectroscopy	
UNIT - IV	**Periods: 9L+0T=9**
CARBON NANOTECHNOLOGY	
Characterization of carbon allotropes, synthesis of diamond - nucleation of diamond, growth and morphology. Applications of nano crystalline diamond films, graphene, applications of carbon nano tubes	
UNIT - V	**Periods: 9L+0T=9**
APPLICATIONS OF NANOTECHNOLOGY	
Applications in material science, biology and medicine, surface science, energy and environment. Applications of nanostructured thin fins, applications of quantum dots.	
TEXT BOOKS:	
1.	M.SRamachandra Rao, ShubraSingh, *Nanoscience and nanotechnology* , Wiley publishers,Year: 2013
2.	K.K.A.N.Banerjee Chattopadhyay,A.N.Banerjee, *Introduction to Nanoscience and Nanotechnology* Year:Feb23,2007.
3.	VladimirV.Mitin,ViatcheslavA.Kochelap,MichaelA.Stroscio, *Introduction To Nanoelectronics: Science, Nanotechnology, Engineering, And Applications* Year:2010.

REFERENCE BOOKS:	
1.	Charles P.Poole, Jr.,Frank J.Owens, *Introduction to NanoTechnology*, Wileypublishers, Apr 16,2004
2.	Jermy JRamsden, *Nanotechnology* Elsevierpublishers,Sep19,2012
3.	A.K.Bandyopadhyay, *NanoMaterials*, NewAgeInternationalPublishers,Year:2007.
4.	T.Pradeep, *NanoEssentials*, TMH,Jan20,2007.
5.	M.AShah,K.AShah, *Nanotechnology the Science of Small* Wiley Publishers, Year:2013.
6.	PhaniKumar, *Principles of Nanotechnology*, Scitech,Year:2010.
WEB RESOURCES:	
1.	https://nptel.ac.in/courses/118102003

QUALITY & RELIABILITY ENGINEERING **(PROFESSIONAL ELECTIVE-II)**											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC323(D)	PE	3	-	-	48	-	-	40	60	100	3

Prerequisite: Industrial Engineering and Management

Course Objectives: Students will be acquainted with the basic knowledge of Quality control and Reliability Engineering

Course Outcomes: At the end of the course the student will be able to	
CO-1	Demonstrate knowledge of quality management principles, techniques and philosophies.
CO-2	Apply the quality tool like QFD and ISO standards for industries
CO-3	Implement the TQM tools in industries.
CO-4	Demonstrate knowledge of reliability management principles, techniques and philosophies.
CO-5	Demonstrate knowledge of models for reliability engineering.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	2	-	-	-	-	1	-	2	2	2	2	2
CO-2	2	-	-	-	-	1	-	2	2	2	2	2
CO-3	2	2	-	-	-	1	-	2	2	2	2	2
CO-4	2	-	-	-	-	1	-	-	-	-	-	-
CO-5	2	2	-	-	-	1	-	-	-	-	-	-

Course Outcomes	PSO1	PSO2
CO-1	-	2
CO-2	-	2
CO-3	-	2
CO-4	-	2
CO-5	-	2

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS	
UNIT - I	**Periods: 10L+0T=10**
INTRODUCTION TO QUALITY MANAGEMENT	
Concepts of TQM: Philosophy of TQM, Quality philosophies of Deming, Crossby. Juran Triology, Customer focus, Organization, Top management commitment, Team work. TQM process: QC tools-, Problem solving methodologies, New management tools, Work habits, Quality circles, Bench marking, Strategic quality planning.	
UNIT - II	**Periods: 10L+0T=10**
TQM TOOLS AND QUALITY SYSTEMS	
TQM systems: Quality function deployment, Standardization, Designing for quality, Manufacturing for quality, Failure Mode Effect Analysis. Quality system: Need for ISO 9000 system, Advantages, Clauses of ISO 9000, Implementation of ISO 9000, Quality costs, Quality auditing, Case studies.	
UNIT - III	**Periods: 10L+0T=10**
IMPLEMENTATION OF TQM	
Implementation of TQM: Steps, KAIZEN, 5S, JIT, POKAYOKE, Case studies.	
UNIT - IV	**Periods: 9L+0T=9**
INTRODUCTION TO RELIABILITY	
Concepts of quality and reliability, a brief history, terms, definitions, reliability function, MTTF, Hazard rate function, bath tub curve, conditional reliability.	
UNIT - V	**Periods: 9L+0T=9**
RELIABILITY MODELS	
Constant failure rate models: Exponential reliability, failure modes, failure modes with exponential distribution, applications, two parameter exponential distribution, Poisson process. Time dependent failure models: Weibull distribution, burn-in screening for Weibull, three parameter Weibull distribution, Normal and Lognormal distributions	
Case studies: System failures and reasons thereof *Only for internal evaluation*	

TEXT BOOKS:	
1.	Besterfield et al., "*Total Quality Management"* Pearson Education, India, 2009
2.	Rose, J.E., "*Total Quality Management"* Kogan Page Ltd., 1993
3.	Charles E Ebeling *, "Introduction to Reliability and Maintenance engineering"*, Tata
4.	Srinath, L. S., *Reliability Engineering,* Affiliated East West Press, New Delhi 2005

REFERENCE BOOKS:	
1.	John Bank, *The Essence of Total Quality Management*, PHI, 1993.
2.	E.E. Lewis, *Introduction to Reliability Engineering*, John Wiley& Sons, New York
3.	S.S.Rao, *"Reliability based design"* McGraw-Hill, New York

WEB RESOURCES:	
1.	http://www.digimat.in/nptel/courses/video/110104080/L07.html

FINITE ELEMENT ANALYSIS											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC 324	SC	1	-	2	16	-	32	40	60	100	2

Prerequisite: Engineering Mathematics-I&II, Engineering Mechanics, Mechanics of solids.

Course Objectives: To introduce the concepts of Mathematical Modeling of Engineering Problems using FEA and to appreciate the use of FEA methodology to a wide range of Engineering Problems.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Analyze nodal displacements, stresses and reactions for one dimensional bar problems.
CO-2	Examine nodal displacements, stresses and reactions for plane truss and beam problems.
CO-3	Explore iso-paramentric formulation of two dimensional structural problems using CST and 4 noded quadrilaterel elements.
CO-4	Investigate thermal analysis of one dimensional steady state Heat transfer problems.
CO-5	Evaluate eigen values and eigen vectors and Modal and Harmonic analysis of Stepped bar.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	3	3	3	3	-	-	-	2	2	-	2
CO-2	3	3	3	3	3	-	-	-	2	2	-	2
CO-3	3	3	3	3	3	-	-	-	2	2	-	2
CO-4	3	3	3	3	3	-	-	-	2	2	-	2
CO-5	3	3	3	3	3	-	-	-	2	2	-	2

Course Outcomes	PSO1	PSO2
CO-1	3	3
CO-2	3	3
CO-3	3	3
CO-4	3	3
CO-5	3	3

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS

UNIT - I	**Periods: 4L+8P=12**

INTRODUCTION:

Introductory Concepts: Introduction to FEA, Refreshing Stress – Strain –Displacement Relationship, General FEA Procedure, types of Elements, Applications of FEA in various fields, Advantages and disadvantages of FEA over other methods,

ONE-DIMENSIONAL BAR PROBLEMS:

Introduction, Finite Element Modelling, Coordinates and Shape Functions, Derivation of Element stiffness matrix and load vectors using Potential-Energy approach, Properties of Stiffness matrix, Treatment of Boundary conditions, Problems.

UNIT - II	**Periods: 3L+6P=9**

ANALYSIS OF TRUSSES AND BEAMS:

ANALYSIS OF TRUSSES:

Plane Trusses-Introduction-Derivation of element stiffness matrix-problems in Plane Trusses.

ANALYSIS OF BEAMS:

Beams-Introduction-Finite Element Formulation, Load vector, Boundary conditions, Simple problems on beams subjected to point loads and UDL.

UNIT - III	**Periods: 3L+6P=9**

ANALYSIS OF TWO DIMENSIONAL PROBLEMS:

Iso-parametric formulation, Three laws used for developing iso-parametric concept, Iso-parametric, Sub-parametric and Super-parametric Elements, convergence requirements, Finite Element Modelling-Constant-Strain Triangle (CST), Four Noded Quadrilateral Elements (only rectangular elements), Jacobian Matrix, Strain-displacement matrix - Simple problems.

UNIT - IV	**Periods: 3L+6P=9**

THERMAL ANALYSIS:

Introduction to Thermal analysis, FEA formulation of One Dimensional Steady State Heat Transfer – 1D Composite walls, 1D Thin uniform Fins, Types of Boundary Conditions used in Heat transfer – Problems on composite walls and fins.

UNIT - V	**Periods: 3L+6P=9**

DYNAMIC ANALYSIS:

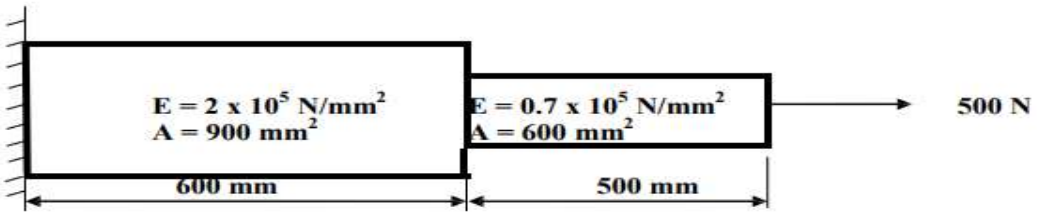
DYNAMIC ANALYSIS:

Formulation of finite element model, element consistent and lumped mass matrices, evaluation of eigen values and eigen vectors, Modal analysis and Harmonic analysis for one dimensional two noded stepped bar problems.

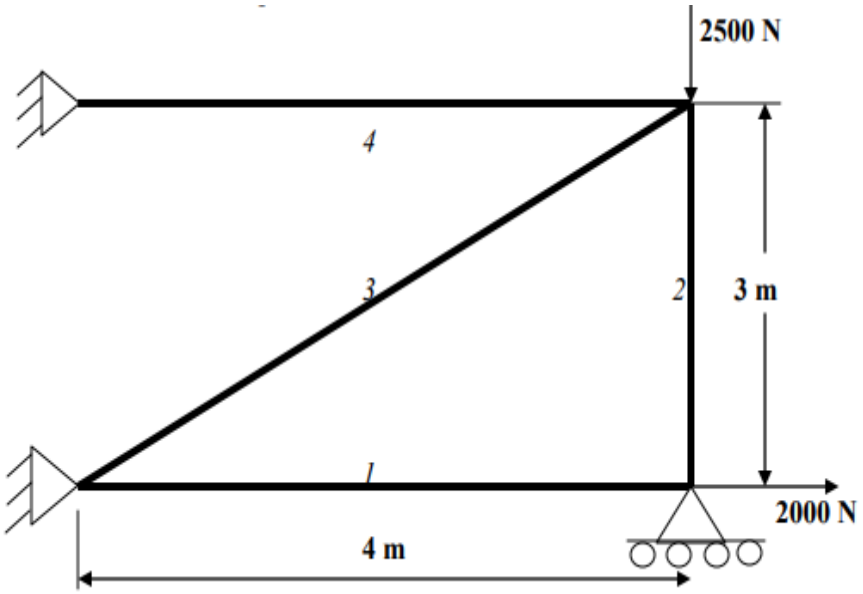
NOTE: Experiments are provided to students to gain skill on practical knowledge using ANSYS APDL Software. These Experiments can be given for assignments (Internal Evaluation Process) not for Mid and Semester Exams

LIST OF EXPERIMENTS:

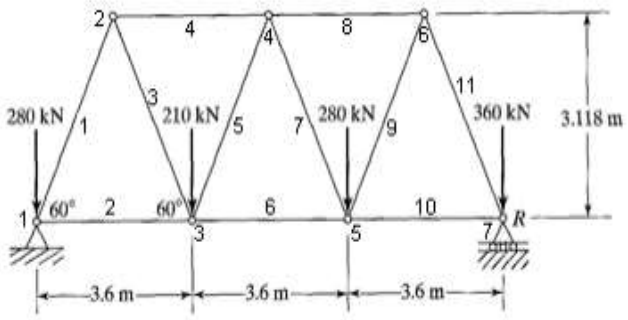
1.Consider the stepped bar shown in figure below. Determine the Nodal Displacement, Stress in each element, Reaction forces.



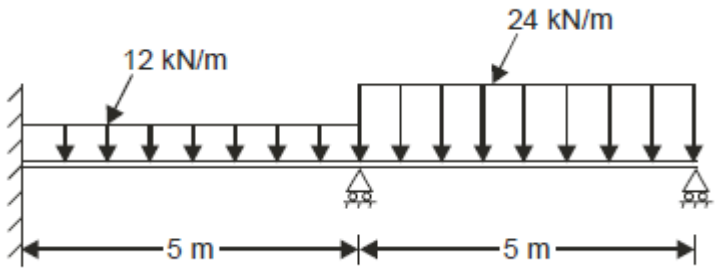
2. Consider the four bar truss shown in figure. For the given data, find Stress in each element, Reaction forces, Nodal displacement. E = 210 GPa, A = 0.1 m^2.



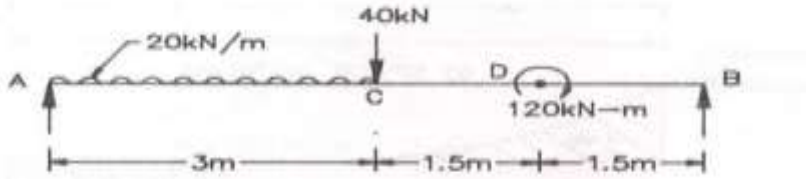
3. Determine the nodal deflections, reaction forces, and stress for the truss system shown below (E = 200GPa, A = 3250mm2).



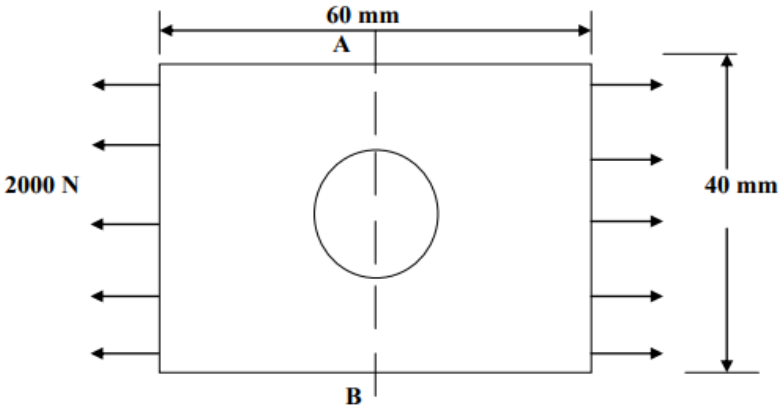
4. Compute mid- point Deflections, Slopes and Shear force and bending moment diagrams for the beam shown and find the maximum deflection. Young's modulus of 210 GPa, Poisson's ratio 0.27. I = 5 * 10^6 N/mm^2



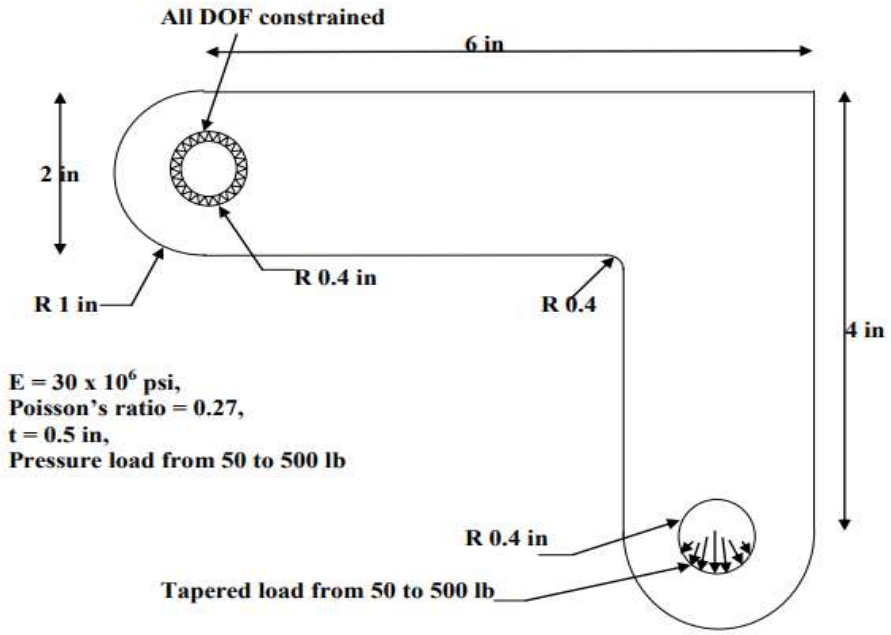
5. Draw the shear force and bending moment diagram for the beam shown in figure. Also find maximum deflection and location. The beam is of rectangular cross section with depth 200 mm and width 120 mm. Find maximum bending stress and location.



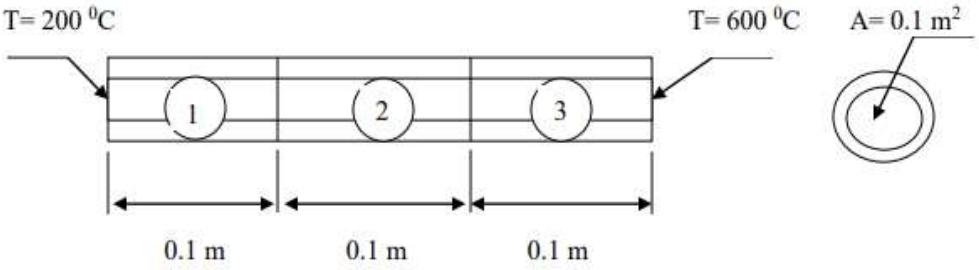
6. In the plate with a hole under plane stress, find deformed shape of the hole and determine the maximum stress distribution alond A-B (you may use t = 1 mm). E = 210GPa, t = 1 mm, Poisson's ratio = 0.3, Dia of the circle = 10 mm, Analysis assumption – plane stress with thickness is used.



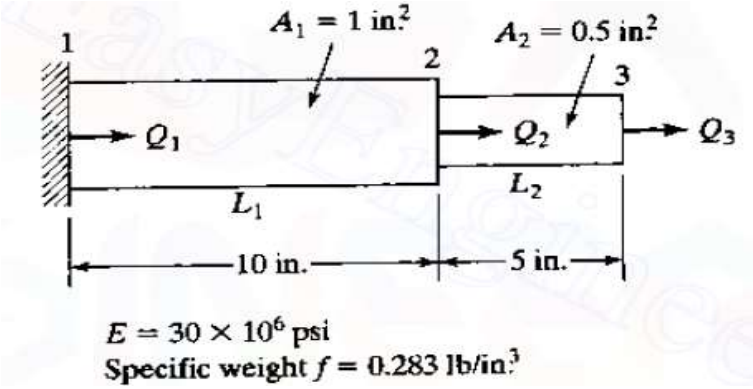
7. The corner angle bracket is shown below. The upper left hand pin-hole is constrained around its entire circumference and a tapered pressure load is applied to the bottom of lower right hand pin-hole. Compute Maximum displacement, Von-Mises stress.



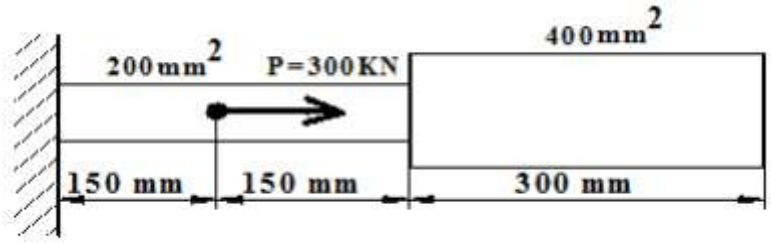
8. For the composite wall idealized by the 1-D model shown in figure below, determine the interface temperatures. For element 1, let K1 = 5 W / m°C, for element 2, K2 = 10 W / m°C and for element 3, K3 = 15 W / m°C. The left end has a constant temperature of 200°C and the right end has a constant temperature of 600°C.



9. Conduct modal analysis to determine natural frequency for the given stepped bar problem.



10. Conduct harmonic analysis of a given axial stepped bar. Modulus of elasticity, E = 2.068 x 10^{11} N/m^2 Poisson's ratio μ = 0.3 Density, ρ = 7830 kg/m^3 Load: Cyclic Load of 300 KN as shown. Frequency Range: 0-5000 Hz



TEXT BOOKS:

1.	Tirupathi R. Chandrupatla, Ashok D.Belegundu *Introduction to Finite Elements in Engineering*, Fourth edition, Pearson education, 2011.
2.	S.S.Rao *The Finite Element Method in Engineering*, 5th edition, Elsevier publications, 2010.
3.	Mary Kathryn Thompson *ANSYS Mechanical APDL for Finite Element Analysis*, 1st edition. Butterworth-Heinemann.

REFERENCE BOOKS:

1.	JN Reddy *An introduction to the Finite Element Method*, McGraw Hill Education; 3rd edition, 2005.
2.	C.S. Krishnamoorthy Finite Element Analysis: Theory and Programming, Tata McGraw-Hill Education, 1995.
3.	S.S. Bhavikatti *Finite Element Analysis*, New Age International, 2005.
4.	KennethH.Huebner, Donald L. Dewhirst, Douglas E. Smith and TedG. Byrom, *The Finite Element Method for Engineers*, John Wiley & sons (ASIA)PteLtd.
5.	Seshu P, *Textbook of Finite Element Analysis*, PHI. 2004
6.	Zeincowicz, *The Finite Element Method* 4 Vol set, 4th Edition, Elsevier 2007.

WEB RESOURCES:

1.	https://onlinecourses.nptel.ac.in/noc16_me02
2.	http://www.open.edu/openlearn/science-maths-technology/introduction-finite-element-analysis/
3	https://www.ansys.com/training-center/course-catalog/structures/introduction-to-ansys-mechanical-apdl

FLUID MECHANICS & HYDRAULIC MACHINERY

Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC 325	PC	2	1	-	32	16	-	40	60	100	3

Prerequisite: Engineering Mathematics-I, Engineering Mechanics

Course Objectives: To acquaint the student with the fundamental & advanced principles of fluid mechanics and their application to any practical problem involving fluids to find a solution and to evaluate the forces exerted by a jet of fluid on vanes of different shapes and further apply this knowledge in the study of hydraulic machinery like turbines, pumps etc.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Calculate the fluid properties and pressure measurement in fluid flow problems and also determine the hydro static forces acting on submerged surfaces of different geometry.
CO-2	Identify the type of fluid flow using the fundamentals of fluid kinematics and also determine the discharge and reaction forces in closed conduit flow.
CO-3	Identify the parameters causing the loss of energy and calculate various losses in fluid flow applications. Determine the force and work done by the water jet when it strikes vanes of different shapes.
CO-4	Analyze the performance of hydraulic turbines.
CO-5	Evaluate the performance of reciprocating and centrifugal pumps.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	2	2	-	-	-	-	-	-	-	-	-	-
CO-2	2	2	-	-	-	-	-	-	-	-	-	-
CO-3	2	2	-	-	-	-	-	-	-	-	-	-
CO-4	2	2	-	-	-	1	1	-	-	-	-	-
CO-5	2	2	-	-	-	1	-	-	-	-	-	-

Course Outcomes	PSO1	PSO2
CO-1	1	
CO-2	1	
CO-3	1	
CO-4	1	
CO-5	1	

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS

UNIT - I	**Periods: 6L+2T=8**
FLUID STATICS:	
Properties of fluids - Fluid Pressure and its measurement - Manometers, Simple manometers, Differential manometers. Hydrostatic forces on surfaces-Total Pressure and Centre of pressure - Horizontal, Vertical, Inclined and Curved plane surfaces submerged in liquid.	
UNIT - II	**Periods: 6L+4T=10**
FLUID KINEMATICS & DYNAMICS:	
Types of fluid flows - velocity and acceleration - continuity equation - velocity potential and Stream Function - Flow net. Forces acting on fluid in motion - Equation of Motion - Euler's equation - Bernoulli's equation and its applications - Venturimeter, Orifice Meter. Momentum Equation - Impulse-Momentum equation - Forces on pipe bend.	
UNIT - III	**Periods: 6L+4T=10**
FLOW THROUGH PIPES & IMPACT OF JETS :	
Reynolds Experiment - Laws of fluid friction - Darcy weisbach equation, Major Losses and Minor losses - Hydraulic gradient line, Total energy line, Pipes in series and Pipes in parallel, Equivalent pipe, Siphon. Impact of jet on stationary surfaces, Impact of jet on moving vanes, Impact of jet on series of vanes-Tangential and Radial flow.	
UNIT - IV	**Periods: 6L+4T=10**
HYDRAULIC TURBINES AND ITS PERFORMANCE:	
General layout of hydro power plant, heads and efficiencies of turbines, classification of turbines. Impulse turbine: Pelton turbine-components, work and efficiencies. Reaction turbine: Francis turbine-constructional features, work and efficiencies, draft tube theory, Axial flow turbine- Kaplan turbine-constructional features, work and efficiencies. Unit quantities, Specific speed of turbines, performance characteristic curves-constant head, constant speed and constant efficiency curves, model testing of turbines, Cavitation in turbines.	
UNIT - V	**Periods: 8L+2T=10**
PUMPS:	
General: Classification of pumps-positive displacement and non-positive displacement. Reciprocating Pumps: Main parts, Classification, work done by pumps, coefficient of discharge, slip, negative slip, Indicator diagram, acceleration head and its effects in suction and delivery pipes, effect of friction, air vessels-construction, working, functions and effect of air vessels on discharge, pressure head, work, indicator diagram, maximum speed and work saved against friction. **Centrifugal Pumps:** Components and working principle, priming of centrifugal pumps, Work done by impeller, head, losses and efficiencies, minimum starting speed, specific Speed, multi stage pumps, NPSH, cavitation.	

TEXT BOOKS:	
1.	Hydraulics and Fluid Mechanics by P.N. Modi &S.M. Seth, 18th ed. 1998,
2.	Fluid Mechanics by YunusCengel and Cimbala.
3.	Dr.R.K.Bansal ,Fluid Mechanics and Hydraulic machinery 9th edition Laxmi Publications 2017.
REFERENCE BOOKS:	
1.	Fluid Mechanics and Fluid Power Engineering by Dr. D.S. Kumar, S.K. Kataria&Sons.
2.	Fluid Mechanics by V.L. Streeter & E.B. Wylie, 1st SI metric ed. 1981, McGraw Hill
3.	
4.	
WEB RESOURCES:	
1.	http://www.science-animations.com/fluidmechanics.html
2.	http://nptel.ac.in/courses/112104117/26
3	http://nptel.ac.in/courses/112104117/33
4	https://iitbmechdamp.wordpress.com/me-203-fluid-mechanics/

DESIGN OF MACHINE ELEMENTS-II											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC 326	PC	2	1	-	32	16	-	40	60	100	3

Prerequisite: Engineering Mathematics, Engineering Mechanics, Mechanics of solids, Design of Machine Elements-I

Course Objectives: The main intent of this course is to enhance creativity in designing of components, analyzing induced stresses in a component based on the type of failure. This is achieved through appropriate material selection and design analysis of components like gears, brakes, clutches, crank shaft, connecting rod etc.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Design the various types of gears based on static and dynamic loads.
CO-2	Design the IC engine components subjected to combined loads and frictional clutches.
CO-3	Design various types of brakes, crane hooks and wire ropes.
CO-4	Design and analyze the life of bearings subjected to static and dynamic loads.
CO-5	Design belt and chain drives for power transmission.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	3	3	-	-	-	-	1	1	-	-	-
CO-2	3	3	3	-	-	-	-	1	1	-	-	-
CO-3	3	3	3	-	-	-	-	1	1	-	-	-
CO-4	3	3	3	-	-	-	-	1	1	-	-	-
CO-5	3	3	3	-	-	-	-	1	1	-	-	-

Course Outcomes	PSO1	PSO2
CO-1	3	-
CO-2	3	-
CO-3	3	-
CO-4	3	-
CO-5	3	-

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS	
UNIT - I	**Periods: 8L+4T=12**
GEARS	
Classification of gears, terminology of gears, standard tooth systems. Force analysis, beam strength, wear strength and effective load of spur, helical, bevel gears. Force analysis and efficiency of worm gears.	
UNIT-II	**Periods: 6L+3T=9**
IC ENGINE PARTS AND FRICTION CLUTCHES	
Classification of I.C. engines, design of cylinder, piston, connecting rod and crank shaft. Types of clutches, torque transmission capacity of single disc, multi disc, and cone and centrifugal clutches.	
UNIT - III	**Periods: 6L+3T=9**
BRAKES, CRANE HOOK AND WIRE ROPES	
Types of brakes, energy equations, band and block brakes, internal expanding shoe brakes and disc brakes. Design of crane hooks with trapezoidal cross-section. Wire rope construction and stresses in wire ropes. Design of wire ropes for lifts and winches.	
UNIT - IV	**Periods: 6L+3T=9**
BEARINGS	
Rolling contact bearings: Types of rolling contact bearings, static and dynamic load carrying capacity, equivalent bearing load, load-life relationship and selection of bearings from manufacturers catalogue. Sliding contact bearings: Basic modes of lubrication, temperature effect on viscosity, hydro static and hydro dynamic bearing design. McKee equations, Reynolds's equation, Raimond and Boyd method.	
UNIT - V	**Periods: 6L+3T=9**
BELT AND CHAIN DRIVES	
Belt drives: - Types of belt drives, geometrical relations, analysis of belt tensions, condition for maximum power, design of flat belt drives. Chain drives: Classification, nomenclature, polygonal effect, power transmission of chain drive, length of chain drive.	
TEXT BOOKS:	
1.	V.B.Bhandari, *Design of Machine Elements* 4th edition, Tata McGraw Hill Publishing Co. Ltd., New Delhi, 2016.
2.	*Design data book* , PSG College of technology, Coimbatore, 2011. **Note:** Design data book is allowed in examinations.
REFERENCE BOOKS:	
1.	R.K. Jain, *Machine Design*, 9th edition, Khanna Publications.
2.	Joseph Edward Shigley, *Mechanical Engineering design*, 8th Edition, McGraw Hill Company, 2011.
3.	R.L.Norton, *Machine design, an integrated approach*, 2nd edition, Pearson Education, 2014.
WEB RESOURCES:	
1.	https://nptel.ac.in/courses/112/106/112106137/
2.	http://www.mrrtechnical.co.in/#dme2

FLUID MECHANICS & HYDRAULIC MACHINERY LAB											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC 327	PC	-	-	3	-	-	48	50	50	100	1.5

Prerequisite: Engineering Mathematics-I &II and Fluid mechanics and Hydraulic Machines.

Course Objectives: To provide practical knowledge in verification of principles of fluid flow, measurement of pressure, discharge and velocity of fluid flow, Major and Minor Losses, Performance testing of Hydraulic Turbines and Hydraulic Pumps at constant speed and Head.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Carry out an experiment to verify Bernoulli's theorem.
CO-2	Demonstrate the calibration of various flow measuring devices.
CO-3	Calculate the Frictional losses in internal flows through experimentation.
CO-4	Determine the co-efficient of impact of jet of water on a fixed flat/curved plate.
CO-5	Carry out an experiment to study performance curves of various hydraulic pumps and turbines at different operating condition.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	2	-	2	-	-	-	3	-	3	-	2
CO-2	3	2	-	2	-	-	-	3	-	3	-	2
CO-3	3	2	-	2	-	-	-	3	-	3	-	2
CO-4	3	2	-	2	-	-	-	3	-	3	-	2
CO-5	3	2	-	2	-	-	-	3	-	3	-	2

Course Outcomes	PSO1	PSO2
CO-1	2	1
CO-2	2	1
CO-3	2	1
CO-4	2	1
CO-5	2	1

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS

LIST OF EXPERIMENTS(any nine) **Periods: 3practicals/week**

1. Verification of Bernoulli's theorem
2. Determination of coefficient of discharge of
   a. Rectangular notch (or)
   b. Triangular notch
3. Determination of coefficient of discharge of
   a. Orifice (or)
   b. Mouthpiece
4. Calibration of flow meters
   a. Venturimeter and
   b. Orificemeter.
5. To demonstrate and study different flow regimes using Reynold's experimental setup.
6. To determine the head losses for flow through pipes and further obtain friction factor.
7. Impact of jet on a
   a. Flat vane (or)
   b. Curved vane
8. To draw the performance characteristic curves for
   a. Pelton turbine and
   b. Francis turbine
9. To draw the performance characteristic curves for Centrifugal pump.
10. To draw the performance characteristic curves for reciprocating pump.

TEXT BOOKS:

1.	R.K. Bansal, *Fluid mechanics& hydraulic Machines* Lakhsmi publication.
2.	R.S.Khurmi, *Fluid mechanics& hydraulic Machines*, S.chand & Co.Ltd.

REFERENCE BOOKS:

1.	Dr. D.S. Kumar, *Fundamentals of fluid mechanics*, ketson pub. house
2.	Ch. Ratnam & K. Arun vikram, *Fluid Mechanics and Machinery,* 2nd revised edition, I K International Publishing House Pvt. Ltd. 2011.

WEB RESOURCES:

1.	https://fm-nitk.vlabs.ac.in/
2.	https://www.iitk.ac.in/me/fluid-mechanics-laboratory

COMPUTER AIDED DESIGN & MANUFACTURING LAB

Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC 328	SC	1	-	3	16	-	48	50	50	100	2.5

Prerequisite: Mechanics of Solids, Manufacturing Processes, Metal Cutting, Machine tools and Metrology, Computer Aided Geometric Modeling.

Course Objectives:

A) The course is designed to impart hands-on-training on using ANSYS Workbench for analyzing and developing solutions for structural and thermal problems.

B) The course is intended to impart programming skills on CNC-Turning & Milling and hands-on-exposure on CNC-Turning operations & 3D-Printing.

C) The course gives an orientation on advanced manufacturing systems.

Course Outcomes: At the end of the course, the student will be able to:	
CO-1	Expound the layout and features of ANSYS-Workbench, import / create geometry and customize meshing controls for generating mesh for a diverse set of components and their assemblies.
CO-2	Perform static structural analysis of beams, frames, 2-D & 3-D bodies and modal analysis using ANSYS-Workbench and further interpret the results.
CO-3	Simulate heat transfer problems to evaluate the heat transfer parameters, thermal stresses and further solve axi-symmetric problems using ANSYS-Workbench.
CO-4	Develop programs for turning and milling operations on CNC Machines and further manufacture a component on CNC turning Machine and 3D Printing.
CO-5	Distinguish advanced manufacturing systems and develop program for simple robot operations(Pick & Place).

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	3	3	3	3	-	-	3	-	3	-	2
CO-2	3	3	3	3	3	-	-	3	-	3	-	2
CO-3	3	3	3	3	3	-	-	3	-	3	-	2
CO-4	3	3	3	2	3	-	-	3	-	3	-	2
CO-5	2	2	-	-	2	-	-	3	-	3	-	2

Course Outcomes	PSO1	PSO2
CO-1	3	3
CO-2	3	3
CO-3	3	3
CO-4	3	3
CO-5	2	2

CO- Course Outcome; PO- Program Outcome; PSO-Program Specific Outcome; Level- 1: Low, 2: Medium, 3: High

SYLLABUS	
	Periods: 1T+3P=4/Week
Module -I: Finite Element Analysis using Ansys Workbench 14.5	
Week 1: Introduction to ANSYS workbench, System Requirements, Layout and features: Analysis Systems, Component Systems, Custom Systems and Design Exploration Tool box. Project schematic window. Unit systems in workbench. Components of an Analysis system. Exercise: 1- Introduction to workbench layout.	
Week 2: Introduction to Engineering data workspace, Selection of Engineering materials, Creating and adding new material to data workspace. Importing CAD geometry, Creating Simple geometry in geometric modular. Exercise: 2 – Selecting the material from the Workbench Engineering material library Exercise: 3 – Adding new material to the Workbench Engineering material library Exercise: 4 - Creating a simple extruded fins in Geometrical Modular	
Week 3: Generating Mesh, Refining the Mesh, Local Mesh controls, Generating Mesh for assembly components, contact regions. Exercise: 5- Generate the Mesh of the component using various control parameters Exercise: 6- Generate mesh of an assembly component and define contact regions	
Week 4: Static Structural Analysis: Component systems, Pre-processing: Meshing, Analysis setting, Boundary conditions-supports, loads; Solution: Setting up the output parameters-stress, strain, deformations; Post Processing: Reviewing results and Generating report. (Trusses, beams, frames) Exercise: 7 – Static Structural Analysis on planar truss problem.	
Week 5: Static Structural Analysis of 2-D problems(plane stress & plane strain) Exercise: 8 - Static Structural Analysis on 2-D Wrench Exercise: 9 - Static Structural Analysis on 2-D Bracket (Home Assignment)	
Week 6: An axisymmetric geometry with axisymmetric loads and support (2-D model) to predict the deformation and stresses in the structure. Exercise: 10- Static Structural Analysis on 2-D axisymmetric fountain Structure	
Week 7: A) Static Structural Analysis of 3-D problems and B) Modal Analysis: Natural frequencies and vibration modes. Exercise: 11- Static Structural Analysis on 3D Base stand assembly Exercise: 12- Modal Analysis on Acoustic Guitar	
Week 8: Thermal Analysis: Steady-State & Transient Thermal Analysis, Thermal stress analysis. Exercise: 13 – Steady State Thermal analysis on Fins Exercise: 14 - Transient Thermal analysis on Fins	

Module -II: **Programming on CNC Turning and Milling using a Simulator and Turning on CNC Machine**
Week 9: Introduction, NC machine tools, structure of CNC machine tool, drives, feedback devices, coordinate system, preparatory functions, miscellaneous functions. Program number, motion commands. Exercise : 15- Introduction to simulation software and its layout.
Week 10: CNC Turning: Canned cycles- Rough turning and Facing along with finishing cycle. Exercise: 16- Rough turning on CNC Turning Machine Exercise: 17- Facing and finishing on CNC Turning Machine
Week 11: CNC Turning: Canned cycles – Screw thread and peck drilling cycle. Exercise: 18- Simulation of Screw thread on CNC Turning Exercise: 19- Simulation of peck drilling cycle on CNC Turning
Week 12: CNC Milling: 2D contour and pocket milling. Exercise: 20- Simulation of 2D contour on CNC milling Exercise: 21- Simulation of 2D pocket on CNC milling
Week 13: CNC Milling: 2D contour and pocket milling with tool length and radius compensation. Exercise: 22- Simulation of 2D contour on CNC milling(Tool length & radius compensation) Exercise: 23- Simulation of 2D pocket on CNC milling(Tool length & radius compensation)
Module -III: 3D- Printing
Week 14: Introduction to 3D printing , Fused Filament Fabrication (FFF), 3D Model Preparation for print, Printing parameters, Materials for FFF. Exercise: 24- 3D Printing of hexagonal bolt and nut
Module -IV: Advanced Manufacturing Systems
Week 15: Group Technology(GT), flexible Manufacturing Systems (FMS), Computer Aided Process Planning (CAPP), Computer Aided Inspection and Quality Control. Computer Aided Material Handling. Demonstration of 6-Axis Material handling Robot.
Module – V: Demonstrating Simulations of Manufacturing processes by Hyper Works Modules
Week 16: Inspire Cast- casting simulation, Inspire Form – Forming simulation, Inspire Extrude- extrusion simulation, and other Hyper Works modules

REFERENCE BOOKS:	
1.	Dr. Xiaolin Chen, Dr. Yijun Liu, *"Finite Element Modeling and Simulation with ANSYS Workbench"*,2nd ed., CRC Press Taylor & Francis Group, ISBN-13: 978-1-1384-8629
2.	M.D. Groover & E.W. Zimmer , CAD/CAM- Computer Aided Design & Manufacturing, 1st Edition, PEARSON Publication, 2003.
3.	Computer Aided Design & Manufacturing Lab Manual.