IV Year

Semester - I

Course Code	Title of the course	Category	Periods						Sessionals Marks	Semester end Exam marks	Total Marks	Credits
			L	T	P	E	O	Total				
MEC 411	***Open Elective-III	OE	3	0	0	0	2	5	40	60	100	3
MEC 412	Professional Elective-III	PE	3	0	0	1	2	6	40	60	100	3
MEC 413	Professional Elective-IV	PE	3	0	0	1	3	7	40	60	100	3
MEC 414	Computer Aided Design & Manufacturing	PC	2	1	0	2	2	7	40	60	100	3
MEC 415	Heat Transfer	PC	2	1	0	2	4	9	40	60	100	3
MEC 416	Computer Aided Design & Manufacturing Lab	PC	0	0	3	0	2	5	50	50	100	1.5
MEC 417	Heat Transfer-Lab	PC	0	0	3	0	1	4	50	50	100	1.5
MEC 418	****Industrial Training	PR	0	0	0	0	0	0	--	100	100	1
MEC 419	Project Phase-I	PR	0	0	4	0	4	8	--	100	100	2
	Total		**13**	**2**	**10**	**6**	**20**	**51**	**300**	**600**	**900**	**21**

IV Year

Semester - II

Course Code	Title of the course	Category	Periods						Sessionals Marks	Semester end Exam marks	Total Marks	Credits
			L	T	P	E	O	Total				
MEC 421	***Open Elective-IV	OE	3	0	0	0	2	5	40	60	100	3
MEC 422	*****Professional Elective-V	PE	3	0	0	1	2	6	40	60	100	3
MEC 423	Project Phase-II	PR	0	0	16	0	16	32	100	100	200	8
	Total		**6**	**0**	**16**	**1**	**20**	**43**	**180**	**220**	**400**	**14**

Total Credits **160**

The assessment for the subject Biology for Engineers shall be “INTERNAL ONLY” for 100 Marks. The subject will not have external end exam.

* The External examination shall be conducted in two parts each for one and half hour duration under the purview of an internal and external examiner. The first part shall be in the conventional drawing format (manually) and the second using Auto CAD software. In conventional drawing, the student has to attempt two problems out of three questions, which will be purely based on drawing. The second part will consist of two questions, the first being a theoretical question on AutoCAD and the second will be an application of AutoCAD(on computer) to produce a drawing.

** The assessment for Basic Electrical Engineering Lab shall be “INTERNAL ONLY” for 50 Marks.

*** Open electives can be interdisciplinary subjects/Emerging subjects/ MOOCS (will be decided by the department).

**** The industrial training programme should be done by the student at the end of III year II semester. The minimum duration of industrial training should not be less than 15 working days. The evaluation process has to be carried out in the final year first semester.

*****Those who are going for full semester project internship in an industry can opt for 2 MOOCS courses in lieu to 2 courses offered in IV-II. The grade for the MOOCS courses will be awarded based on an evaluation by the departmental committee.

List of Professional electives and other electives

Professional Elective-I	Production Planning & Control	Gas Turbines & Jet Proplusions	Additive Manufacturing	Non-Destructive Testing
Professional Elective-II	Refrigeration & Air-conditioning	Statistical Quality Control	Computational Fluid Dynamics	Nano Technology
Professional Elective-III	Automobile Engineering	Automation in Manufacturing	Unconventional machining process	Quality & Reliability Engineering
Professional Elective-IV	FEA	Alternate fuels	Industrial Tribology	Advanced Mechanics of Materials
Professional Elective-V	Mechanical Measurements & Control systems	Non-Conventional Energy sources	Power Plant Engineering	Condition Monitoring

Open Electives: Artificial Intelligence, Internet of things, C++, Java, Python, MATLAB etc.

Emerging Subjects: Robotics, Additive Manufacturing, Mechtronics etc.

Humanities Elective-A) MANAGERIAL ECONOMICS AND FINANCIAL ANALYSIS
B) INDUSTRIAL ENGINEERING AND MANAGEMENT
C) ENTREPRENEURSHIP DEVELOPMENT
D) SUPPLY CHAIN MANAGEMANT

AUTOMOBILE ENGINEERING (PROFESSIONAL ELECTIVE-III)											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC 412 (A)	PE	3	-	-	48	-	-	40	60	100	3

Prerequisite: Applied Thermal Engineering - II, Kinematics of Machinery, Material science & Metallurgy, Basic Electrical Engineering, Basic Electronics Engineering

Course Objectives: To acquaint the students with the working of various automobile systems, hybrid vehicles and electric vehicles.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Categorize automobiles and describe the constructional features of engine parts, and explain the emission norms.
CO-2	Examine the operational features of various systems of engines used in an automobile.
CO-3	Explain various transmission systems of an automobile and describe the suspension, steering and braking system of an automobile.
CO-4	Explain the different configurations of Hybrid vehicle systems and Illustrate the principles related to electrical and electronic systems used in an automobile.
CO-5	Describe the different components of Electric vehicle system and explain the battery and its management system.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	2	-	-	-	-	-	-	-	-	-	-
CO-2	3	2	-	-	-	-	-	-	-	-	-	-
CO-3	3	2	-	-	-	-	-	-	-	-	-	-
CO-4	3	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: 8L+0T=08**

INTRODUCTION:

Automobile - Definition, layout, classification; chassis.

Engine components: cylinder block and crank case, cylinder, cylinder head, piston and piston rings, crank shaft, connecting rod, muffler.

Engine Classification: based on arrangement of cylinders, Multi-Valve engines, VCR engines.

Exhaust Emissions and their control: EGR and Catalytic Converters, EURO/Bharat Stage Norms.

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

ENGINE AND GEAR BOX:

Fuel Systems: Petrol Engines: Basic components, Multipoint Fuel Injection, Electronic Fuel Injection. Ignition Systems: Conventional and Electronic. Diesel Engines: Basic components, Conventional-Jerk type and distributor type; CRDI.

Engine Cooling: Natural circulation and forced circulation.

Lubrication: Mist, dry sump and wet sump.

Clutch: Necessity, Working of single & multi plate, centrifugal, CVT and Fluid coupling/Torque converter. **Gearbox**: Necessity of Transmission and Transaxle, Working Principle of Constant mesh clutch, Synchromesh and Automatic Gearbox.

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

TRANSMISSION, SUSPENSION AND VEHICLE CONTROL SYSTEM:

Differential: Necessity, Constructional Features and Working of LSD. **Front/Rear Axles**: Constructional Features and Types of Rear Axle. **Tires**: Tire Construction, Radial Tires, Tire specification, Tire rotation. **Wheel alignment and balancing**: importance of Castor, Camber, Toe-in, Toe-out and balance weight.

Suspension System: Types of suspension systems: MacPherson strut and Wishbone, air suspension. **Vehicle Control**: Steering system: Steering gear box and its types, Power Steering. **Brake system**: Necessity, Drum, Disc, Parking and Power Brakes, Working Principle of Air and Hydraulic Brakes, ABS, EBD.

UNIT - IV	**Periods: 10L+0T=10**
HYBRID VEHICLES:	
Hybrid Vehicles - Need for hybrid and electric vehicles - Series parallel architecture of Hybrid Electric Vehicles (HEV) – Plug-in Hybrid Electric Vehicles (PHEV)- Power train components. Power Split devices for Hybrid Vehicles - Operation modes - Control Strategies for Hybrid Vehicle -Economy of hybrid Vehicles. **Electrical system**: Battery, starting system, Charging System, Lighting and Signaling System, A/C Electrical System. **Electronic System**: Electronic Engine Management system, Automotive Embedded Systems-Vehicle Security System.	
UNIT - V	**Periods: 10L+0T=10**
ELECTRIC VEHICLES	
Design requirement for electric vehicles- Range, maximum velocity, acceleration, power requirement, mass of the vehicle and transmission efficiency. Types of Motors, Characteristic of DC motors, PM motors, Switched reluctance motors, Motor Drives and speed controllers, Regenerative Braking. **Battery Parameters**- Different types of batteries – Lead Acid- Nickel based-Sodium based-Lithium based- Metal Air based. Battery charging- Quick Charging devices. Battery Management System.	
TEXT BOOKS:	
1.	Kirpal Singh, Automobile Engineering Vol-I & II, 12thedition, Standard Publishers, 2011.
2.	William H. Crouse and Donald L. Anglin, Automotive Mechanics, 10thedition, Tata McGraw- HillPublishing Company Limited, 2006.
3.	KK Jain & RB Asthana,Automobile Engineering, 9thedition ,Tata McGraw-Hill Publishing Company Limited, 2002.
4.	James Larminie and John Lowry, "Electric Vehicle Technology Explained " John Wiley & Sons,2003.
REFERENCE BOOKS:	
1.	S. Srinivasan, Automotive Mechanics, 2nd edition, Tata McGraw-Hill Publishing Company Limited, 2003
2.	Joseph Heitner, Automotive Mechanics (principles and practices,2nd edition, East West press, 2006.
3.	S Srinivasan,*Automotive Engines, 4th* edition, Tata McGraw-Hill Publishing Company Limited, 2001.
4.	Iqbal Husain, " Electric and Hybrid Vehicles-Design Fundamentals", CRC Press,2003

WEB RESOURCES:	
1.	https://saeindia.org/mobility-engineering/
2.	https://www.autocarindia.com/stories
3.	https://www.autocarpro.in/segments/autotechnology
4.	https://www.motorauthority.com/news/technology
5.	https://www.princeton.edu/~ota/disk1/1995/9514/9514.PDF

AUTOMATION IN MANUFACTURING (PROFESSIONAL ELECTIVE-III)											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC412(A)	PE	3	-	-	48	-	-	40	60	100	3

Prerequisite: Metal cutting, Machine Tools & Metrology

Course Objectives: To make the students familiarize themselves with the concept of automation, its strategies and various production systems and make them to understand the automated flow lines, line balancing, material storage and 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 equipments, 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

UNCONVENTIONAL MACHINING PROCESS (PROFESSIONAL ELECTIVE-III)											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC412(C)	PE	3	-	-	48	-	-	40	60	100	3

Prerequisite: Metal cutting, Machine Tools & Metrology

Course Objectives: To impart the understanding and the usage of unconventional machining processes.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Classify the various Un-Conventional Machining Processes
CO-2	Explain the working of AJM, WJM, UM and calculate MRR.
CO-3	Describe the working of EDM and calculate MRR.
CO-4	Elucidate the working principle of chemical and electro chemical machining processes.
CO-5	Explain the various thermal based machining processes and calculate MRR

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

Course Outcomes	PSO1	PSO2
CO-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: 10L+0T=10**
UNCONVENTIONAL MACHINING PROCESS	
Introduction to Unconventional Machining Process (UCM), Merits and demerits of Unconventional machining vis-a-vas conventional Machining, classification of UCM process and its applications. Importance of process parameters on Quality of the machine products.	
UNIT - II	**Periods: 10L+0T=10**
MECHANICAL ENERGY BASED PROCESSES	
Abrasive Jet Machining, Water Jet Machining and Ultrasonic Machining - Working Principles, Equipment, Process parameters, Material removal rate, Applications.	
UNIT - III	**Periods: 10L+0T=10**
ELECTRICAL ENERGY BASED PROCESSES	
Electric Discharge Machining - Working Principles, Equipment, Process Parameters, Material removal rate, Electrode / Tool, Tool Wear, Dielectric, Flushing, Wire cut EDM, Die Sinking Process - Applications.	
UNIT - IV	**Periods: 9L+0T=9**
CHEMICAL AND ELECTRO-CHEMICAL ENERGY BASED PROCESSES	
Chemical machining - Etchants, Maskants - techniques. Electro-chemical machining — Working principle, Equipment, Process Parameters, Material removal rate, Electrical circuit. Electro-chemical grinding - Electro-chemical honing - Applications.	
UNIT - V	**Periods: 9L+0T=9**
THERMAL ENERGY BASED PROCESSES	
Laser Beam machining, Plasma Arc Machining - Principles, Equipment. Electron Beam Machining -Principles, Equipment, Types, Beam control techniques, Material removal rate - Applications.	
TEXT BOOKS:	
1.	P. K. Mishra, *Non-Conventional Machining*, Narosa Publishing House, New Delhi, 2007.
2.	P. C. Pandey and H.S. Shan, *Modern Machining Processes*, Tata McGraw Hill Publishing Company Pvt Ltd., New Delhi, 2008.
3.	Joao Paulo Davim, *Nontraditional Machining Processes: Research Advances*, Springer, New York, 2013.
REFERENCE BOOKS:	
1.	Vijaya Kumar Jain, *Advanced Machining Processes*, Allied Publishers Pvt. Ltd., New Delhi, 2005.
2.	Hassan El-Hofy, *Advanced Machining Processes: Nontraditional and Hybrid* Machining Processes, McGraw-Hill Professional, New Delhi, 2005
WEB RESOURCES:	
1.	https://onlinecourses.nptel.ac.in/noc21_me56/preview
2.	https://nptel.ac.in/courses/112/105/112105212.

QUALITY & RELIABILITY ENGINEERING (PROFESSIONAL ELECTIVE-III)											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC412(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, processes 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 the knowledge of quality and reliability.
CO-5	Demonstrate the knowledge of failure rate models and applications 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.	
UNIT - III	**Periods: 10L+0T=10**
IMPLEMENTATION OF TQM	
Implementation of TQM: Steps, KAIZEN, 5S, JIT, POKAYOKE.	
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 McGrawhill, India.
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 (PROFESSIONAL ELECTIVE-IV)											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC 413(A)	PE	2	1	-	32	16	-	40	60	100	3

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	Evaluate nodal displacements of springs and bar problems using Rayleigh-Ritz and Galerkin method, compare and contrast FEA with other analytical methods and explain the steps involved in FEA.
CO-2	Analyze nodal displacements, stresses and reactions for one dimensional bar problems.
CO-3	Examine nodal displacements, stresses and reactions for plane truss and beam problems.
CO-4	Explore iso-paramentric elements of two dimensional structural problems using CST and Axisymmetric elements.
CO-5	Investigate one dimensional steady state problems in Heat transfer and Dynamic analysis of Stepped bar.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	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	2	-
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: 8L+3T=11**

INTRODUCTION:

Introductory Concepts: Introduction to FEA, General FEA Procedure, Applications of FEA in various fields, Advantages and disadvantages of FEA over other methods.

Elasticity Relations: Stresses and Equilibrium, Boundary conditions, Strain-Displacement relations, Stress-strain relations, Compatibility conditions, Plane stress and Plane strain conditions.

Approximate Methods for a General field problem: Minimum Potential energy Principle, Rayleigh-Ritz method and Galerkin method.

Simple problems on Strain-displacement relations, plane stress and plane strain, Minimum potential energy principle (only Spring system problems), Rayleigh-Ritz Method and Galerkin method (only bar problems)

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

ONE-DIMENSIONAL BAR PROBLEMS:

Introduction, Finite Element Modelling, Coordinates and Shape Functions, Derivation of Element stiffness matrix and load vectors using Potential-Energy approach, Assembly of the Global Stiffness Matrix and Load Vector, Properties of Stiffness matrix, Convergence requirements, The Finite Element Equations, Treatment of Boundary conditions, Problems.

Case Study will be given for internal evaluation.

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

ANALYSIS OF TRUSSES AND BEAMS:

ANALYSIS OF TRUSSES:

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.

Case Study will be given for internal evaluation.

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

ANALYSIS OF TWO DIMENSIONAL PROBLEMS:

TWO-DIMENSIONAL PROBLEMS USING CST:

Introduction Iso-parametric representation, differences among sub-parametric elements, iso-parametric elements and super parametric elements, Finite Element Modelling Constant-Strain Triangle (CST), Problem modelling and Boundary Conditions-Problems.

AXISYMMETRIC SOLIDS SUBJECTED TO AXISYMMETRIC LOADING:

Introduction-Axisymmetric Formulation-Finite Element Modelling: Triangular element, Problem Modelling and Boundary conditions-problems.

Case Study will be given for internal evaluation.

UNIT - V	**Periods: 6L+4T=10**
HEAT TRANSFER AND DYNAMIC ANALYSIS:	
SCALAR FIELD PROBLEMS: Introduction-one dimensional steady state heat transfer in thin composite walls and fins. **DYNAMIC ANALYSIS:** Formulation of finite element model, element consistent and lumped mass matrices, Evaluation of Eigen values and Eigen vectors for one dimensional two noded stepped bar problems. **Case Study** will be given for internal evaluation.	
NOTE: Case study problems are intended for deep understanding of the subject. Case studies can be given for assignments (Internal Evaluation Process) not for Mid and Semester Exams.	
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.
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/

FEA CASE STUDIES

Solving the below list of Case Studies, the Student will acquire the following Skills:

1. The ability to model 1-D, 2-D, Thermal and Dynamic problems in ANSYS APDL.

2. The ability to adapt element types to specific situations by supressing degrees of freedom

3. The ability to generate finite element models using the direct method (i.e., defining nodes and then defining elements linking those nodes, as opposed to taking a solid model and dividing it up into elements)

4. The ability to define element types, real constants and material parameters for a finite element model

5. The ability to apply boundary conditions, and loads to specific nodes in a finite element model.

6 The ability to run a simple linear static, dynamic and thermal analysis

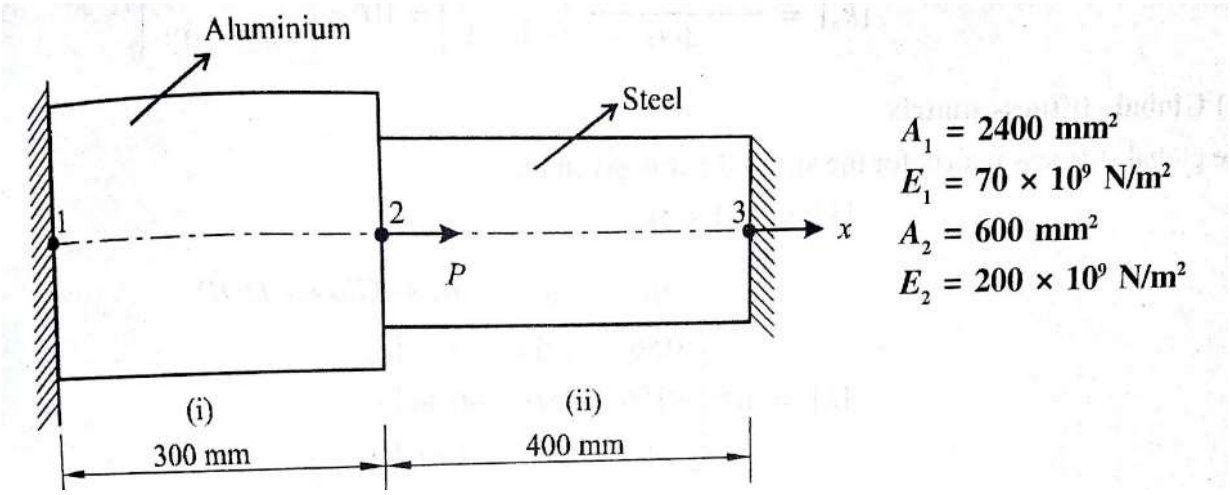
7. The ability to list displacement results for each node in the finite element model

8. The ability to create an element table to obtain additional results from a finite element model and to list these results

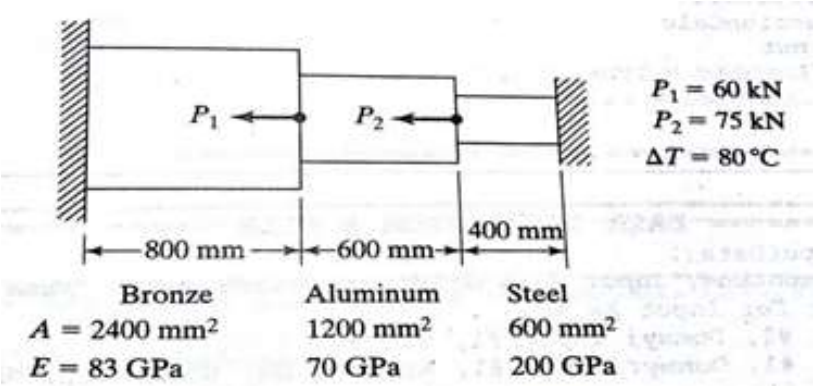
9. Experience in comparing the results obtained from your finite element model with other results and validating your results against the other results

UNIT-II

1.For the bar element shown, determine the following Nodal displacements, Element Stresses and Reactions at Supports. P = 200KN. Solve the problem using ANSYS APDL and plot the table containing results from software solution and hand calculation solutions and check for accuracy. Also submit contour plots.

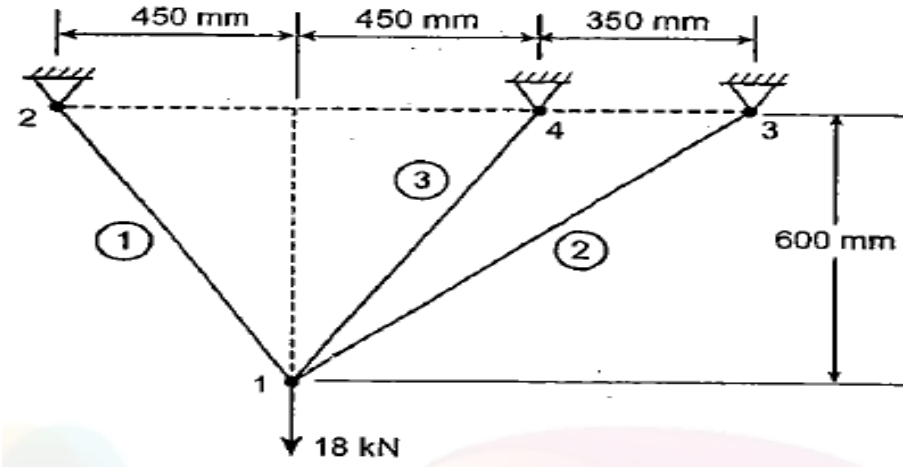


2.The stepped bar is subjected to an increase in temperature, .Use elimination method for Treatment of boundary conditions. Determine Nodal displacements and element stresses. Solve the problem using ANSYS APDL and plot the table containing results from software solution and hand calculation solutions and check for accuracy. Also submit contour plots.

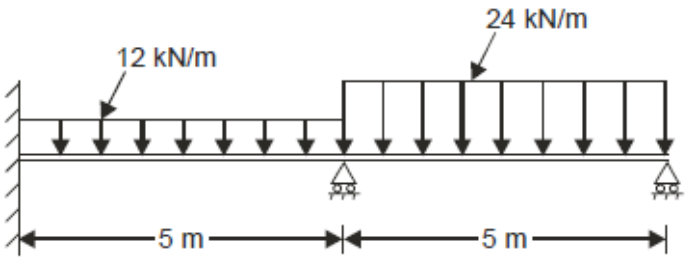


UNIT-III

3.For the given truss structure, find nodal displacements Stresses and Reactions E = 200 GPa A = 100 mm^2 Solve the problem using ANSYS APDL and plot the table containing results from software solution and hand calculation solutions and check for accuracy. Also submit contour plots.

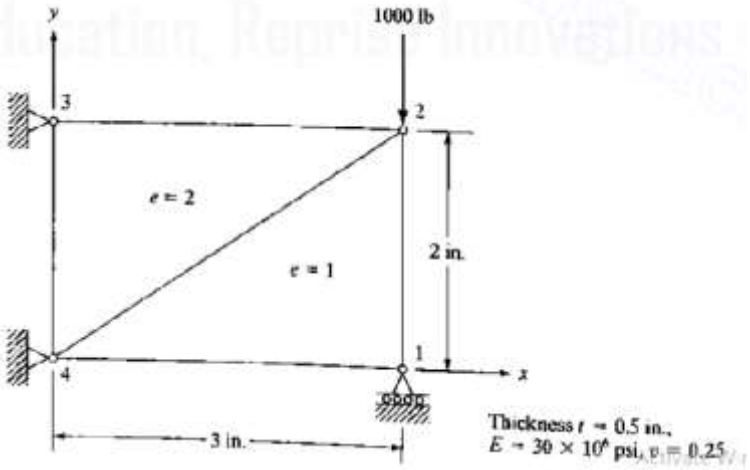


4.Compute mid- point Deflections, Slopes and Shear force and bending moment diagrams for the beam shown and find the maximum deflection. Young's modulus of 210 GPa, Poisson's ratio 0.27. I = 5 * 10^6 N/mm^2. Solve the problem using ANSYS APDL and plot the table containing results from software solution and hand calculation solutions and check for accuracy. Also submit contour plots.

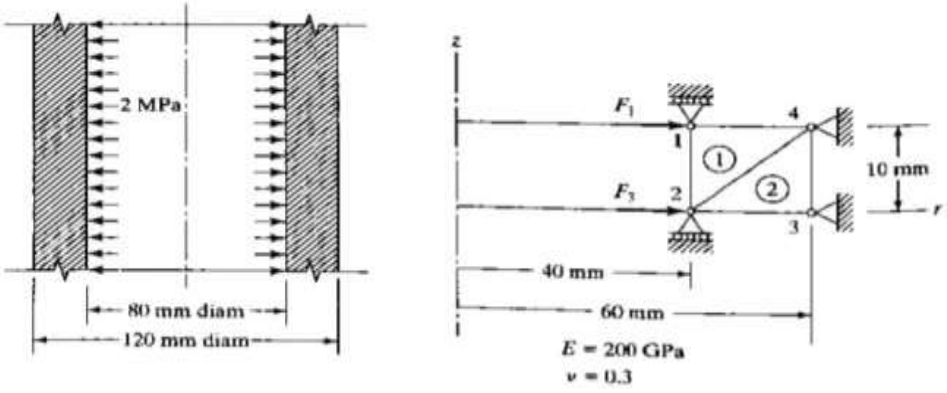


UNIT-IV

5.For 2D plate determine nodal displacements stresses and reactions for the CST problem. Solve the problem using ANSYS APDL and plot the table containing results from software solution and hand calculation solutions and check for accuracy. Also submit contour plots.

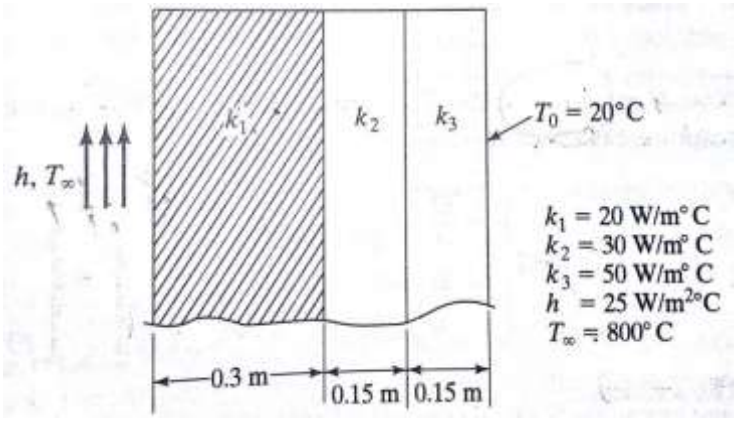


6.Figure shows a long cylinder of inside diameter 80 mm and outside diameter 120 mm snugly fits in a hole over its full length. The cylinder is then subjected to an internal pressure of 2Mpa. Using two elements on the 10 mm length shown. Find the displacements at the inner radius. Solve the problem using ANSYS APDL and plot the table containing results from software solution and hand calculation solutions and check for accuracy. Also submit contour plots.

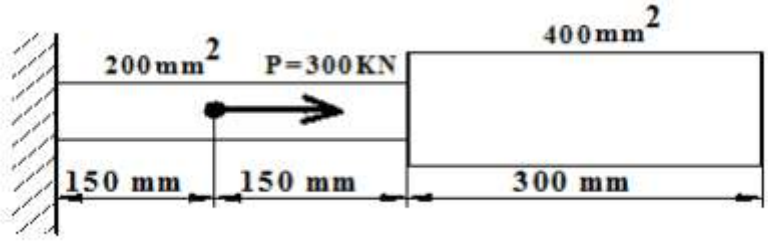


UNIT-V

7.A composite wall consists of three materials as shown, determine the temperature distribution in the wall. Solve the problem using ANSYS APDL and plot the table containing results from software solution and hand calculation solutions and check for accuracy. Also submit contour plots.



8.Conduct Modal analysis of a given axial stepped bar to determine natural frequencies. Modulus of elasticity, E = 2.068 x 10^{11} N/m^2 Poisson's ratio μ = 0.3 Density, ρ = 7830 kg/m^3 . Solve the problem using ANSYS APDL and plot the table containing results from software solution and hand calculation solutions and check for accuracy. Also submit contour plots.



ALTERNATE FUELS (PROFESSIONAL ELECTIVE-IV)											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC413(B)	PE	3	-	-	48	-	-	40	60	100	3

Prerequisite: Basic Thermodynamics, Applied Thermal Engineering -II

Course Objectives: To create an awareness on various alternate fuels as a primary source of energy, understand their relative importance and limitations with reference to various distinct applications and toacquaint the student with their production.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Explain the need for alternate fuels, categorize and outline their relative merits and demerits .
CO-2	Illustrate the properties of alcohols as engine fuels and analyze the functioning of engines using alcohols.
CO-3	Evaluate the properties of different gaseous fuels and further study the working of engines using these fuels.
CO-4	Demonstrate the production of biodiesel fuel, illustrate and compare their characteristics and further investigate the performance of engines using biodiesel.
CO-5	Outline the layout of electric, hybrid, fuel cell driven and solar powered vehicles.

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	2	-	-	-	-	2	2	-	-	-	-	-
CO-2	2	2	-	-	-	2	2	-	-	-	-	-
CO-3	2	2	-	-	-	2	2	-	-	-	-	2
CO-4	2	2	-	-	-	2	2	-	-	-	-	2
CO-5	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: 8L+0T=8**
Introduction to alternate fuels	
Availability and properties of alternate fuels, general use of alcohols, LPG, hydrogen, ammonia, CNG and LNG, vegetable oils and biogas, merits and demerits of various alternate fuels.	
UNIT - II	**Periods: 12L+0T=12**
Alcohols	
Properties as engine fuels, alcohols and gasoline blends, methanol and gasoline blends, combustion characteristics in CI engines, emission characteristics, DME, DEE properties performance analysis, performance in SI & CI Engines.	
UNIT - III	**Periods: 12L+0T=12**
Gases as alternate fuels	
Availability of CNG, properties, modification required to use in engines, performance and emission characteristics of CNG using LPG in SI & CI engines, performance and emission of LPG. Hydrogen; storage and handling, performance and safety aspects.	
UNIT - IV	**Periods: 8L+0T=8**
Diesel/Bio-diesel fuels-Oil feed stocks	
Trans-esterification-Bio-diesel production from Vegetable oils and waste cooking oil-High blend levels of bio-diesel-Testing, Bio diesel-Oxidation stability-Performance in Engines, Properties of bio-fuels and their importance in the context of IC Engines. Vegetable Oils: Various vegetable oils for engines, esterification, performance in engines, performance and emission characteristics, bio diesel and its characteristics.	
UNIT - V	**Periods: 8L+0T=8**
Electric, Hybrid, Fuel Cell And Solar Cars	
Layout of an electric vehicle, advantage and limitations, specifications, system components, electronic control systems, high energy and power density batteries, hybrid vehicle, fuel cell vehicles, solar powered vehicles.	
TEXT BOOKS:	
1.	Alternate Fuels – Dr. S. S. Thipse – Jaico Publications
2.	Richard. L. Bechfold, Alternative Fuels Guide BooK, SAE International
REFERENCE BOOKS:	
1.	Alcohols as motor fuels progress in technology, Series No. 19 – SAE Publication USE
2.	Alternative Fuels Guidebook – Bechtold R
3.	Nagpal, Power Plant Engineering, Khanna Publishers, 1991.
WEB RESOURCES:	
1.	https://afdc.energy.gov/fuels/
2.	https://www.fueleconomy.gov/feg/current.shtml

INDUSTRIAL TRIBOLOGY (PROFESSIONAL ELECTIVE-IV)											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC413(C)	PE	3	-	-	48	-	-	40	60	100	3

Prerequisite: Fluid Mechanics & Hydraulic Machinery, Design of machine Elements I & II

Course Objectives : To make the students understand the different theories of friction and wear and their applications, further introduce the concepts of hydrostatic and hydrodynamic lubrication and their industrial applications and lastly the fundamentals of lubricants and their classification, properties and selection.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Calculate the viscosity of fluids and analyze the properties of surfaces
CO-2	Determine the friction and wear of metals and non-metals
CO-3	Design hydrostatic step bearings
CO-4	Analyze the hydrodynamic behavior of journal bearings
CO-5	Analyze various lubricants in hydrostatic and elasto hydrodynamic lubrication

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO-1	3	2	-	-	-	-	-	-	2	2	-	1
CO-2	3	2	-	-	-	-	-	-	2	2	-	1
CO-3	3	2	2	-	-	-	-	-	2	2	-	1
CO-4	3	2	-	-	-	-	-	-	2	2	-	1
CO-5	3	2	-	-	-	-	-	-	2	2	-	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: 9L+0T=9**
Introduction	
Tribology in design, tribology in industry Viscosity, flow of fluids, viscosity and its variation absolute and kinematic viscosity, temperature variation, viscosity index determination of viscosity, different viscometers, Tribological considerations Nature of surfaces and their contact; Physic mechanical properties of surface layer, Geometrical properties of surfaces, methods of studying surfaces; Study of contact of smoothly and rough surfaces	
UNIT - II	**Periods: 9L+0T=9**
Friction and wear	
Role of friction and laws of static friction, causes of friction, theories of friction, Laws of rolling friction; Friction of metals and non-metals; Friction measurements. Definition of wear, mechanism of wear, types and measurement of wear, friction affecting wear, Theories of wear; Wear of metals and non-metals	
UNIT - III	**Periods: 10L+0T=10**
Hydrostatic lubrication	
Principle of hydrostatic lubrication, General requirements of bearing materials, types of bearing materials., Hydrostatic step bearing, application to pivoted pad thrust bearing and other applications, Hydrostatic lifts, hydrostatic squeeze films and its application to journal bearing, optimum design of hydrostatic step bearing	
UNIT - IV	**Periods: 10L+0T=10**
Hydrodynamic theory of lubrication	
Principle of hydrodynamic lubrication, Various theories of lubrication, Petroff's equation, Reynold's equation in two dimensions -Effects of side leakage - Reynolds equation in three dimensions, Friction in sliding bearing, hydro dynamic theory applied to journal bearing, minimum oil film thickness, oil whip and whirl, anti –friction bearing, hydrodynamic thrust bearing	
UNIT - V	**Periods: 10L+0T=10**
Lubrication and lubricants	
Introduction, dry friction; Boundary lubrication; classic hydrodynamics, hydrostatic and elasto hydrodynamic lubrication, Functions of lubricants, Types of lubricants and their industrial uses; SAE classification, recycling, disposal of oils, properties of liquid and grease lubricants; lubricant additives, general properties and selection	
TEXT BOOKS:	
1.	S K Basu, S N SenGupta and B B Ahuja, *Fundamentals of Tribology,* Publishers PHILearning Pvt Ltd, 2005
2.	Sushil Kumar Srivatsava, *Tribology in Industry,* Publishers S. Chand & Co Ltd ,2004
3.	H.G.Phakatkar and R.R.Ghorpade, *Engineering Tribology,* Nirali Publications, 2015
4.	B.C. Majumdar, *Introduction to Tribology of bearings* , Publishers Tata McGraw Hill Co Ltd, 2014.

REFERENCE BOOKS:	
1.	J Halling, *Introduction to Tribology*, , Publishers Wykeham Publications Ltd, 1976
2.	Michael J Neale, *The Tribology Hand Book*, Elsevier Publications 2nd Edition , 1995
3.	FT Barwell, *Bearing Systems, Principles and Practice, Publishers oxford university*
WEB RESOURCES:	
1.	https://nptel.ac.in/courses/112102015
2.	https://onlinecourses.nptel.ac.in/noc22_me03/preview

ADVANCED MECHANICS OF MATERIALS (PROFESSIONAL ELECTIVE-IV)											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC413(D)	PE	2	1	-	32	16	-	40	60	100	3

Prerequisite: Engineering Mechanics, Mechanics of Solids

Course Objectives: To make students understand the advanced topics related to flat plates, torsion in rectangular and circular bars, curved beams, assumptions and analysis of contact stresses.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Analyse deflection of straight beams in non-symmetric Bending
CO-2	Design Curved beams subjected to various loads
CO-3	Design various mechanical systems subjected to torsional loads .
CO-4	Analyse the stresses in Flat Plates
CO-5	Design new components based on the concept of contact stresses

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

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**
SHEAR CENTRE	
Bending axis and shear center-shear center for axi-symmetric and unsymmetrical sections. Unsymmetrical bending: Bending stresses in Beams subjected to Nonsymmetrical bending; Deflection of straight beams due to nonsymmetrical bending.	
UNIT - II	**Periods: 6L+3T=9**
CURVED BEAM THEORY	
Winkler Bach formula for circumferential stress – Limitations – Correction factors – Radial stress in curved beams – closed ring subjected to concentrated and uniform stresses in chain links.	
UNIT - III	**Periods: 6L+3T=9**
TORSION	
Torsion of a cylindrical bar of Circular cross Section; Saint-Venant's semi-inverse methods; Linear elastic solution; Prandtl elastic membrane (Soap-Film) Analogy; Narrow rectangular cross Section; Thin wall torsion members with restrained ends Axi-Symmetric Problems: Rotating Discs – Flat discs, Discs of uniform thickness, Discs of Uniform Strength, Rotating Cylinders.	
UNIT - IV	**Periods: 8L+4T=12**
THEORY OF PLATES	
Introduction; Stress resultants in a flat plate; Kinematics: Strain- Displacement relations for plates; Equilibrium equations for small displacement theory of flat plates; Stress – Strain – Temperature relation for Isotropic plates: Strain energy of a plate; Boundary conditions for plate; Solution of rectangular plate problem; Beams on Elastic Foundation	
UNIT - V	**Periods: 6L+3T=9**
CONTACT STRESSES	
Introduction, problem of determining contact stresses; Assumptions on which a solution for contact stresses is based; Expressions for principal stresses; Methods of computing contact stresses; Deflection of bodies in point contact; Stresses for two bodies in contact over narrow rectangular area (Line contact), Loads normal to area; Stresses for two bodies in line contact. Normal and Tangent to contact area.	
TEXT BOOKS:	
1.	Ugural and Fenster, *Advanced Mechanics of Materials and Applied Elasticity*, 5th Ed., Prentice Hall, 2011
2.	Boresi & Sidebottom , *Advanced Mechanics of materials* ,wiley international
REFERENCE BOOKS:	
1.	Stephen Timoshenko, *Theory of Plates and Shells*,TATA McGraw Hill Second Edition
2.	Ferdinand P. Beer, E. Russell Johnston, *Mechanics of Materials*, TATA McGraw Hill
3.	Jacob Pieter Den Hartog, *Advanced strength of materials*, Dover Publications NewYork
4.	Seely and Smith, *Advanced Mechanics of materials*, John Willey
WEB RESOURCES:	
1.	https://ocw.mit.edu/courses/materials-science-and-engineering/3-11-mechanics-of-materials-fall-1999/modules/

COMPUTER AIDED DESIGN & MANUFACTURING

Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC 414	PC	2	1	-	32	16	-	40	60	100	3

Prerequisite: Advanced Engineering drawing, Design of Machine Elements-I, Metal cutting, Machine Tools & Metrology

Course Objectives: Introduction to CAD Hardware and Geometric modelling techniques. Further the student is also trained on development of programs for CNC Turning and Milling operations. The student is also introduced to Group Technology, Flexible Manufacturing Systems, CAPP, CAMH and CAQC.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Explain the usage of computers in product design and manufacturing.
CO-2	Analyze different types of geometric modeling techniques.
CO-3	Discuss the features of CNC and further develop manual part program for Lathe and Milling operations.
CO-4	Describe group technology and flexible manufacturing systems.
CO-5	The student will be able to expound and explain the methods of computer aided process planning and material handling systems and quality control

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

Course Outcomes	PSO1	PSO2
CO-1	2	-
CO-2	3	-
CO-3	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: 8L+0T=8**
FUNDAMENTALS OF CAD	
Introduction - The design process - Application of computers for design, Hardware in CAD - The design work station - CAD system configuration - Creating database for manufacturing - Benefits of CAD. Interactive Computer Graphics - Graphic display devices- Graphics system- Graphics standards - Graphical user interface.	
UNIT - II	**Periods: 6L+6T=12**
GEOMETRIC MODELING AND TRANSFORMATIONS	
Wire frame Modeling - Surface Modeling - Solid Modeling: Sweep representation, Constructive Solid Geometry and Boundary representation. Solid modeling based applications. Windowing and Clipping. 2D and 3D transformations: Matrix representation of Translation, Scaling and Rotation.	
UNIT - III	**Periods: 6L+4T=10**
CNC TURNING AND MILLING PROGRAMMING	
Introduction, NC machine tools, structure of CNC machine tool, drives, feedback devices, coordinate system, preparatory functions, miscellaneous functions, program number, tool length compensation, axes system, motion commands, thread cutting, canned cycles, cutter radius compensation, and program examples for CNC Turning and Milling.	
UNIT - IV	**Periods: 6L+3T=9**
GROUP TECHNOLOGY AND FLEXIBLE MANUFACTURING SYSTEMS (FMS)	
Group Technology(GT): Part families, Classification and coding, production flow analysis, cellular manufacturing, Advantages of GT. **Flexible Manufacturing Systems (FMS):** Introduction, FMS components, types of FMS, FMS layouts, Planning for FMS, advantages and applications.	
UNIT - V	**Periods: 6L+3T=9**
COMPUTER AIDED PROCESS PLANNING	
Computer Aided Process Planning (CAPP): Introduction, methods of process planning, CAPP systems, **Computer Aided Material Handling**: Robots, Automatic conveyor systems, Automated guided vehicles, **Computer Aided Inspection and Quality Control**: Quality assurance and quality control, Contact and Non-contact inspection, Coordinate measuring machine.	
TEXT BOOKS:	
1.	M.D. Groover & E.W. Zimmer, *CAD/CAM- Computer Aided Design & Manufacturing*, 1st Edition, PEARSON Publication, 2003.
2.	P.N. Rao, "*CAD/CAM Principles and Applications*", TMH, 3rd Edition, 2015
3.	Dr.Sadhu Singh , "*Computer Aided Design and Manufacturing"* , by, Khanna Publishers, 5th Edition, Khanna Publisher, 2015.

REFERENCE BOOKS:	
1.	*Computer Aided Design in Mechanical Engineering*, by V. Rama Murthy, 3rd Edition, McGraw-Hill, 1998.
2.	*Elements of Computer Aided Design & Manufacturing*, by Y.C.Pao, 1st edition, Wiley publications, 1984.
3.	*Radhakrishna, CAD/CAM/CIM*, New Age International Pvt. Ltd. Publishers, 2009.
4.	C.B.Besant & C.W.K.Lui , *Computer Aided Design and Manufacturing*, 3rd edition, Ellis Horwood Ltd, 1985.
WEB RESOURCES:	
1.	http://nptel.ac.in/courses/Webcourse-contents/IITDelhi/Computer%20Aided%20Design%20&%20ManufacturingI/index.htm
2.	http://www.mrrtechnical.co.in/#cad

HEAT TRANSFER											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC 415	PC	2	1	-	32	16	-	40	60	100	3

Prerequisite: Engineering Mathematics-I & II, Basic Thermodynamics , Fluid Mechanics& Hydraulic Machinery

Course Objectives: To make the student understand the principles and applications of heat transfer and design thermal equipment.

Course Outcomes: At the end of the course, the student will be able to:	
CO-1	Analyze and evaluate the heat transfer rate in regular cross-sections like plate, cylinders and spheres in conduction.
CO-2	Evaluate the temperature distribution and heat transfer rate in regular cross sections under transient conditions and also in extended surfaces.
CO-3	Analyze and evaluate the heat transfer rate in regular cross-sections like plate, cylinders and spheres in free and forced convection.
CO-4	Analyse heat transfer in phase change process and estimate the performance of heat exchange devices.
CO-5	Interpret and calculate properties of various radiating bodies.

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

CONDUCTION HEAT TRANSFER

Basic Concepts:
Mechanism and modes of heat transfer, Fourier law of conduction, thermal conductivity, thermal resistance and electrical analogy, thermal contact resistance, generalized heat conduction equations in Cartesian, Cylindrical & Spherical coordinate systems.

One-Dimensional Steady conduction:
Systems without internal heat generation – Steady state heat conduction through plate, composite slabs, cylinders & spheres, Variable thermal conductivity, Critical radius of insulation.

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

EXTENDED SURFACES & UNSTEADY HEAT CONDUCTION

Extended Surfaces:
Heat conduction through fins of uniform cross section only – Fin efficiency & effectiveness.

Transient heat conduction (One-Dimensional):
Lumped system analysis, systems with negligible surface resistance, semi-infinite bodies, Heisler's chart and Grober chart solutions.

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

CONVECTIVE HEAT TRANSFER

Fundamentals:
Dimensional Analysis applicable to free and forced convection–Buckingham's ∏ method only**.**
Non- Dimensional numbers in free and forced convection, continuity, momentum and energy equations. (without derivations)
Thermal boundary layer over flat plate and inside hollow cylinder. Analogies – Reynolds, Colburn analogies, Significance of non-dimensional numbers.

Forced & Free Convection:
Empirical equations for free and forced convention (both internal and external flow). Constant wall temperature and constant heat flux problems. Application to horizontal, vertical and inclined plates, solid and hollow cylinders, spheres.
**** Case Studies on free and forced convection.***

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

HEAT TRANSFER WITH PHASE CHANGE & HEAT EXCHANGERS

Boiling & Condensation:
Boiling: Pool boiling regimes – Pool boiling correlation, flow boiling inside tube.
Condensation: Laminar film wise condensation, Nusselt's theory condensation on vertical flat plate, horizontal tubes, drop-wise condensation.

Heat Exchangers:
Classification of Heat Exchangers, Overall heat transfer coefficient, fouling in heat exchanger, Analysis of heat exchanger – LMTD method and NTU method (parallel & Counter flow only).

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

RADIATION HEAT TRANSFER

Fundamentals:
Introduction, Electromagnetic wave spectrum, Thermal radiation; Black body radiation – Stefan Boltzmann's law, Plank's law, Wein's Displacement law; Radiation intensity – Lambert's cosine law; Radiation properties – Emissivity, absorptivity, reflectivity, transmissivity, Kirchoff's law;

Radiation heat exchange between surfaces:
Shape factor, shape factor algebra; Radiation in non-absorbing media – Radiosity; Radiation heat transfer between gray bodies, electrical analogy, radiation heat transfer in two surface enclosure, radiation shields.

TEXT BOOKS:

1.	Dr. Sachdeva, *Fundamentals of Engineering Heat and Mass Transfer*, edition 4, New Age International Publishers Limited, 2010.
2.	A.F. Mills & V. Ganeshan, *Heat Transfer*, edition 2, Pearson Publishers, 2009.

DATA BOOKS:

1.	Heat and Mass Transfer Data Book ,C.P.Kothandaraman , S. Subramaniam, 8th Edition, New Age International Publishers Limited.

REFERENCE BOOKS:

1.	Er. R.K. Rajput, *Heat and Mass Transfer*, edition 4, S. Chand Limited, 2007.
2.	Heat and Mass Transfer: Fundamentals and Applications, Yunus A Cengel; Afshin J. Ghajar, 5thEditiion, Tata McGraw Hill.

WEB RESOURCES:

1.	http://www.mie.uth.gr/labs/ltte/grk/pubs/ahtt.pdf

NOTE: Heat Transfer Data Books are permitted for internal and external examinations.

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 416	PC	-	-	3	-	-	48	50	50	100	1.5

Prerequisite: Advanced Engineering drawing, Design of Machine Elements-I, Metal cutting, Machine Tools & Metrology

Course Objectives: To train the students in using drafting, modelling and analysis softwares in mechanical engineering applications like preparing 2D and 3D drawings, structural analysis, thermal analysis and modal analysis of components and further acquaint the students with CNC programming and ROBO programming.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Draw two dimensional views of any mechanical component using Auto CAD software.
CO-2	Create three dimensional part models and assemblies of machine components using Solidworks software.
CO-3	Evaluate the stresses in 2D beams and trusses in static conditions using ANSYS software.
CO-4	Determine the stresses in 3D Components using Solidworks software.
CO-5	Develop and execute programs for CNC Machine, further fabricate a 3D model using 3D Printing.

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

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

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

SYLLABUS

LIST OF EXPERIMENTS

CAD EXPERIMENTS:

1. Drawing the orthographic views of cotter joint using AutoCAD
2. Drawing the orthographic views of knuckle joint using AutoCAD
3. Preparing Part model, Assembly and drawing of Oldham coupling using Solid works
4. Preparing Part model, Assembly and drawing of Universal coupling Solid works
5. Preparing Part model, Assembly and drawing of Screw Jack Solid works
6. Static analysis of beam using ANSYS
7. Static analysis of Truss using ANSYS
8. To evaluate the temperature distribution and the heat loss from a fin subjected to temperature boundary conditions.
9. Evaluating the mode shapes and frequencies of a cantilever beam.

CAM EXPERIMENTS:

1. Preparation of manual part programming for CNC Turning /Milling.
2. Machining of stepped bar on CNC machine tool.
3. 3D Printing of a given model.

REFERENCES: CAD LAB Manual.

HEAT TRANSFER LABORATORY

Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC 417	PC	-	-	3	-	-	48	50	50	100	1.5

Prerequisite: Engineering Mathematics-I & II, Basic Thermodynamics , Fluid Mechanics& Hydraulic Machinery

Course Objectives: To demonstrate the principles of conduction , convection and radiation through experimentation.

Course Outcomes: At the end of the course, the student will be able to:	
CO-1	Evaluate thermal conductivity of liquids and solids.
CO-2	Analyze the variation of temperature with time in different mediums and performance of extended surfaces.
CO-3	Analyse the heat transfer in free, forced convection.
CO-4	Compute emissivity of a grey body and evaluate Stefan-Boltzmann constant .
CO-5	Determine overall heat transfer coefficient in double pipe heat exchanger and on condensing surfaces.

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

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

LIST OF EXPERIMENTS

1. Determination of thermal conductivity of asbestos powder at different heat inputs in hollow sphere.
2. Determination of thermal conductivity of glass wool at different heat inputs in composite cylinder.
3. Determination of thermal conductivity of metal rod (Brass).
4. Determination of thermal conductivity of Liquid (Liquid Paraffin)
5. Determination of overall heat transfer coefficient of composite wall.
6. Determination of convective heat transfer coefficient of vertical cylinder in free convection.
7. Determination of convective heat transfer coefficient of horizontal pipe in forced convection.
8. Determination of Stefan-Boltzmann constant.
9. Determination of Emissivity of Grey body.
10. Determination of fin effectiveness and efficiency under forced convection.
11. Determination of time interval in different mediums under unsteady state heat transfer.
12. Determination of condensation coefficient in film and dropwise condensation.
13. Determination of overall heat transfer coefficient of a double pipe heat exchanger.

DATA BOOK:

1	Heat and Mass Transfer Data Book, C.P.Kothandaraman, S. Subramaniam, 8th Edition, New Age International Publishers Limited.

WEB RESOURCES:

1.	https://vlab.amrita.edu/index.php?sub=1&brch=194

NOTE: Heat Transfer Data Books are permitted for internal and external examinations.

INDUSTRIAL TRAINING											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC 418	PR	-	-	-	-	-	-	100	-	100	1

Prerequisite: Core subjects of Mechanical Engineering

Course Objectives: The Industrial training program is 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.

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 industrial processes.
CO-3	Develop skills to engage in independent learning in view of the technological changes.

Guidelines: The industrial training program is for a minimum duration of a fortnight and can be extended to one month. The student can choose an industry of his/her choice for the program. It has to be carried out at the end of III year – II semester The student has to submit a comprehensive report at the end of the program.

The evaluation process is done in the final year Ist semester and is based on internal Viva – voce examination.

PROJECT PHASE-I

Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC 419	PR	-	-	4	-	-	64	-	100	100	2

Prerequisite: All Courses of Mechanical Engineering

Course Objectives: The project work is intended to give the student an opportunity to apply the theoretical and practical concepts of sciences, mathematics and engineering to formulate and analyze engineering problems to obtain valid solutions by using experimental or analytical methods or software tools.

In the project first phase, the student is exposed to the requirements to be met in the project. The student is given an opportunity to decide the area of work based on his interest. Thereafter, the student has to review the literature and summarize the findings. Based on the review, the student and the guide finalize the problem and chart out the procedure for executing the project work.

- For analytical work, the governing equations and mathematical modeling is completed.
- For projects involving experimental analysis, the setting up of experimentation, procurement of materials & accessories should be completed.
- For Analytical projects which is executed using software tools, modeling should be completed.
- For fabrication projects, the basic design & development of the model and procurement of accessories should be completed.

The evaluation of Phase-I of the project work is based on an internal Viva-voce examination which is conducted twice. The first evaluation is done in the mid of the semester followed by the final evaluation at the end of the semester. The student has to submit a report.

MECHANICAL MEASUREMENTS & CONTROL SYSTEMS (PROFESSIONAL ELECTIVE-V)											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC422(A)	PE	3	-	-	48	-	-	40	60	100	3

Prerequisite: Engineering Mathematics-III, Basic Thermodynamics, Basic Electronics Engineering, Basic Electrical Engineering

Course Objectives: The course focuses on imparting the principles of measurement which includes the working mechanism of various transducers and devices that are in use to measure the important physical variables

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Explain the basic principles & performance characteristics of measurement and also select a suitable displacement measuring instrument for a given application /experimentation.
CO-2	Explain the basic principles, working, advantages, disadvantages and applications of temperature and pressure measuring devices and select a suitable pressure & temperature measuring instrument for a given application/experimentation.
CO-3	Elucidate the basic principles, working, advantages, disadvantages and applications of level, flow, speed, acceleration and vibration measuring instruments and also select a suitable instrument for a given application/experimentation.
CO-4	Describe the basic principles, working, advantages, disadvantages and applications of stress strain, humidity, force, torque and power measuring instruments and also select a suitable instrument for a given application/experimentation.
CO-5	Explain the basic principles, working, advantages, disadvantages and applications of various control systems for measuring instruments.

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

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: 8L+0T=8**

MEASUREMENT OF DISPLACEMENT

Basic principles of measurement – Measurement systems, generalized configuration and functional description of measuring instruments – examples. Static and Dynamic performance characteristics – sources of errors, Classification and elimination of errors. Sensors and transducers.

Measurement of Displacement: Theory and construction of various transducers to measure displacement – Piezo-electric, Inductive, capacitance, resistance, ionization and Photo electric transducers, Calibration procedures,

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

MEASUREMENT OF TEMPERATURE & PRESSURE

Measurement of Temperature: Various Principles of measurement-Classification: Expansion Type: Bimetallic Strip- Liquid in glass Thermometer; Electrical Resistance Type: Thermistor, Thermocouple, RTD; Radiation Pyrometry: Optical Pyrometer; Changes in Chemical Phase: Fusible Indicators and Liquid crystals.

Measurement of Pressure: Different principles used- Classification: Manometers, Dead weight pressure gauge. Tester (Piston gauge), Bourdon pressure gauges, Bulk modulus pressure gauges Bellows – Diaphragm gauges. Low pressure measurement – Thermal conductivity gauges, ionization pressure gauges, Mcleod pressure gauge.

UNIT - III	**Periods: 12L+0T=12**

MEASUREMENT OF LEVEL, FLOW, SPEED, ACCELERATION AND

Measurement of Level: Direct methods – Indirect methods – Capacitive, Radioactive, Ultrasonic, Magnetic, Cryogenic Fuel level indicators – Bubbler level indicators.

Flow measurement: Rotameter, magnetic, Ultrasonic, Turbine flow meter, Hot – wire anemometer, Laser Doppler Anemometer (LDA)

Measurement of Speed : Mechanical Tachometers, Electrical tachometers, Non- contact type-Stroboscope

Measurement of Acceleration and Vibration: Different simple instruments – Principles of Seismic instruments – Vibrometer and accelerometer using this principle- Piezo electric accelerometer.

UNIT - IV	**Periods: 12L+0T=12**

MEASUREMENT OF STRESS-STRAIN, HUMIDITY, FORCE, TORQUE AND POWER

Stress-Strain measurements : Various types of stress and strain measurements –Selection and installation of metallic strain gauges- electrical strain gauge – gauge factor – method of usage of resistance strain gauge for bending compressive and tensile strains – Temperature compensation techniques, Use of strain gauges for measuring torque, Strain gauge Rosettes.

Measurement of Humidity: Moisture content of gases, Sling Psychrometer, Absorption Psychrometer, Dew point meter.

Measurement of Force, **Torque and Power**- Elastic force meters, load cells, Torsion meters, Dynamometers.

UNIT - V	**Periods: 6L+0T=6**
Elements of Control Systems	
Elements of Control Systems: Introduction, Importance – Classification – Open and closed systems- Servomechanisms – Examples with block diagrams – Temperature, speed and position control systems- Transfer functions- First and Second order mechanical systems	
TEXT BOOKS:	
1.	A.K.Sawheny, "*Mechanical Measurements and Instrumentation*",3rd edition, Dhanpat Rai, 2004.
2.	I.J. Nagrath & M.Gopal, "*Control Systems Engineering*", New age international, 4 th edition, 2006.
3.	R. K. Jain -*Mechanical and Industrial Measurements* - Khanna Publishers
4.	Sirohi and Radhakrishna -*Mechanical Measurements* - New Age International
5	A.K.Sawheny, "*Mechanical Measurements and Instrumentation*",3rd edition, Dhanpat Rai, 2004.
REFERENCE BOOKS:	
1.	D.S.Kumar, "*Measurement Systems: Applications & design*", 6 th edition, Metropolitan, 2002
2.	J.P.Holman, "*Experimental Methods for Engineers*", 7 th edition McGraw-Hill, 2010.
3.	A.K.Tayal & Akash Tayal, "*Instrumentation, Mechanical Measurements and Control*", 2nd Edition, Galgotia Publications Pvt Ltd, 1999.
4.	S. Bhaskar – *Basic Principles – Measurements (Instrumentation) & Control Systems* – Anuradha Publications.
WEB RESOURCES:	
1.	http://ecoursesonline.iasri.res.in/course/view.php?id=82

NON-CONVENTIONAL ENERGY SOURCES (PROFESSIONAL ELECTIVE-V)											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC422(B)	PE	3	-	-	48	-	-	40	60	100	3

Prerequisite: Engineering Mechanics, Basic Thermodynamics.

Course Objectives: In the backdrop of depleting fossil fuels, the course is intended to give a overall perspective of the potential of non-conventional energy sources like solar, wind, ocean, geothermal etc. The course also attempts to stress the importance of direct energy conversion systems.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Distinguish various renewable energy sources & principles of solar radiation.
CO-2	Classify solar collectors, solar storage systems & demonstrate the various solar photovoltaic systems
CO-3	Evaluate the performance characteristics of wind machines and classify the Bio-gas plants.
CO-4	Elucidate the working principles of OTEC, tidal power generation & geothermal power plants.
CO-5	Illustrate the principle and importance of Direct energy conversion devices (MHD & Fuel cells).

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

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

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

SYLLABUS	
UNIT - I	**Periods: 9L+0T=9**
INTRODUCTION TO NON-CONVENTIONAL ENERGY RESOURCES	
India's production and reserves of commercial energy sources need for non-conventional energy sources, energy alternatives, solar, thermal, photovoltaic. Water power, wind biomass, ocean temperature difference, tidal and waves, geothermal. **Principles of solar radiation:** Solar constant, extraterrestrial and terrestrial solar radiation, direct & diffuse radiation, solar radiation on titled surface.	
UNIT - II	**Periods: 9L+0T=9**
SOLAR THERMAL SYSTEMS	
Solar Thermal Systems Types of solar collectors-non-concentric & concentric type, flat plate collectors, Absorber coatings. Solar energy storage systems-types & Applications-Solar Photovoltaic Systems	
UNIT - III	**Periods: 10L+0T=10**
WIND ENERGY & BIO-MASS	
Wind energy: Sources and potentials of WEC systems, horizontal and vertical axis wind mills, performance characteristics, Betz criteria. **Bio-mass**: Principles of Bio-conversion, Anaerobic/aerobic digestion, types of bio gas digesters, Case study - utilization for cooking, IC engines operation and economic aspects.	
UNIT - IV	**Periods: 10L+0T=10**
GEOTHERMAL ENERGY & OCEAN ENERGY	
Geothermal energy: Geothermal sources-classification-vapour, liquid dominating systems, applications, potential in India. **Ocean energy:** Ocean Thermal Energy Conversion (OTEC)-principles and thermodynamic cycles. Energy of tides: introduction, principles, components, operation methods, limitations of tidal power generation. Wave energy conversion techniques.	
UNIT – V	**Periods: 10L+0T=10**
DIRECT ENERGY CONVERSION & FUEL CELLS:	
Direct energy conversion: Principles of DEC, Thermo-electric generators, seebeck, peltier and joule Thomson effects, Selection of materials, applications. **Magneto Hydro dynamic generators (MHD):** principles, dissociation and ionization, Thermal efficiency, MHD Engine, power generation systems. **Fuel cells**: Design &principle of operation, classification, types of fuel cells, efficiency and applications of Fuel cells.	
TEXT BOOKS:	
1.	G.D. Rai, "*Non-Conventional Energy Sources*", Khanna publishers, 2004
2.	Tiwari and Ghosal, "*Renewable energy resources*", Narosa publications, 2004
REFERENCE BOOKS:	
1.	Twidell & Weir, Taylor & Francis "*Renewable Energy Sources*", 2006
2.	Sukhatme "*Solar Energy*", Tata McGraw-Hill Education, 1996
3.	John Twideu and Tony Weir "*Renewal Energy Resources*", BSP Publications, 2006
4.	Ashok V Desai "*Non-Conventional Energy*", Wiley Eastern publications,
WEB RESOURCES:	
1.	http://nptel.ac.in/courses/112101098
2.	http://nptel.ac.in/courses/121106014

POWER PLANT ENGINEERING (PROFESSIONAL ELECTIVE-V)											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC 422 (C)	PE	3	0	0	48	0	0	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, Benson boiler, Velox boiler, mountings and accessories.

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 POWER 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.New Age International limited, 2006.
WEB RESOURCES:	
1.	http://nptel.ac.in/courses/108105058/9
2.	http://www.powermag.com

CONDITION MONITORING (PROFESSIONAL ELECTIVE-V)											
Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC422(D)	PE	3	0	0	48	0	0	40	60	100	3

Prerequisite: Dynamics of Machinery

Course Objectives: To familiarize the students with different types and causes of failure of mechanical components and different condition monitoring techniques available for reactive, preventive, predictive maintenance types.

Course Outcomes: At the end of the course the student will be able to:	
CO-1	Interpret various types of failure and different maintenance techniques
CO-2	Explain different condition monitoring techniques and fault detection sensors
CO-3	Predict the causes of vibration by using vibration monitoring technique
CO-4	Describe and analyse wear debris monitoring methods
CO-5	Apply thermography as a tool for condition monitoring and further explain the intricacies of it.

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

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

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

SYLLABUS

UNIT - I	**9L+0T=9**
INTRODUCTION ABOUT CONDITION MONITORING	
Failures, Types of failures, Causes of failures, Bath tub curve, Maintenance types- Reactive, Preventive, Predictive and Proactive maintenances **Condition Monitoring Techniques:** Visual monitoring, Thermography, Vibration monitoring, Shock pulse monitoring, Wear debris monitoring, Motor current signature analysis, Acoustic emission, Ultrasound monitoring, ISO standards, fault detection sensors**.**	
UNIT - II	**9L+0T=9**
STRUCTURAL HEALTH MONITORING(SHM)	
Definition, Principle of SHM, applications, Sensor technology, piezoelectric wafer active sensors, Identifying damage sensitive properties , signal processing, State-of-Art damage identification and pattern reorganization methods, Defect identification in weld joints case study.	
UNIT - III	**10L+0T=10**
VIBRATION MONITORING	
Definition, principles of vibration monitoring, causes of vibration, unbalance, misalignment, bent shaft, oil whirl, antifriction bearings, mechanical looseness, gear problems, vibration transducer, vibration analyzer, vibration software, any simple case study with example.	
UNIT - IV	**10L+0T=10**
WEAR DEBRIS MONITORING	
Introduction, Types of wear, benefits of wear debris analysis, detection of wear particles – Spectroscopy, Ferrography, Particle count, common wear materials, oil sampling technique, oil analysis, limits of oil analysis	
UNIT - V	**10L+0T=10**
THERMOGRAPHY	
Introduction, thermograms, thermal imaging devices- Optical pyrometer , Infrared cameras, use of IR camera , industrial applications of thermography - leakage detection, machineries, advantages, disadvantages and applications of thermography in condition monitoring with a case study with example.	

TEXT BOOKS:

1.	Amiya R.Mohanty, *Machinery condition monitoring: Principles and Practices* , CRC Press publisher (2015)
2.	R.A. Collacott, *Mechanical Fault Diagnosis and condition monitoring,* Springer Netherlands Publisher

REFERENCE BOOKS:

1.	Cornelius scheffer, Paresh Girdhar *Practical Machinery vibration analysis andPredictive Maintenance* , Newnes(Elsevier)

2.	Alan Davies, *Hand book of condition monitoring techniques and Methodology* , Chapman and Hall Publisher
3.	J.S.Rao, *Vibratory condition monitoring of Machines*, Narosa Publishing House
WEB RESOURCES:	
1.	http://nptel.ac.in/courses/112105048/33
2.	http://nptel.ac.in/courses/112103112/40

PROJECT PHASE-II

Code	Category	Periods/Week			Total			Sessional Marks	End Exam Marks	Total Marks	Credits
		L	T	P	L	T	P				
MEC 423	PR	-	-	16	-	-	256	100	100	200	8

Prerequisite: All Courses of Mechanical Engineering

Course Objectives: The project work is intended to give the student an opportunity to apply the theoretical and practical concepts of sciences, mathematics and engineering to formulate and analyze engineering problems to obtain valid solutions by using experimental or analytical methods or software tools.

In the second phase of the project work, the student should continue the work from the stage where he has left in the phase-I.

The evaluation of Phase-II of the project work is based on both internal and external examination. The internal evaluation is done in the mid and also at the end of the semester. The student has to give a PowerPoint presentation followed by Viva – voce in both the internal and external examinations.