Department of Mechanical Engineering

M. Tech Mechanical Curriculum

For Academic Year

2024-25

In affiliation with Savitribai Phule Pune University

M. Tech. (Mechanical Engineering) Semester-I

Course Code	Name of Course	Course Category (As per NEP)	Teaching Scheme				Credits	Evaluation Scheme					
			L	T	P	Total		Theory			Practical		Total Marks
								TAE	CAE	ESE	INT	EXT	
24PMEM101	Thermodynamics and Combustion	Core (Program)	04	-	-	04	04	25	25	50	-	-	100
24PMEM102	Advanced stress Analysis	Core (Program)	04	-	-	03	04	25	25	50	-	-	100
24PMEM103	Research Methodology and IPR	Core (Program)	04	-	-	03	04	25	25	50	-	-	100
24PMEE101	Elective-I	Core (Elective) Group 1	03	-	-	03	03	25	25	50	-	-	100
24PMEE102	Elective-II	Core (Elective) Group 2	03	-	-	03	03	25	25	50	-	-	100
24PMEP101	Lab Practice-I	Core (Skill Enhancement)	-	-	04	04	02				50	50	100
	Total		**18**	**-**	**04**	**19**	**20**						**600**

Elective - I			Elective - II	
24PMEE101A	Advance machine design		24PMEE102A	Mechanical Vibrations
24PMEE101B	Solar energy		24PMEE102B	Energy conservation and management
24PMEE101C	Mechatronics		24PMEE102C	Computer aided Design

Semester-II

Course Code	Name of Course	Course Category (As per NEP)	Teaching Scheme				Credits	Evaluation Scheme					
			L	T	P	Total		Theory			Practical		Total Marks
								TAE	CAE	ESE	INT	EXT	
24PMEM201	Advanced Fluid Mechanics and Heat Transfer	Core (Program)	04	-	-	03	04	25	15	50	-	-	100
24PMEM202	Mechanical Design Analysis	Core (Program)	04	-	-	03	04	25	25	50	-	-	100
24PMEE203	Elective -III	Core (Elective) Group 3	03	-	-	03	03	25	25	50	-	-	100
24PMEE204	Elective -IV	Core (Elective) Group 4	03	-	-	03	03	25	25	50	-	-	100
24PMEP205	Lab Practice-II	Core (Skill Enhancement)	-	-	04	04	02				50	50	100
24PMES206	Seminar	Seminar (Skill Enhancement)	-	-	08	08	04				50	50	100
	Total		**14**	**-**	**12**	**26**	**20**						**600**

Elective - III			**Elective - IV**	
24PMEE203A	Additive Manufacturing & Tooling		24PMEE204A	Numerical Methods and Computational Techniques
24PMEE203B	Industrial Robotics & Material handling system		24PMEE204B	Condition based Monitoring
24PMEE203C	Alternative fuel for I.C Engines		24PMEE204C	Refrigeration and cryogenics

Semester-III

Course Code	Name of Course	Course Category (As per NEP)	Teaching Scheme				Credits	Evaluation Scheme					
			L	T	P	Total		Theory			Practical		Total Marks
								TAE	CAE	ESE	INT	EXT	
24PMEM301	Advanced Optimization Techniques	Core (Program)	04	-	-	04	04	25	25	50		-	100
24PMEE302	Elective V	Core (Elective) Group 5	04	-	-	04	04	25	25	50		-	100
24PMEO303	Open Elective	Open Elective	04	-	-	04	04	25	25	50		-	100
24PMEMD304	Dissertation Stage I	Project	-	-	16	16	08				50	50	100
	Total		**12**	**-**	**16**	**28**	**20**						**400**

Elective - V	
24PMEME302A	Modelling and Simulation
24PMEME302B	Computational Fluid dynamics
24PMEME302C	Finite Element Method

Open Elective	
24PMEO303 A	Industrial Safety
24PMEO303 B	Business Analytics
24PMEO303 C	Operations Research
24PMEO303 D	Cost Management of Engineering Projects
24PMEO303 E	Waste to Energy
24PMEO303 F	Composite Materials

Semester-IV

Course Code	Name of Course	Course Category (As per NEP)	Teaching Scheme				Credits	Evaluation Scheme					
			L	T	P	Total		Theory			Practical		Total Marks
								TAE	CAE	ESE	INT	EXT	
24PMEMD402	Dissertation Stage II	Dissertation	-	-	40	40	20				100	100	200
	Total		**-**	**-**	**40**	**40**	**20**						**200**

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M. Tech Mechanical Curriculum							
Course	**Thermodynamics and Combustion**			**Code**	24PMEM101		
Course Cadre	Compulsory			**Semester**	I		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	4	-	-	**Marks**	25	25	50
Total Credits	4	-	-	**Total Marks**	100		

Prerequisites: Basic Thermodynamics, Engg Mathematics

Course Outcomes:
On completion of the course, learner will be able to
CO1: Review the laws of thermodynamics
CO2: Explain the use of Maxwell's relations, Clapeyron equation and apply equations of state for real gases and compare.
CO3: Implement the basic signal processing techniques.
CO4: Understand the role of vibration monitoring, its methodology and its use in condition monitoring of rotating and reciprocating machines.
CO5: - Understand the significance of mechanical fault diagnosis and non-destructive testing techniques in monitoring and maintenance.
CO6: Study condition monitoring of rolling element bearing, gears and tool condition monitoring techniques in machining.

Course Contents:

Unit 1: Review of laws of Thermodynamics 4 hrs

First law of thermodynamics for a closed system undergoing a cycle and change of state, Limitation of first law of thermodynamics, Second Law of Thermodynamics cycle heat engine, refrigerator and heat pump, Kelvin- Plank and Clausius statements and their equivalence, Reversibility and Irreversibility, Carnot cycle, Carnot theorem, Absolute thermodynamic temperature scale.

Unit 2: Entropy 6 hrs
Entropy as a property of system. entropy of pure substance., entropy change in a reversible and irreversible processes, increase of entropy principle, Introduction to Available and unavailable energy: The Entropy Change of Ideal Gases, Reversible Steady-Flow Work, Entropy Change of a System, ΔS system, Mechanisms of Entropy Transfer during Heat and mass transfer, Entropy Generation for closed Systems and Control Volumes

Unit 3: Thermodynamic relations 6 hrs
The Ideal-Gas Equation of State, Other Equations of State:Van der Waals Equation of State,Beattie-Bridgeman Equation of State,Benedict-Webb-Rubin Equation of State, Virial Equation of State, Maxwell's equation, joule- kelvin effect, clausius-clapeyron equation.

Unit 4: Properties of Steam **6 hrs**
Dryness fraction, enthalpy, internal energy and entropy, steam table and Mollier chart, first law applied to steam processes. Vapour Power Cycles and Gas Power Cycles: Carnot vapour cycle, Rankine cycle, Ideal reheat, Rankine cycle, Introduction to cogeneration. Air standard assumptions, Otto cycle, Diesel cycle, dual cycle, Stirling cycle, Ericsson cycle, Atkinson cycle, Brayton cycle.

Unit 5: Refrigeration Cycles **8 hrs**
The Reversed Carnot Cycle, The Ideal Vapor-Compression Refrigeration Cycle, Actual Vapor-Compression Refrigeration Cycle, Selecting the Right Refrigerant, Innovative Vapor-Compression Refrigeration Systems, Multistage Compression Refrigeration Systems, Multipurpose Refrigeration Systems with a Single Compressor Liquefaction of Gases, Gas Refrigeration Cycles, Absorption Refrigeration Systems

Unit 6: Fuels and Combustion **6 hrs**
Types of fuels, calorific values of fuel and its determination, combustion equation for hydrocarbon fuel, determination of minimum air required for combustion and excess air supplied conversion of volumetric analysis to mass analysis, fuel gas analysis. Stoichiometric A/F ratio, lean and rich mixture, products of combustion, properties of engine fuels.

Text Books:

1. P. K. Nag, "Engineering Thermodynamics", Tata McGraw Hill, 3rd edition, New Delhi, 2005.
2. Y. A. Cengel, M. A. Boles, "Thermodynamics–An Engineering Approach", Tata McGraw Hill, 5th edition, 2006.

References:

1. G. J. Van Wyle, R. E. Sonntag, "Fundamental of Thermodynamics", John Wiley & Sons, 5th edition, 1998.
2. M. J. Moran, H. N. Shaprio, "Fundamentals of Engineering Thermodynamics", John Wiley and Sons, 4th edition, 2004.

E-content Links:

1. https://nptel.ac.in/courses/112103313
2. https://nptel.ac.in/courses/112106310

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M. Tech Mechanical Curriculum							
Course	**Advanced Stress Analysis**			**Code**	24PMEM102		
Course Cadre	Compulsory			**Semester**	I		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	4	-	-	**Marks**	25	25	50
Total Credits	4	-	-	**Total Marks**	100		

Prerequisites: Engineering Mathematics, Engineering Physics, Engineering Mechanics, Strength of Materials

Course Outcomes:
At the end of the course students will be able to:
1. Determine stress distribution along a component under different loading conditions.
2. Understand behavior of walled sections.
3. Solve real time problems subjected under bending.
4. Prepare composite material sample.
5. Investigate components subjected to Hartezian contact stresses
6. Measure stress strain through experiments.

Course Contents:

Unit I: **6 hrs.**
Elasticity problems in two dimensions - stress strain relationship for brittle materials, ductile materials. Compatibility equations in two and three dimensions, free body diagram of complicated structures and stress calculations

Unit 2 **7 hrs.**
Stress functions in rectangular and cylindrical coordinate systems, evaluation of stresses in flat rectangular plates with different clamp and load conditions evaluation of the stresses in the flat and circular plate with center hole/holes using stress function

Unit 3 **6 hrs.**
Torsion of general prismatic bars of solid section, Membrane Analogy, Torsion of Thin walled tubes, Torsion of Thin walled Multiple-Cell closed sections, Torsion of rolled sections.

Unit 4 **7 hrs.**
Introduction to Linear Elastic Fracture Mechanics, Modes of fractures, Stress intensity factor, crack initiation and Crack opening phenomenon, stress distribution around crack tip under various loading conditions, Fracture toughness.

Unit 5 **7 hrs.**
Geometry of contact surfaces, method of computing contact stresses and deflection of bodies in point

contact, stress for two bodies in line contact with load normal to contact area and load normal and tangent to contact area, gear contacts, contacts between cam and follower, ball bearing contacts.

Unit 6 **5 hrs.**
Dimensional analysis, analysis techniques, strain gauges, types of strain gauges, materials, configuration, instrumentation, characteristics of strain gauge measurement, theory of photo-elasticity.

References:
1. Advanced Mechanics of Materials - Cook and Young , Prentice Hall
2. Theory of elasticity - Timoshenko and Goodier , McGraw Hill
3. Advance Strength of Materials- vol 1 and 2 – Timoshenko, CBS publisher
4. Advanced Mechanics of Materials – Boresi, Schmidt, Sidebottom, Willey Mechanics of Materials - vol 1 and 2 - E J Hearn , Butterworth- Heinemann

e Content:
1. https://archive.nptel.ac.in/courses/112/101/112101095/
2. https://www.youtube.com/@iit
3. https://www.youtube.com/@mbarkey.mechanics/videos

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M. Tech Mechanical Curriculum							
Course	**Research Methodology and IPR**			**Code**	24PMEM103		
Course Cadre	Compulsory			**Semester**	I		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	4	-	-	**Marks**	25	25	50
Total Credits	4	-	-	**Total Marks**	100		

Prerequisites:

1. The learner should know the basics of a research project.
2. The learner should be familiar with research ethics and should have inclination towards critical thinking
3. The learner should have prior knowledge of project management to understand research methodology.

Course Objectives:

1. To explain the functions of the literature review in research.
2. To explain carrying out a literature search and writing a review.
3. To explain various research designs and their characteristics.
4. To explain different methods of data collection.
5. To explain the art of interpretation and the art of writing research reports.
6. To explain various forms of intellectual property, its relevance and business impact.
7. To discuss leading International Instruments concerning Intellectual Property Rights

Course Outcomes:

On completion of the course, learner will be able to

CO1: Understand research methodology in step-by-step approach

CO2: Locate requisite literature, draw inferences and develop the literature review.

CO3: Apply the understanding of sampling and experimental design

CO4: Collect and analyze the data of experimentation

CO5: Write research findings in form of thesis and research articles

CO6: Understand and apply the IPR, copyright laws

Course Contents:

Unit 1 Research Methodology: **6 hrs.**

Introduction, Meaning of Research, Objectives of Research, Types of Research,
Research Approaches, Significance of Research, Research Methods versus Methodology, Research and Scientific Method, Research Process, Criteria of Good Research, Problems Encountered by Researchers in India. Defining the Research Problem: Research Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem

Unit 2 Literature Review and experimental design **7 hrs.**

Reviewing the literature: Place of the literature review in research, bringing clarity and focus to research problem, improving research methodology, broadening knowledge base in research area, enabling contextual findings, Review of the literature, developing a theoretical framework, developing a conceptual framework, writing about the literature reviewed.
Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Different Research Designs, Basic Principles of Experimental Designs

Unit 3 Sampling and Scaling **6 hrs.**

Design of Sample Surveys: Design of Sampling: Introduction, Sample Design, Sampling and Non-Sampling Errors, Sample Survey versus Census Survey, Types of Sampling Designs.
Measurement and Scaling: Qualitative and Quantitative Data, Classifications of Measurement Scales, Sources of Error in Measurement, Techniques of Developing Measurement Tools, Scaling, Scale Classification Bases, Scaling Technics, Multidimensional Scaling, Deciding the Scale

Unit 4 Data Collection and Hypotheses Testing **8 hrs.**

Data Collection: Introduction, Experimental and Surveys, Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection Hypothesis, Basic Concepts Concerning Testing of Hypothesis, Test Statistics and Critical Region, Critical Value and Decision Rule, Procedure for Hypothesis Testing, Hypothesis Testing for Mean, Proportion, Variance, for Difference of Two Mean, for Difference of Two Proportions, for Difference of Two Variances, P-Value approach, Power of Test, Limitations of the Tests of Hypothesis. Chi-square Test: Test of Difference of more than Two Proportions, Test of Independence of Attributes, Test of Goodness of Fit, Cautions in Using Chi Square Tests.

Unit 5 Thesis Writing and Publication **7 hrs.**

Interpretation and Report Writing: Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports, Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports.

Unit 6 IPR Introduction **8 hrs.**

The Concept, Intellectual Property System in India, Development of TRIPS Complied Regime in India, Patents Act, 1970, Trade Mark Act, 1999, The Designs Act, 2000, The Geographical Indications of Goods (Registration and Protection) Act1999, Copyright Act,1957, The

Protection of Plant Varieties and Farmers' Rights Act, 2001Trade Secrets, Utility Models, IPR and Biodiversity, World Intellectual Property Organization (WIPO), WIPO and WTO, Paris Convention for the Protection of Industrial Property, National Treatment, Right of Priority, Common Rules, Patents, Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition, Patent Cooperation Treaty (PCT), Advantages of PCT Filing, Geographical indications, Industrial Designs, Patents, Patentable Subject Matter, Rights Conferred, Exceptions, Term of protection, Conditions on Patent Applicants, Process Patents, Other Use without Authorization of the Right Holder, Layout-Designs of Integrated Circuits, Protection of Undisclosed Information, Enforcement of Intellectual Property Rights, UNSECO

Textbooks

1. Research Methodology: Methods and Techniques, C.R. Kothari, Gaurav Garg, New Age International, 4th Edition, 2018
2. Research Methodology a step-by step guide for beginners, Ranjit Kumar, SAGE Publications Ltd, 3rd Edition, 2011
3. Intellectual Property Law: An Introduction, Saurabh Bindal, EBC Webstore, 2nd Edition, 2023

Reference books

1. Research Methods: the concise knowledge base, Trochim, Atomic Dog Publishing, 2005
2. Conducting Research Literature Reviews: From the Internet to Paper, Fink A, Sage Publications, 2009.
3. Law Relating to Intellectual Property Rights, M.K. Bhandari, Central Law Publications, 6th Edition, 2021

E-content Links:

1. https://www.coursera.org/learn/research-methodologies
2. https://www.coursera.org/learn/protect-business-innovations-copyright

E-books:

1. https://dst.gov.in/sites/default/files/E-BOOK%20IPR.pdf - Intellectual Property - A Primer for Academia
2. https://ccsuniversity.ac.in/bridge-library/pdf/Research-Methodology-CR-Kothari.pdf - Research Methodology - CR Kothari

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M. Tech Mechanical Curriculum							
Course	**Advance Machine Design**			**Code**	24PMEE101A		
Course Cadre	Elective I			**Semester**	I		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	3	-	-	**Marks**	25	25	50
Total Credits	3	-	-	**Total Marks**	100		

Prerequisites:

1. The learner should have understanding of Design of Machine Elements
2. The learner should be familiar with Design of Mechanical System.

Course Objectives:

1. Understand how to design machine with proper mechanism.
2. Develop skills to optimize multivariable search methods.
3. Implement skills to design complex mechanical system with proper mechanism.

Course Outcomes:

On completion of the course, learner will be able to
CO1: Understand the concepts of factorial Design
CO2: Develop product design on basis of fatigue and creep failure.
CO3: Optimize variable search methods in Design
CO4: Analyze stress concentration in composite laminates.
CO5: Apply Design process for different machining processes.
CO6: Apply Design Process for different complex elements.

Course Contents:

1. **Engineering statistics**: - **6 hrs.**

Analysis of variance (ANOVA), factorial design and regression analysis. Reliability theory, design for reliability, Hazard analysis, fault tree analysis

2. **Fatigue and Creep: -** **7 hrs.**

Introduction, Fatigue strength, factors affecting fatigue behavior, Influence of super imposed static stress, Cumulative fatigue damage, fatigue under complex stresses, Fatigue strength after over stresses, True stress and true strength, mechanism of creep of material at high temperature, Exponential creep law, hyperbolic sine creep law, stress relaxation, bending etc

3. **Optimization: -** **6 hrs.**

Introduction, multivariable search methods, linear & geometric programming, structural and shape optimization and simplex method.

4. **Composite materials: -** **7 hrs.**

Composite materials and structures, classical lamination theory, elastic stress analysis of composite material, Fatigue strength improvement techniques, stresses, stress concentration around cutouts in composite laminates, stability of composite laminate plates and shells, Hybrid materials, applications.

5. **Design for Materials and Process: -** **6 hrs.**
Design for brittle fracture, Design for fatigue failure, Design for different machining process, assembly & safety etc.

6. **Design of Mechanical components: -** **7 hrs.**
   i. **Gear Design: -** Involute gears, tooth thickness, interference, undercutting, rack shift etc. Profile modification, S and So spur, helical gears etc.

   ii. **Spring Design**: - Vibration and surging of helical springs, helical springs for maximum space efficiency, analysis of Belleville springs, ring spring, volute spring & rubber springs. Design for spring suspension.

   iii. **Design of Miscellaneous components (to be detailed)** Cam shaft with valve opening mechanism, piston, cylinder, connecting rod etc.

REFERENCE BOOKS

1. Mechanical Design Analysis – M.F. Spotts
2. Machine Design - Robert Norton
3. Practical Gear design - D.W. Dudley
4. Optimum design - R.C. Johnson
5. Mechanical Springs – A.M. Wahl.
6. An introduction to composite materials – D. Hull and T.W. Clyne

Textbook

1. Practical Gear design - D.W. Dudley
2. Machine Design- V B Bhandari

E content-

1. https://archive.nptel.ac.in/courses/112/105/112105124
2. https://www.coursera.org/learn/machine-design1

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M. Tech Mechanical Curriculum							
Course	**Solar Technology**			**Code**	24PMEE101B		
Course Cadre	Elective I			**Semester**	I		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	3	-	-	**Marks**	25	25	50
Total Credits	3	-	-	**Total Marks**	100		

Prerequisites: Thermal engineering, Heat transfer, electrical systems

Course Objectives:

1. Be able to use engineering terminology associated with solar thermal energy system
2. Be able to apply the solar thermal system from an engineering perspective
3. To enable the student to make judgments, and studies of alternatives in the context of engineering projects.

Course Outcomes:

On completion of the course, learner will be able to
CO1: Understand role of solar energy in every terms like regional and global energy system, its economic, social and environmental conditions and the impact of technology.
CO2: Understand the concept of the solar collector and its uses
CO3: Understand the physical principles of the photovoltaic (PV) solar cell and what its sources of losses are.
CO4: Understand the concept of energy quality and energy services in a system engineering context.
CO5: Capable of independent self-directed practice in the area of solar thermal power system
CO6: Understand and Capable to practice in the area of solar thermal application.

Course Contents:

Unit 1 Solar Radiation **6 hrs.**
Introduction Solar radiation, Radiation geometry, Solar time, Sun earth angles, Sun path diagram, Sunshine hours, Measurement of solar diffuse, Global and direct solar radiation, Equipment's, Estimation of solar radiation on horizontal and tilted surfaces

Unit 2 Solar Thermal Collectors **6 hrs.**
Liquid flat collector, Energy balance for flat plate collectors, Overall heat loss coefficient, Heat transfer between parallel surfaces, testing methods, Types of flat plate collectors, Liquid and air flat plate collectors, focusing collectors, Types of focusing collectors

Unit 3 Solar photovoltaic system **8 hrs.**
PV system design, Array design, PV system installation, Operation and maintenance, Balance of PV system (BOS), Issues and challenges of PV system operation and maintenance, Factor affecting the PV system performance, Performance measurements and characterization of PV power plant, Stand alone, Hybrid and grid connected system, Grid connected PV system design and optimization, Rooftop PV systems.

Unit 4 Solar Cells **8 hrs.**

Fundamentals of semiconductor physics, Doping, Interaction of light and semiconductors, P-N junction, Function of solar cell, Equivalent circuit of solar cell, Analysis of PV cells, Dark and illumination characteristics, Figure of merits of solar cell, Efficiency limits, Efficiency measurements, High efficiency cells, Recent developments in solar cells, Solar modules, Photo-voltaic system technology

Unit 5 Solar Thermal Power System **10 hrs.**

Parabolic through collector system, power tower system, dish systems, thermal analysis of solar thermal power plants, solar ponds, Solar thermal electric power plants based on parabolic trough, solar central receiver.

Unit 6 Solar Thermal Applications **10 hrs.**

Selection criteria of storage materials for heating and cooling applications, selection of heat transfer fluid for heating and cooling applications, active and passive solar water heating system, solar space heating, solar cooling with absorption and adsorption refrigeration, solar desalination systems, solar powered absorption air conditioning system, solar irrigation system, solar chimney, drier, dehumidifier, solar still

Textbooks

1. SP Sukhatme, Solar Energy: Principles of Thermal Collection and Storage, Tata McGraw-Hill,1984
2. JA Duffie and WA Beckman, Solar Engineering of Thermal Processes, John Wiley, 1991
3. Garg HP, J Prakash, Solar Energy: Fundamentals and Applications, Tata McGraw Hill, New Delhi, 1997
4. DY Goswami, F Kreith and JF Kreider, Principles of Solar Engineering,Taylor and Francis
5. T Bhattacharya, Terrestrial Solar Photovoltaic, Narosa Publishers Ltd, New Delhi LD Partain (ed), Solar Cells and their Applications, John Wiley and Sons, Inc, New York, 1995
6. AL Fahrenbruch and RH Bube, Fundamentals of Solar Cells: PV Solar Energy Conversion, Academic Press, New York, 1983

Reference books

7. Tiwari GN. Solar Energy, Fundamentals design, modeling and Applications. Narosa, 2002
8. Duffie JA. Beckman WA. Solar Engineering of Thermal Processes, John Wiley, 2006 HS Rauschenbach, Solar Cell Array Design Handbook, Van Nostrand Reinfold Company, New York, 1980
9. R Messenger and J Vnetre, Photovoltaic Systems Engineering, CRC Press Stand
10. Alone PV Systems: A Handbook of Recommended Design Practices, Report No SAND 87-7023, Sandia National Lab USA

E-content Links:

1. NPTEL :: Physics - NOC:Solar Energy Engineering and Technology
2. Photovoltaic solar energy Course by École Polytechnique | Coursera

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M. Tech Mechanical Curriculum							
Course	**Mechatronics**			**Code**	24PMEE101C		
Course Cadre	Elective I			**Semester**	I		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	3	-	-	**Marks**	25	25	50
Total Credits	3	-	-	**Total Marks**	100		

Prerequisites:

1. Basics of Electrical components, Op amp Circuits.
2. Binary to Decimal Conversion, Data communication Module.
3. Linear Algebra, Laplace Transformation method.
4. Logic gates.

Course Objectives:

1. UNDERSTAND the key elements of mechatronics, principle of sensor and its characteristics.
2. UNDERSTAND the concept of signal processing and use of interfacing systems such as ADC, DAC, Digital I/O.
3. UNDERSTAND the block diagram representation and concept of transfer function.
4. UNDERSTAND the system modeling and analysis in frequency domain.
5. UNDERSTAND the system modeling and analysis in time domain, controller modes and its industrial applications.
6. UTILIZE the concepts of PLC system and its ladder programming and significance of PLC system in industrial application.

Course Outcomes:

On completion of the course, learner will be able to

CO1: DEFINE key elements of mechatronics, principle of sensor and its characteristics.

CO2. UTILIZE concept of signal processing and MAKE use of interfacing systems such as ADC, DAC, Digital I/O.

CO3. DETERMINE the transfer function by using block diagram reduction technique.

CO4. EVALUATE Poles and Zero, frequency domain parameter for mathematical modeling for mechanical system.

CO5. APPLY the concept of different controller modes to an industrial application.

CO6. DEVELOP the ladder programming for industrial application.

Course Contents:

Unit 1 Introduction to Mechatronics, Sensors & Actuators 6 hrs.

Introduction to Mechatronics and its Applications Measurement Characteristics (Static/Dynamic),

Sensors: Types of sensors; Motion Sensors Encoder (Absolute & incremental), Lidar, Eddy Current, Proximity (Optical, Inductive, Capacitive), MEMS Accelerometer; Temperature sensor Pyrometer, Infrared Thermometer; Force / Pressure Sensors Strain gauges, Piezoelectric sensor; Flow sensors Electromagnetic, Ultrasonic, Hot-wire anemometer; Color

sensor RGB type; Biosensors Enzyme, ECG, EMG
Actuators: Servo motor; Hydraulic and Pneumatic (must be restricted to classification and working of one type of linear and rotary actuator); linear electrical actuators Selection of Sensor & Actuator

Unit 2 Data Acquisition and Signal Communication 7 hrs.

Signal Communication: Serial, Parallel; Synchronous, Asynchronous
Introduction to DAQ, Types, Components of a Data Acquisition System (Sensor, Signal conditioning, processing, controlling and storage/display/action) Data Acquisition: Signal collection, Signal conditioning Isolation& Filtering, Amplification, Sampling, Aliasing, Sample and hold circuit, Quantization, Analog-to-digital converters (4-bit Successive Approximation type ADC), Digital-to-Analog converters (4 bit R2R type DAC), Data storage Applications: DAQ in Household, Digital Pressure Gauge, Digital Flow measurement, (DVB) Digital Video Broadcast, AM/FM

Unit 3 Control systems & transfer function based modelling 6 hrs.

Introduction to control systems, need, Types- Open and Closed loop, Concept of Transfer Function, Block Diagram & Reduction principles and problems; Applications (Household, Automotive, Industrial shop floor) Transfer Function based modeling of Mechanical, Thermal and Fluid system; Concept of Poles & Zeros; Pole zero plot, Stability Analysis using Routh Hurwitz Criterion (Numerical Approach)

Unit 4 Time and Frequency Domain Analysis 8 hrs.

Time Domain Analysis - Unit step Response analysis via Transient response specifications (Percentage overshoot, Rise time, Delay time, Steady state error etc.) Frequency Domain Analysis - Frequency Domain Parameters - Natural Frequency, Damping Frequency and Damping Factor; Mapping of Pole Zero plot with damping factor, natural frequency and unit step response ; Introduction to Bode Plot, Gain Margin, Phase Margin

Unit 5 Controllers 7 hrs.

Introduction to controllers, Need for Control, Proportional (P), Integral (I) and Derivative (D) control actions; PI, PD and PID control systems in parallel form; (Numerical approach), Feed forward anticipatory control Manual tuning of PID control, Ziegler Nichols method
Applications: Electro Hydraulic/Pneumatic Control, Automotive Control

Unit 6 Programmable Logic Controller (PLC) 6 hrs.

Introduction to PLC; Architecture of PLC; Selection of PLC; Ladder Logic programming for different types of logic gates; Latching; Timers, Counters; PLC control of Hydraulics / Pneumatics / Mechatronics systems involving timing and counting operations.

Textbooks

1. William Bolton, Mechatronics: Electronics Control Systems in Mechanical and Electrical Engineering, 6th Ed, 2019
2. K.P. Ramchandran, G.K. Vijyaraghavan, M.S. Balasundaram, Mechatronics: Integrated Mechanical Electronic Systems, Willey Publication, 2008

Reference books

1. Alciatore and Histand, Introduction to Mechatronics and Measurement Systems, 5th Ed, 2019
2. Bishop (Editor),Mechatronics An Introduction CRC 2006
3. Mahalik, Mechatronics Principles, concepts and applications, Tata Mc-Graw Hill publication, New Delhi
4. C.D.Johnson, Process Control Instrumentation Technology, Prentice Hall,New Delhi
5. Bolton, Programmable Logic Controller, 4th Ed, Newnes, 2006

E-content Links:

1. https://www.elprocus.com/what-is-a-biosensor-types-of-biosensors-and-applications
2. https://www.elprocus.com/color-sensor-working-and-applications
3. https://www.youtube.com/watch?v=kbjCGGTXqUo&ab_channel=Controlengineering
4. https://youtu.be/clTA0pONnMs?list=PLHMDN3JFtE5wEz95H2XuzRaafK3fUsaki
5. https://nptel.ac.in/content/storage2/courses/108105063/pdf/L-12(SS)%20(IA&C)%20((EE)NPTEL).pdf
6. https://nptel.ac.in/content/storage2/courses/112104158/lecture5.pdf

E-books:

1. http://160592857366.free.fr/joe/ebooks/Mechanical%20Engineering%20Books%20Collection/MECHATRONICS/Mechatronic%20Systems%20Devices,%20Design,%20Control,%20Operation%20and%20Monitoring.pdf
2. https://www.freebookcentre.net/Mechanical/Mechatronics-Books.html#google_vignette
3. http://www.sze.hu/~szenasy/Szenzorok%20%E9s%20aktu%E1torok/Szenzakt%20jegyzetek/Mechatronics_handbook%5B1%5D.pdf

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M. Tech Mechanical Curriculum							
Course	**Mechanical Vibrations**			**Code**	24PMEE102A		
Course Cadre	Elective II			**Semester**	I		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	3	-	-	**Marks**	25	25	50
Total Credits	3	-	-	**Total Marks**	100		

Prerequisites:

1. The learner should know the basics of a Engineering Mechanics.
2. The learner should be familiar with Theory of Machines and should have inclination towards fundamentals

Course Objectives:

1. To make the student conversant with fundamentals of Mechanical Vibrations.
2. To develop competency in understanding of Mechanical Vibrations in Industry.
3. To develop analytical competency in solving Mechanical Vibrations problems.
4. To make the student conversant with natural frequencies, Eigen values & Eigen vectors.
5. To understand the various techniques of measurement and Mechanical Vibrations control

Course Outcomes:

On completion of the course, learner will be able to

CO1: Ability to understand the fundamentals of Mechanical Vibrations. 14. 15. 1617.

CO2: Ability to understand measurement and control of Mechanical Vibrations.

CO3: Apply the understanding of sampling and experimental design

CO4: Ability to calculate natural frequencies, Eigen values & Eigen vectors.

CO5: Ability to measure and control Vibrations for real life problems.

CO6: Understand and apply the knowledge in practical problems

Course Contents:

Unit 1 Balancing 8 hrs.

Static and dynamic balancing, Balancing of rotating masses in single and several planes, Primary and secondary balancing of reciprocating masses,Balancing in single cylinder engines, Balancing in multicylinder in-line engines, Direct and reverse cranks method -Radial and V engines Vibratory Systems. Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem

Unit 2 Single Degree of Freedom Systems – Free Vibrations 8 hrs.

Fundamentals of Vibration: Elements of a Vibratory System, vector representation of S.H.M., degrees of freedom, types of Vibration, Natural frequency, Equivalent springs, Modeling of a system, Formulation of equation of motion by equilibrium and energy methods. Undamped Free Vibrations: Natural frequency for longitudinal, Transverse and Torsional Vibratory Systems.

Unit 3 Single Degree of Freedom Systems – Damped Free Vibrations 6 hrs.

Different types of damping, free vibrations with viscous damping - over damped, critically damped and under damped systems, Initial conditions, Logarithmic decrement, Introduction to equivalent viscous damping, dry friction or coulomb damping - frequency and rate of decay of oscillations.

Unit 4 Single Degree of Freedom Systems - Forced Vibration 10 hrs.

Forced Vibration: Forced vibrations of longitudinal and torsional systems, Frequency Response to harmonic excitation, excitation due to reciprocating and rotating unbalance, base excitation, magnification factor, resonance phenomenon and phase difference, Quality Factor. Critical speed of shafts: Introduction, Critical speed of shaft having single rotor of undamped systems.

Unit 5 Two Degree of Freedom Systems-Undamped Vibrations 8 hrs.

Free vibration of spring coupled systems – longitudinal and torsional, natural frequency and mode shapes, Eigen value and Eigen vector by Matrix method, Geared systems. Introduction to Physical and Mathematical modeling: Motor bike and Quarter Car.

Unit 6 Measurement and Control of Vibrations 8 hrs.

Vibration Measurements: Force and Motion transmissibility, Vibration Measuring devices, Accelerometers, Impact hammer, Vibration shaker-Construction, principles of operation and uses, Vibration Analyzer, Analysis of Vibration Spectrum, Standards related to measurement of vibration and accepted levels of vibration. Vibration Control: Introduction, vibration control methods, passive and active vibration control, reduction of excitation at the source, control of natural frequency, Vibration isolators, Dynamic Vibration Absorbers, Introduction to Torsional Damper.

Textbooks

1. Rao S. S. “Mechanical Vibrations“, Pearson Education Inc. Dorling Kindersley (India) Pvt. Ltd. New Delhi.
2. Grover G. K. “Mechanical Vibrations”, Nem Chand and Bros.,Roorkee
3. Wiiliam J Palm III, “Mechanical Vibration” Wiley India Pvt. Ltd, New Delhi
4. UickerJ.John, Jr, Pennock Gordon R, Shigley Joseph E.“Theory of Machines and Mechanisms” International Version, OXFORD University Press, New Delhi
5. M L Munjal, “ Noise and Vibration Control” Cambridge University Press India P Ltd., New Delhi

Reference books

1. Thomson,W.T.,“Theory of Vibration with Applications”, CBS Publishers and Distributors
2. V P Singh “ Mechanical Vibrations DhanpatRai& Sons, New Delhi
3. DrDebabrata, “ Mechanical Vibrations”, Wiley India Pvt. Ltd, New Delhi.
4. Kelly S. G. “Mechanical Vibrations“, Schaum‘s outlines, Tata McGraw Hill Publishing Co. Ltd., New Delhi.
5. Meirovitch, “Elements of Mechanical Vibrations”, McGraw Hill
6. Steinberg, D. S., “Vibration Analysis for Electronic Equipments”, John Wiley and Sons.
7. ShrikantBhave, Mechanical Vibrations Theory and Practice, Pearson, NewDelhi.

E-Content links

1. **https://youtu.be/hWNpID0TWYU?feature=shared**

2. https://youtu.be/IsIQvdVkQxg?feature=shared
3. https://youtu.be/3i2gu74ghKg?feature=shared
4. https://youtu.be/n4BUoM-oeuQ?feature=shared
5. https://youtu.be/RkWJvpgpjuc?feature=shared

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M. Tech Mechanical Curriculum							
Course	**Energy Conservation and Management**			**Code**	24PMEE102B		
Course Cadre	Elective II			**Semester**	I		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	3	-	-	**Marks**	25	25	50
Total Credits	3	-	-	**Total Marks**	100		

Prerequisites:

1. The learner should have known basics of thermodynamics.
2. The learner should be familiar devices learnt in applied Thermodynamics.
3. The learner should have prior knowledge Heat transfer and turbo machines

Course Objectives:

1. To understand the importance energy security for sustainable development and the fundamentals of energy conservation.
2. To introduce performance evaluation criteria of various electrical and thermal installations to Facilitate the energy management
3. To relate the data collected during performance evaluation of systems for identification of energy saving opportunities.

Course Outcomes:

On completion of the course, learner will be able to
CO1: Student will be able to acquire insight about the importance of energy
CO2: Student will be able to analyze all scenarios from energy consumption.
CO3: Student will be able to understand scenarios of energy consumption and predict the future trend.
CO4: Student will be able to create and plan energy conservation solutions
CO5: Student should familiar of energy management of engineering systems.
CO6: Students will interpret the importance and principles of energy conservation.

Course Contents:

Unit 1 Energy Scenario: 6 hrs.

World's production and reserves of commercial energy sources. India's production & reserves energy alternatives, utilization pattern and future strategy, Importance of energy management.

Unit 2 Energy Auditing 7 hrs.

Methodology and analysis: Introduction, Types, Preliminary audit, and Intermediate and Comprehensive audit, Procedure of auditing, Case studies and Recommendations.

Unit 3 Energy Economics 6 hrs.

Initial & annual costs, Definitions of annual solar savings, Life cycle savings, Present worth calculations, Repayment of loan in equal Annual instalments, Annual solar savings, Cumulative Solar Savings and life cycle Savings, Pay-back period

Unit 4 Energy Conservation 7 hrs.

Energy conservation in industries, Cogeneration, Combined heating and power systems: Importance, Principles, Planning for Energy Conservation-Electrical energy,
Thermal energy, Human & animal muscle energy. Waste Recovery /Recycling, Cogeneration.

Unit 5 Energy Management 7 hrs.

Energy Strategic Planning, Management of supply side, Elements, steps, Flow. Management of Utilization side-Elements, transmission, Equipment and control systems, principles of Energy Management

Unit 6 International Standards and Laws 5 hrs.

Relevant international standards and laws.

Textbooks

1. L.C. Witte, P.S. Schmidt, D. R. Brown, "Industrial Energy Management and Utilization", Hemispherical Publication, 1988
2. D. A. Reeg, "Industrial Energy Conservation", Pergamon Press, 1980.
3. T.L. Boyen, "Thermal Energy Recovery" Wiley, 1980.
4. L.J. Nagrath, "Systems Modeling and Analysis", Tata McGraw Hill, 1982.
5. W.C. Turner, "Energy Management Handbook ", Wiley, New York, 1982.
6. I.G.C. Dryden, "The Efficient Use of Energy ", Butterworth, London, 1982.

Reference books

1. TERI Publications.
2. Callaghan "Energy Conservation".

E-content Links:

1. http://www.energy.gov/eere/buildings/analysis-tools.
2. http://www.sciencedirect.com/science/article/pii/S0306261907000153
3. https://www.aspentech.com/Products/Activated-Energy-Analysis
4. http://www.nptel.ac.in/courses/108106022

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M. Tech Mechanical Curriculum							
Course	**Computer Aided Design**			**Code**	24PMEE102C		
Course Cadre	Elective II			**Semester**	I		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	3	-	-	**Marks**	25	25	50
Total Credits	3	-	-	**Total Marks**	100		

Prerequisites:
1. Basic understanding of engineering design principles.
2. Familiarity with computer usage and software applications.

Course Objectives:
The CAD for Engineers course provides an opportunity for engineering students to gain proficiency in the use of CAD software for designing and modeling in various engineering disciplines. At the end of the course, a student will be able to:
1. Gain Knowledge on Basic Concepts of CAD
2. Basic Drawing and Editing Techniques
3. Introduction to 3D Modeling
4. Mechanical Component and Assembly Design
5. Technical Documentation and Standards
6. Design for Manufacturability (DFM) and Assembly (DFA)

Course Outcomes:
On completion of the course, learner will be able to
CO1: Define CAD Tools and understand their significance in engineering design.
CO2: Explore different types of CAD systems and evaluate them based on established criteria.
CO3: Develop proficiency in modelling, viewing, and software documentation.
CO4: Master wireframe modelling techniques and mathematical representations of curves.
CO5: Understand surface modelling and solid modeling principles.
CO6: Learn advanced modeling concepts such as feature-based modeling and assembly modeling.

Course Contents:

Unit No.1 CAD Tools 7 hrs
Definition of CAD Tools, Types of CAD systems, CAD/CAM system evaluation criteria, Graphics standards, Functional areas of CAD, Modeling and viewing techniques, Software documentation, Efficient use of CAD software

Unit No.2 Wireframe Modeling Tools 8 hrs
Types of mathematical representation of curves, Wireframe models and entities, Parametric representation of synthetic curves, Hermite cubic splines, Bezier curves, B-Splines, Rational curves (NURBS)

Unit No.3 Surface Modeling 7 hrs

Mathematical representation of surfaces, Surface model and entities, Parametric representation of surfaces, Plane surface, ruled surface, surface of revolution, tabulated surface

Unit No.4 Parametric Representation of Synthetic Surfaces 8 hrs
Hermite Bicubic surface, Bezier surface, B-Spline surface, COONs surface, Blending surface, Sculptured surface, Surface manipulation techniques, Displaying, segmentation, trimming, Intersection, transformations (2D and 3D)

Unit No.5 Solid Modeling 7 hrs
Solid representation techniques, Boundary Representation (B-rep), Constructive Solid Geometry (CSG), Design applications, Mechanical tolerances, mass property calculations, CAD database structure, CAD/CAM Data Exchange, Evaluation of data-exchange formats, IGES data representations and structure, STEP Architecture, implementation, ACIS & DXF

Unit No.6 Advanced Modeling Concepts 7 hrs
Feature-based modeling, Assembly modeling, Behavioural modeling, Conceptual design & top-down design, Techniques for visual realism, Hidden line removal, Surface removal, Algorithms for shading and rendering, Parametric and variational modeling, Feature recognition, Design by features, Assembly and tolerance modeling, Tolerance representation, Specification, analysis, and synthesis, AI in Design

Textbooks

1. Engineering Drawing and Design" by David A. Madsen and David P. Madsen.
2. "Technical Drawing with Engineering Graphics" by Frederick E. Giesecke, Alva Mitchell, Henry C. Spencer, and Ivan L. Hill.
3. "Introduction to AutoCAD 2022: A Modern Perspective" by Paul F. Richard and Jim Fitzgerald.
4. "Mastering AutoCAD 2022 and AutoCAD LT 2022" by Brian C. Benton and George Omura.
5. "SolidWorks 2021 for Designers" by Sham Tickoo.
6.

Reference Books:

1. Ibrahim Zeid, CAD/CAM Theory and Practice, McGraw Hill international.
2. P. N. Rao, CAD/CAM Tata McGraw Hill.
3. Foley, Van Dam, Feiner and Hughes, Computer Graphics Principles and Practice, second edition, Addison–Wesley, 2000.
4. Martenson, E. Micheal, Geometric Modelling, John Wiley & Sons, 1995.
5. Hill Jr, F.S., Computer Graphics using Open GL, Pearson Education, 2003

E-content Links:

1. https://archive.nptel.ac.in/courses/112/102/112102101/ Computer Aided Design for Engineers –AN NPTEL course
2. https://www.coursera.org/specializations/computer-aided-design

E-books:

1. http://ndl.ethernet.edu.et/bitstream/123456789/87814/3/Computer%20Aided%20Engineering%20Design%20-%20Saxena%2C%20Sahay%20%28Springer%29.pdf-Computer Aided Engineering Design by Saxena, Sahay
2. https://www.cadcim.com/catia - by Prof. Sham Tickoo

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M. Tech Mechanical Curriculum							
Course	**Advanced Fluid Mechanics and Heat Transfer**			**Code**	24PMEM201		
Course Cadre	Compulsory			**Semester**	II		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	4	-	-	**Marks**	25	25	50
Total Credits	4	-	-	**Total Marks**	100		

Prerequisites: Engineering Mathematics, Engineering Thermodynamics, Fluid Mechanics, Heat Transfer

Course Outcomes:
On completion of the course, learner will be able to
CO1: Analyze fluids as continua, analyze forces and stresses, and describe fluid motion using mathematical tools.
CO2: Analyze fluid motion by relating fluid element deformation, continuity, and mathematical tools.
CO3: Solve fluid flow problems using Navier-Stokes equations, understand boundary layer theory, and apply it to flat plates, cylinders, and lubrication.
CO4: Apply heat transfer concepts & solve 1D/2D steady-state & transient conduction problems using finite difference methods.
CO5: Analyze transient heat transfer using lumped systems, Heisler charts, and product solutions for various geometries.
CO6: Analyze convective heat transfer using empirical relations for flow geometries, predict entry lengths, and apply correlations for boiling and condensation.

Course Contents:
Unit I:
Concept of continuum and definition of a fluid. Body and surface forces, stress tensor, Scalar and vector fields, Eulerian and lagrangian approach.

Unit 2
Motion of fluid element - translation, rotation and vorticity; strain rate tensor, continuity equation, stream function and velocity potential. Transport theorems, constitutive equations

Unit 3
Derivation of Navier Stokes equations for compressible flow. flow over a flat pate, cylinders and spherical bodies, theory of hydrodynamic lubrication, Boundary layer: derivation, exact solutions, Non dimensionalization of Boundary layer equation, Blasius (similarity solution), Computational fluid dynamics: Introduction, fundamentals of numerical analysis of partial differential equations (PDE).

Unit 4

Brief introduction to different modes of heat transfer: conduction: general heat conduction equation-initial and boundary conditions. Finite difference methods for conduction: 1d & 2d steady state and simple transient heat conduction problems-implicit and explicit methods.

Unit 5

Transient heat conduction: lumped system analysis, Heisler charts, semi-infinite solid, use of shape factors in conduction, 2d transient heat conduction, product solutions.

Unit 6

Convection and Boiling: Flow over a flat plate: Application of empirical relations to variation geometries for laminar and turbulent flows. hydrodynamic & thermal entry lengths; use of empirical correlations. Approximate analysis on laminar free convective heat transfer, combined free and forced convection. Boiling curve, correlations, assumptions & correlations of film condensation for different geometries

Text Books:

1. Franck P. Incropera, David P. DeWitt – Fundamentals of Heat and Mass Transfer,
2. Y. A. Cengel and A.J. Ghajar, Heat and Mass Transfer – Fundamentals and Applications, Tata McGraw Hill Education Private Limited.
3. S.P. Sukhatme, A Textbook on Heat Transfer, Universities Press.

References:

1. Holman, Fundamentals of Heat and Mass Transfer, McGraw – Hill publication.
2. A.F. Mills, Basic Heat and Mass Transfer, Pearson.

E-content Links:

1. https://www.youtube.com/watch?v=qa-PQOjS3zA&list=PL5F4F46C1983C6785
2. https://www.youtube.com/watch?v=J_zqQcncAu4&index=3&list=PLpCr5N2IS7Nmu22MOgDWOr0sSlIpUNUz3

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M. Tech Mechanical Curriculum							
Course	**Mechanical Design Analysis**			**Code**	24PMEM202		
Course Cadre	Compulsory			**Semester**	II		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	4	-	-	**Marks**	25	25	50
Total Credits	4	-	-	**Total Marks**	100		

Prerequisites:

1. The learner should know the basics of kinematics of Mechanism.
2. The learner should be familiar with synthesis and Mechanisms of Machine

Course Objectives:

1. To explain the indirect acceleration analysis.
2. To Design Mass and Stiffness matrix and system matrices.
3. To explain various curvature theory.
4. To explain different techniques of synthesis of Mechanism.
5. To explain the analysis of Mechanisms.
6. Analysis of Special Mechanism

Course Outcomes:

On completion of the course, learner will be able to
CO1: Understand the concept of indirect acceleration analysis
CO2: Design mass and stiffness matrix and system matrices
CO3: Develop various curvature theory
CO4: Design and synthesis of different Mechanisms
CO5: Design and Analysis of different Mechanisms
CO6:

Course Contents:

Unit 1. **Complex Mechanisms** - - Types of complex mechanisms, velocity-acceleration analysis of complex mechanisms by the normal acceleration and auxiliary point methods, Goodman's indirect acceleration analysis

Unit 2. **Planar Mechanisms**- Dynamic Analysis Inertia forces in linkages, principle of super position, analysis of elastic mechanisms, beam element, displacement fields for beam element, element mass and stiffness matrices, system matrices, elastic linkage model, equations of motion.

Unit 3. **Curvature theory-** Fixed and moving centrodes, inflection circle, Euler- Savvy equation, Bobillier constructions, cubic of stationary curvature, Ball's point, applications in dwell mechanisms

Unit 4. **Synthesis of Planar Mechanisms** -Types, number and dimensional synthesis, function generation, path generation and rigid body guidance problems, accuracy (precision) points, Chebychev spacing, types of errors, graphical synthesis for function generation and rigid body guidance with two, three and four accuracy points using pole method, center point and circle point curves, Berm ester points, synthesis for five accuracy points, branch and order defects, synthesis for path generation. 6. Kinematics of Spatial Mechanisms

Unit 5. **Analytical synthesis of Planar Mechanisms-** Freudenstein's equation, synthesis for four accuracy points, compatibility condition, synthesis of four-bar for prescribed angular velocities and accelerations using complex numbers, complex numbers method of synthesis, the dyad, center point and circle point circles, ground pivot specifications, three accuracy point synthesis using dyad method, Robert Chebychev theorem, cognates

Unit 6**. Transformations describing planar finite displacements**, planar finite transformations, identity transformation, rigid-body transformations, spatial transformations Denavit-Hartenberg parameters, matrix method of analysis of spatial mechanisms

References: 1. Theory of Machines and Mechanisms, A. Ghosh and A.K.Mallik, Affiliated East-West Press.
2. Kinematic Synthesis of Linkages, R. S. Hartenberg and J. Denavit, McGraw-Hill.
3. Mechanism Design - Analysis and Synthesis (Vol.1 and 2), A. G. Erdman and G. N. Sandor, Prentice Hall
4. Theory of Machines and Mechanisms, J. E. Shigley and J. J. Uicker, 2nd Ed. McGraw-Hill.
5. Design of Machinery: An Introduction to the Synthesis and Analysis of Mechanisms and Machines, Robert L. Norton, Tata McGraw-Hill, 3rd Edition.
6. Kinematics and Linkage Design, A. S. Hall, Prentice Hall of India.

Econtent-

1. https://archive.nptel.ac.in/courses/112/105/112105125/
2. https://www.coursera.org/learn/mechanical-engineering-design-manufacturing

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M. Tech Mechanical Curriculum							
Course	**Additive Manufacturing & Tooling**			**Code**	24PMEE203A		
Course Cadre	Elective III			**Semester**	II		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	3	-	-	**Marks**	25	25	50
Total Credits	3	-	-	**Total Marks**	100		

Prerequisites:

1. The learner should know the basics of manufacturing processes.
2. The learner should be familiar with CAD Knowledge, Machining operation & tool.

Course Objectives:

1. To provide comprehensive knowledge of the wide range of additive manufacturing processes, capabilities and materials.
2. To understand the software tools and techniques used for additive manufacturing.
3. To create physical objects that facilitates product development/prototyping requirements.

Course Outcomes:

On completion of the course, learner will be able to

CO1: Acquire knowledge about the fundamentals for additive manufacturing with compare to traditional manufacturing.

CO2: Understand and use techniques for processing of CAD models for rapid Prototyping.

CO3: Understand the operating principles, capabilities, and limitations of liquid based, solid based powder based additive manufacturing system.

CO4: Understand and use techniques for processing of LOM & FDM.

CO5: Apply the proper tooling methods for rapid prototyping process.

CO6: Discover the rapid prototyping techniques for reverse engineering with different applications.

Course Contents:

Unit 1: Introduction AM&T **6 hrs**

Traditional Prototyping Vs. Rapid Prototyping (RP), Classification of Rapid Manufacturing Processes: Additive, Subtractive, Formative, Generic RP process, STL file Generation, Build File Creation, Part Construction, Part Cleaning and finishing, Process Strength and its limitations.

Unit 2: CAD Modelling and Data Processing **7 hrs**

CAD model preparation, Data interfacing: formats like STL, SLC, CLI, RPI, LEAF, IGES, HP/GL, CT, STEP, conversation; Part orientation and support generation, Support structure design, direct and adaptive slicing, Tool path generation.

Unit 3: Liquid based systems **8 hrs**

Stereo lithography apparatus (SLA): Models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, applications, advantages and disadvantages. Solid ground curing (SGC): Models and specifications, process, working, principle, applications, advantages and disadvantage, Rapid Freeze Prototyping (RFP), Solid Object Ultraviolet-Laser Printer (SOUP) process & Two Laser Beams process

Unit 4: Solid based systems **7 hrs**

Laminated object manufacturing (LOM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Case studies. Fused Deposition Modeling (FDM): Models and specifications, Process, Working principle, Applications, Advantages and disadvantages, Benchtop System: Process, Working principle, Applications. Multi-Jet Modeling System.

Unit 5: Rapid Tooling **6 hrs**

Indirect Rapid Tooling - Silicone rubber tooling, Aluminum filled epoxy tooling, Spray metal tooling, etc. Direct Rapid Tooling - Direct AIM, Quick cast process, Direct Metal Laser Sintering Tooling (DMLS) Rapid Tool, ProMetal, Laminate tooling, soft tooling vs hard tooling.

Unit 6: Additive Manufacturing Applications **8 hrs**

Design, Engineering Analysis and planning applications, Medical Applications of RP, Forensic Science and Anthropology, Arts and Architecture, Aerospace Industry, Automotive Industry, Jeweler Industry, Coin Industry etc.

Textbooks

1. Ian Gibson, David W Rosen, Brent Stucker., "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing", 2nd Edition, Springer, 2015.
2. Patri K. Venuvinod and Weiyin Ma, "Rapid Prototyping: Laser-based and Other Technologies", Springer, 2004. Research Methodology a step-by step guide for beginners, Ranjit Kumar, SAGE Publications Ltd, 3rd Edition, 2011

Reference books

1 Rapid Prototyping: A Brief Introduction, Ghosh A., Affiliated East West
2 Rapid Prototyping Technology: Selection and Application, Kenneth G. Cooper, CRC Press
3. Rapid Prototyping: Principles and Applications, Chua Chee Kai, Leong Kah Fai, Lim Chu -Sing, World Scientific
4. Rapid Prototyping theory & practice, Ali K. Kamarani, Manufacturing System Engineering Series, Springer Verlag
5. Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing, Gibson I, Rosen D W., and Stucker B, Springer
6. Rapid Prototyping: Principles and Applications in Manufacturing, Noorani R, John Wiley & Sons
7. Rapid Tooling: Technologies and Industrial Applications, Hilton P, Jacobs P F, CRC press

E-books:

1. https://mdpires.com/bookfiles/book/7329/Advanced_Manufacturing_Technology_and_Systems.pdf?v=1714352663 Advance Manufacturing Technology.
2. https://www.researchgate.net/publication/317785694_Advanced_Manufacturing_Technologies/link/594bfeccaca272ea0a914128/download?_tp=eyJjb250ZXh0Ijp7ImZpcnN0UGFnZSI6InB1YmxpY2F0aW9uIiwicGFnZSI6InB1YmxpY2F0aW9uIn19

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ME Mechanical Curriculum							
Course	**Industrial Robotics & Material handling system**			**Code**	24PMEE203B		
Course Cadre	Elective III			**Semester**	II		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	3	-	-	**Marks**	25	25	50
Total Credits	3	-	-	**Total Marks**	100		

Prerequisites:

1. Basic knowledge of mechanical engineering principles.
2. Understanding of manufacturing processes and logistics operations

Course Objectives:

1. Understand the principles and components of industrial robots.
2. Understand components of industrial robots.
3. Learn the fundamentals of robot programming and control.
4. Explore different types of material handling systems.
5. Study the integration of robotics with material handling systems.
6. Analyse case studies and real-world applications of industrial robotics and material handling systems.

Course Outcomes:

On completion of the course the learner will be able to;

CO1: Students will demonstrate knowledge of the components comprising industrial robots, including actuators, sensors, controllers, and manipulators.

CO2: Students will be able to describe the basic principles of industrial robotics, including kinematics, dynamics, and end-effector design.

CO3: Students will acquire proficiency in programming languages commonly used for industrial robots, such as teach pendant programming and robot programming languages.

CO4: Students will be able to analyse and optimize material flow in manufacturing and logistics operations.

CO5: Students will analyse the benefits of integrating robotics with material handling systems in terms of productivity, efficiency, and safety.

CO6: Students will gain practical experience through hands-on projects and case studies.

Course Contents:

Unit No.1 Introduction to Industrial Robotics **7 hrs**

Definition and history of industrial robotics, Types and classifications of industrial robots, Components and structure of industrial robots, Applications of industrial robots in manufacturing industries.

Unit No.2 Robot Kinematics and Dynamics **8 hrs**

Forward and inverse kinematics of robots, Robot motion control, Robot dynamics and trajectory planning, End-effector design and tooling.

Unit No.3 Robot Programming **7 hrs**

Programming languages for industrial robots (e.g., teach pendant, robot programming languages), Offline programming and simulation, Robot safety programming and standards Robot Vision Systems: Introduction to robot vision systems, Image processing techniques for robot vision, Integration of vision systems with industrial robots

Unit No.4 Material Handling Systems **8 hrs**

Types of material handling systems (e.g., conveyor systems, AGVs, AS/RS), Material handling equipment and components, Material flow analysis and optimization

Unit No.5. Integration of Robotics and Material Handling **7 hrs**

Automated material handling systems, Robot-assisted material handling applications, Case studies of integrated robotic material handling systems

Unit No.6 Robotics in Warehousing and Logistics **7 hrs**

Robotics applications in warehousing and distribution centres, Automated guided vehicles (AGVs) and mobile robots for logistics, Pick-and-place systems and order fulfilment automation.

Textbooks

1. "Industrial Robotics: Technology, Programming, and Applications" by Mikell P. Groover, Mitchell Weiss, Roger N. Nagel, and Nicholas G. Odrey.
2. "Introduction to Robotics: Mechanics and Control" by John J. Craig.
3. "Robotics: Control, Sensing, Vision, and Intelligence" by K.S. Fu, R.C. Gonzalez, and C.S.G. Lee.
4. "Automation, Production Systems, and Computer-Integrated Manufacturing" by Mikell P. Groover.
5. "Material Handling Systems: Designing for Safety and Health" by Charles Reese.
6. "Handbook of Material Handling Systems" by John R. Immer.

Reference Books:

1. "Robot Dynamics and Control" by Mark W. Spong and M. Vidyasagar.
2. "Fundamentals of Robotics: Analysis and Control" by Robert J. Schilling.
3. "Industrial Automation and Robotics" by A.K. Gupta and S.K. Arora.
4. "Material Handling Equipment" by Rudenko N.
5. "Principles of Robot Motion: Theory, Algorithms, and Implementations" by Howie Choset.
6. "Robot Modeling and Control" by Mark W. Spong, Seth Hutchinson, and M. Vidyasagar.

E-content Links:

1. https://onlinecourses.nptel.ac.in/noc21_me67/preview / Industrial Automation and Control–AN NPTEL course

2. https://www.coursera.org/specializations/robotics

E-books:

1. https://onlinelibrary.wiley.com/doi/book/10.1002/9780470172506 - Industrial Robotics & Material handling system
2. https://swira.se/wp-content/uploads/2023/12/The-Industrial-Robot-Book-sample.pdf

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M. Tech Mechanical Curriculum							
Course	**Alternative fuel for I.C Engines**			**Code**	24PMEE203C		
Course Cadre	Elective III			**Semester**	II		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	3	-	-	**Marks**	25	25	50
Total Credits	3	-	-	**Total Marks**	100		

Prerequisites:

1. Applied Thermodynamics.
2. IC Engines.

Course Objectives:

1. To understand Combustion process in SI and CI engines, Petroleum based liquid fuels and refining.
2. To Know and distinguish Liquid alternative fuels such as vegetable oils, biodiesel, and emulsified fuels.
3. To do analysis of lubricating oils composition and effect of alternate fuels.
4. To Compare the Gaseous alternative fuels such as hydrogen, compressed natural gas, Liquefied petroleum gas, di-methyl ether, and hythane.
5. To Learn Modern developments in IC Engines.
6. To make aware about Pollution monitoring instruments and techniques

Course Outcomes:

On completion of the course, learner will be able to Understand
CO1: Combustion process in SI and CI engines, Petroleum based liquid fuels and refining; CO2: Liquid alternative fuels such as vegetable oils, biodiesel, and emulsified fuels,
CO3: lubricating oils composition and effect of alternate fuels
CO4: Gaseous alternative fuels such as hydrogen, compressed natural gas, liquefied petroleum gas, di-methyl ether, and hythane;
CO5: Modern developments in IC Engines &
CO6: Pollution monitoring instruments and techniques

Course Contents:

Unit 1 Introduction to Alternative Fuels & SI Engine 6 hrs.

Renewable energy sources, pollutants (regulated and unregulated emissions), effect on human health, Alternative fuel for transportation sector. Introduction to fuel properties, calculation of air- fuel ratio. Petroleum refining processes. Important qualities of SI and CI engine fuels.
Combustion in SI engines, Different phases of combustion. Thermodynamic analysis of SI engine combustion, combustion efficiency and various losses. Abnormal combustion in SI engines, Fuel factors responsible for knocking.

Unit 2 CI Engine & Biofuels 8 hrs.

Combustion in CI engines. Design of engine combustion chamber for IDI and DI engines. Characteristics of common diesel combustion systems. Ignition delay, chemical delay, factors affecting delay period. Swirl, Combustion DI engine and heat release analysis, comparison of DI and IDI engine combustion chambers. Alternative fuels: environmental implication of using fossil fuels, alternative fuel factors. Introduction to biofuels, Chemistry of vegetable oils, Advantages/ Disadvantages of vegetable oils as fuels, Transesterification for biodiesel production. Performance and emission test of biodiesel, emulsified fuels

Unit 3 Engine Modifications and Adaptations, CNG, LPG. 6 hrs.

Functions of lubricating oil, Types of lubrication, Formulation of lubricating oils, Additives. Lubricating oil tribology for alternative fuelled engines, Maintenance philosophies. FTIR working principle and evaluation procedure, Causes of additive depletion, test for fuel dilution, wear measurement.

CNG, Advantages/ Disadvantages, Properties, Various CNG induction techniques. CNG performance, emissions, maintenance, LNG, unregulated emissions, Storage systems, leak detection systems and safety instrumentation.

Unit 4 Hydrogen as a Fuel 8 hrs.

Hydrogen fuelled vehicles, Hydrogen generation processes. Combustion properties & design of Hydrogen engines based on induction methods. LPG, Di-methyl ether, Hythane. Exhaust gas recirculation (EGR), Classification of EGR systems, EGR ratio, Internal and external EGR systems. HCCI, Comparison with SI & CI, Combustion in HCCI, Fuel induction strategies.

MPFI Systems, Speed density electronic multi point port fuel injection system (D-Jetronic).

Air mass flow meter system (L-Jetronic) and K-Jetronic systems.

Unit 5 Advanced Alternative Fuel Technologies 7 hrs.

Turbocharger, various systems and turbocharger controls. GDI engine, Key technical features, Two-stage mixing. Two-combustion modes, Compliance with emission standards. Optical diagnostic techniques: Fundamentals of PIV, types of LASER. PIV working principle, components and general aspects, applications, advantages, 3D and holographic PIV. Spray visualization, Phase Doppler interferometry for spray characterization. Optical engine and engine endoscopy.

Unit 6 Environmental and Regulatory Considerations 8 hrs.

Exhaust gas emission analysis, FID and NDIR. Chemiluminescense technique, smoke opacity.

Exhaust gas after-treatment, Three Way Catalysts, DOC. DPF, CRT. LNT and its working, LNT issues.Urea SCR catalyst system.

Textbooks

1. Alternate Fuels, Reda Moh. Bata, SAE Publications, 1995.
2. Alternative Fuels Guidebook, Properties, Storage, Dispensing, and Vehicle Facility Modifications, Richard L. Bechtold, SAE Publications 1997.

Reference books

1. Internal Combustion engine fundamentals: J B Heywood, Mc-Graw Hill Publications.

2. Fundamentals of internal combustion engines: Gill, Smith and Ziurys, Oxford and IBH.
3. The Internal combustion Engine in theory and practice: C F Taylor, MIT Press, Cambridge.
4. Internal Combustion Engines and Air Pollution: E F Obert, Intext Educational Publishers, NY.
5. Hydrogen Fuel for Surface Transportation: Joseph Norbeck, SAE Publications, 1996
6. Alternative Fuels Guidebook, Properties, Storage, Dispensing, and Vehicle Facility Modifications, Richard L. Bechtold, SAE Publications 1997.
7. Alternate Fuels, Reda Moh. Bata, SAE Publications, 1995.
8. Alternative Cars in the 21st Century, Robert Q. Rile, SAE Publications 1994
9. Fuels and Engines, J.C. Guibet, SAE Publications 1999.
10. Emission from Combustion engines and their control, Patterson D J and Henein N A: Ann Arbor science publishers.
11. Advanced Engine Technology: Heinz Heisler ISBN 0340568224, SAE Publications.

E-content Links:

1. https://www.combustioninstitute.org/wp-content/uploads/2019/04/Lecture-Notes_Internal-Combustion-Engines-Heat-Engines-II-Mechanical-Engineering-Faculty-UBudapest.pdf - IC Engine Fundamental
2. https://ocw.mit.edu/courses/2-61-internal-combustion-engines-spring-2017/pages/lecture-notes/ - MIT Lectures
3. https://www.lth.se/fileadmin/kcfp/SICEC/f3SICEC_Delrapport1_Fuel_properties_final.pdf - Fuel Properties

E-Books:

1. https://deewanbittal.wordpress.com/wp-content/uploads/2017/12/145914078-i-c-engines-r-k-rajput.pdf
2. https://www.intechopen.com/chapters/66638
3. https://mrcet.com/downloads/digital_notes/ME/III%20year/ALTERNATIVE%20FUELS%20FOR%20I.C.%20ENGINES.pdf

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M. Tech Mechanical Curriculum							
Course	**Numerical Methods and Computational Techniques**			**Code**	24PMEE204A		
Course Cadre	Elective IV			**Semester**	II		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	3	-	-	**Marks**	25	25	50
Total Credits	3	-	-	**Total Marks**	100		

Prerequisites:

The learner should know the system of linear equations and matrices, calculus, partial differentiation, statistics, probability, problem solving and programming

Course Objectives:

1. To Understand Fundamental Numerical Techniques.
2. Explore Advanced Computational Algorithms.
3. Apply Numerical Methods to Real-World Problems.
4. Evaluate Numerical Solutions.
5. Programming Proficiency.

Course Outcomes:

On completion of the course, learner will be able to

CO1: SOLVE system of equations using direct and iterative numerical methods. students will be able to apply numerical methods demonstrating an understanding of convergence and stability of these methods.

CO2: ESTIMATE solutions for differential equations using numerical techniques. students will be proficient in performing regression analysis effectively interpreting and analyzing data.

CO3: DEVELOP solution for engineering applications with numerical integration. Students will demonstrate competency in computing derivatives. ensuring accuracy and efficiency in calculations.

CO4: DESIGN and CREATE a model using a curve fitting and regression analysis. students will be able to compute eigenvalues and eigenvectors of matrices and apply these techniques in practical problem-solving scenarios.

CO5: APPLY statistical Technique for quantitative data analysis. students will be proficient in solving ordinary differential equations

CO6: DEMONSTRATE the data, using the concepts of probability and linear algebra.

Course Contents:

Unit 1 Linear Algebraic Equations **8 hrs.**

Gauss - Elimination, Gauss - Seidel, LU Decomposition, Solution of algebraic and transcendental equations: - Bisection Method, False position method, Newton - Raphson Method, Muller's method, Bairstow's Method, Convergence and stability

Unit 2 Regression Analysis **7 hrs.**

i) Linear regression, multiple linear regressions, polynomial regression.
ii) Non linear regression - Gauss - Newton method, multiple non linear regression.

Interpolation: Newton's Divided Difference, Lagrange's Inverse, Spline, Hermite Interpolation, Extrapolation technique of Richardson's Gaunt

Unit 3 Differentiation & Integration **7 hrs.**

Divided difference formulae, Romberg integration, Gauss quadrature for double & triple integration

Unit 4 Eigen Values & Eigen Vectors of Matrices **8 hrs.**

Faddeev- Laeverrier's method, Power Method, Householder & Given's method.

Unit 5 Ordinary differential equations **7 hrs.**

Euler's method, Heun's method, Mid - point method, Runge - Kutta methods, Multi step Methods - explicit Adams - Bashforth technique & Implicit Adams - Moulton Technique, Adaptive RK method, Embedded RK method, step size control. Higher order ODE - Shooting method. Non linear ODE - Collocation technique.

Unit 6 Partial Differential Equations **8 hrs.**

Solution of Parabolic and Hyperbolic equations -Implicit & Explicit Schemes, ADI methods, Non linear parabolic equations-Iteration method. Solution of elliptic equation - Jacobi method, Gauss - Seidel & SOR method. Richardson method.

Text books

1. 'Numerical Methods for Engineers', by Steven C. Chapra and Raymond P. Canale, McGraw-Hill Education, 2014, 7th Edition
2. 'Applied Numerical Methods with MATLAB for Engineers and Scientists', by Steven C. Chapra, McGraw-Hill Education, 2017, 4th Edition
3. 'Numerical Methods: Problems and Solutions', by M.K. Jain, S.R.K. Iyengar, and R.K. Jain, New Age International Publishers, 2007, 2nd Edition
4. 'An Introduction to Numerical Methods and Analysis', by James F. Epperson, Wiley, 2013, 2nd Edition
5. 'Numerical Methods for Engineers and Scientists', by Joe D. Hoffman and Steven Frankel, CRC Press, 2018, 3rd Edition
6. 'Numerical Methods for Engineering Applications', by Joel H. Ferziger, Wiley, 1998, 2nd Edition

Reference books

1. 'Numerical Methods in Engineering with Python', by Jaan Kiusalaas, Cambridge University Press, 2013, 3rd Edition.
2. 'Numerical Analysis', by Richard L. Burden and J. Douglas Faires, Cengage Learning, 2015, 10th Edition.

3. 'Introduction to Numerical Analysis', by Josef Stoer and Roland Bulirsch, Springer, 2002, 3rd Edition.
4. 'Numerical Recipes: The Art of Scientific Computing', by William H. Press, Saul A. Teukolsky, William T. Vetterling, and Brian P. Flannery, Cambridge University Press, 2007, 3rd Edition.
5. 'Fundamentals of Engineering Numerical Analysis', by Parviz Moin, Cambridge University Press, 2010, 2nd Edition.
6. 'Advanced Engineering Mathematics', by Erwin Kreyszig, Wiley, 2011, 10th Edition.

E-content Links:

1. https://archive.nptel.ac.in/courses/127/106/127106019/
2. https://archive.nptel.ac.in/courses/111/107/111107105/

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M. Tech Mechanical Curriculum							
Course	**Condition based Monitoring**			**Code**	24PMEE204B		
Course Cadre	Elective IV			**Semester**	II		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	3	-	-	**Marks**	25	25	50
Total Credits	3	-	-	**Total Marks**	100		

Prerequisites: Dynamics of Machinery

Course Objectives:

Course Outcomes:
On completion of the course, learner will be able to
CO1: Understand the types of maintenance used and its significance, role of condition based maintenance in industries.
CO2: Familiarize with different condition monitoring techniques and its advantages in industries.
CO3: Implement the basic signal processing techniques.
CO4: Understand the role of vibration monitoring, its methodology and its use in condition monitoring of rotating and reciprocating machines.
CO5: - Understand the significance of mechanical fault diagnosis and non-destructive testing techniques in monitoring and maintenance.
CO6: Study condition monitoring of rolling element bearing, gears and tool condition monitoring techniques in machining.

Course Contents:

Unit 1 **5 hrs.**
Introduction to maintenance and condition based maintenance Definition, system approach, objectives, responsibilities of maintenance department, maintenance strategies, principles of maintenance, concepts of maintainability, availability and reliability.

Unit 2 **6 hrs**
Introduction to condition monitoring Basic concept, Implementation of CBM, comparison of CBM with other maintenance techniques and case studies (overview). techniques - visual monitoring, temperature monitoring, vibration monitoring, lubricant monitoring, crack monitoring, thickness monitoring, noise and sound monitoring.

Unit 3 **7 hrs**
Basic signal processing techniques Probability distribution and density, Fourier analysis, Hilbert Transform, Cepstrum analysis, Digital filtering, Deterministic/random signal separation, Time frequency analysis. Wavelet Transform Introduction to Wavelets, Continuous Wavelet Transform (CWT), Discrete Wavelet Transform (DWT), Wavelet Packet Transform (WPT), types of wavelets – Haar wavelets, Shannon wavelets, Meyer wavelets, Daubechies wavelets, Coifmann wavelets and applications of wavelets.

Unit 4 **7 hrs**

Vibration Monitoring Introduction, vibration data collection, techniques, instruments, transducers, selection, measurement location, time domain analysis, frequency domain analysis, time-frequency domain analysis and commonly witnessed machinery faults diagnosed by vibration analysis. Rotating and reciprocating machines Vibration signals from rotating and reciprocating machines – signal classification, signals generated by rotating machines, signals generated by reciprocating machines.

Unit 5 **6 hrs**

Mechanical fault diagnosis Wear monitoring and lubricant analysis - sources of contamination, techniques, Spectrometric Oil Analysis Procedure (SOAP) and ferrography. Nondestructive testing techniques Measurement of surface and subsurface flaws – liquid penetrant inspection, eddy current inspection, radiographic inspection, ultrasonic inspection.

Unit 6 **5 hrs**

Condition monitoring of rolling element bearings and gear Introduction, construction, types of faults, rolling element bearing diagnostics and gear diagnostics. Tool wear monitoring Introduction, techniques and case studies.

Textbooks

1. Robert Bond Randall – Vibration-Based Condition Monitoring – Industrial, Aerospace and Automotive applications, John Wiley & Sons Ltd., 2011
2. R.A.Collacot – Mechanical Fault Diagnosis – Chapman and Hall Ltd., 1977.
3. ISTE Course material on Condition Monitoring.
4. R.C.Mishra, K.Pathak – Maintenance Engineering and Management, Prentice Hall of India Pvt. Ltd., 2002.
5. K. P. Soman, K. I. Ramachandran, N. G. Resmi – Insight into wavelet from theory to practice, Third Edition, Prentice Hall of India, ISBN: 978-81-203-4053-4
6. Amiya R Mohanty-Machinery Condition Monitoring: Principals and Monitoring,CRC press Taylor and Francis Group.

Reference books

1.Dr. K.Balaveera Reddy, ISTE Summer School on Machinery Diagnostics and Preventive Maintenance, KREC, Surathkal, June 19-25, 1995.
2. Dr. A.Ramachandra, ISTE-STTP on Maintenance of Machinery, SJCE, Mysore, June 18-31, 2000.
3. John S.Mitchell, Introduction to Machinery Analysis and Monitoring, Penn Well Books, 1993.

E-content Links:

1. https://archive.nptel.ac.in/courses/112/105/112105232/
2. https://nptel.ac.in/courses/112105048

E-books:

1. https://perpus.univpancasila.ac.id/repository/EBUPT200305.pdf Machinery condition Monitoring: Principals and Practice by A.R.Mohanty

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M. Tech Mechanical Curriculum							
Course	**Refrigeration and cryogenics**			**Code**	24PMEE204C		
Course Cadre	Elective IV			**Semester**	II		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	3	-	-	**Marks**	25	25	50
Total Credits	3	-	-	**Total Marks**	100		

Prerequisites:

1. The learner should have known basics of thermodynamics.
2. The learner should be familiar devices learnt in applied Thermodynamics.
3. The learner should have prior knowledge Heat transfer and, condensation and boiling, heat exchanger.
4. The learner should have known basics of fluid properties, fluid dynamics.

Course Objectives:

1. This course will enable the students to learn concepts of refrigeration and refrigeration systems.
2. This course will enable the students to learn refrigerants, and different types of refrigeration equipment's.
3. This course will enable the students to learn properties of cryogenic systems, cryogenic cycles.

Course Outcomes:

On completion of the course, learner will be able to
CO1: Understand the basics of refrigeration and cryogenics
CO2: Know the developments in refrigeration and cryogenics
CO3: Learn about ODP, GWP and related environment issues.
CO4: Analyze various refrigeration systems for thermal performance.
CO5: Evaluate the performance of various refrigeration systems.
CO6: Design the refrigeration systems for domestic and industrial applications

Course Contents:

Unit 1 Fundamentals of Refrigeration 6 hrs.

fundamental methods of refrigeration, Vapour compression refrigeration cycle, Representation on P-h, T-s diagram, actual VCR cycle, second law efficiency and COP.

Unit 2 Multistage Systems and Analysis 7 hrs.

Multistage compression with inter-cooling, Multi-evaporator systems, Cascade systems, Concept of Heat Pump.

Refrigeration applications: Industrial Refrigeration, Chemical and process industries, Dairy plants, Petroleum refineries, Food preservation, Transport, etc.

Unit 3 Refrigerants 6 hrs.
Refrigerants & their nomenclature, types and properties. Primary & Secondary refrigerants, Alternative eco-friendly refrigerants and their properties, Refrigerant-lubricant mixture behavior, Blending of refrigerants, ODP, GWP concepts, CFC/HCFC phase-out regulations,
Montreal and Kyoto Protocols.

Unit 4 Refrigeration Equipment's 7 hrs.
Performance characteristics and capacity control of reciprocating and centrifugal compressors, screw compressor and scroll compressor, Design, selection of evaporators, condensers, control systems, motor selection.

Unit 5 Introduction to Cryogenics Engineering 7 hrs.
Introduction to Cryogenics Systems – Mechanical Properties at low temperatures – Properties of cryogenic fluids. Gas Liquefaction: Minimum work for liquefaction – Methods to produce low temperature – Liquefaction systems for gases other than Neon, Hydrogen and Helium.

Unit 6 Cryogenics cycles and Applications 5 hrs.
Carnot Liquefaction Cycle, Linde Hampson Cycle, Precooled Linde Hampson Cycle, Claudes Cycle Dual Cycle, Critical Components in Liquefaction Systems. J. T. Cryocoolers, Stirling Cycle Refrigerators, G.M.Cryocoolers, Pulse Tube Refrigerators.

Textbooks

1. R.J. Dossat: Principles of Refrigeration, Pearson Education Asia, 2001.
2. C. P. Arora: Refrigeration & Air-Conditioning, Tata McGraw Hill, Third Edition, 2004.
3. Manohar Prasad: Refrigeration & Air-Conditioning, New Age Intl. Publications, Third edition, 2010.
4. R. Barron: Cryogenic systems, McGraw–Hill Company, New York, 1985.

Reference books

1. Stoecker & Jones: Refrigeration and Air-conditioning, McGraw Hill Book Company, New York, 1982.
2. Jordan & Priester: Refrigeration & Air Conditioning, Prentice-Hall India, Second edition, 1973.
3. W.F.Stoecker: Industrial Refrigeration Handbook, McGraw-Hill, 1998.
4. A.R.Trott: Refrigeration and Air-conditioning", Butterworths, 2000.
5. P.C.Koelet: Industrial Refrigeration: Principles, Design and Applications, Macmillan, 1992.
6. ASHRAE HANDBOOKS (i) Fundamentals (ii) Refrigeration.
7. Graham Walker: Miniature Refrigerators for Cryogenic Sensors and Cold Electronics, Clarendon Press, 1989.
8. Robert W. Vance, Cryogenic Technology, John wiley& Sons, Inc., New York, London.

E-content Links:

1. http://nptel.ac.in/courses/112105128/

2. http://nptel.ac.in/downloads/112105129/
3. http://nptel.ac.in/courses/112107208/
4. http://www.emersonclimate.com/en-US/Brands/Vilter/Pages/brochure.aspx
5. https://www.beestarlabel.com/

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M. Tech Mechanical Curriculum							
Course	**Advanced Optimization Techniques**			**Code**	24PMEM301		
Course Cadre	Compulsory			**Semester**	III		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	4	-	-	**Marks**	25	25	50
Total Credits	4	-	-	**Total Marks**	100		

Prerequisites:

1. The learner should know basic knowledge of calculus.
2. The learner should be familiar with basic understanding of linear algebra
3. The learner should be familiar with fundamental engineering principles.

Course Objectives:

1. To introduce the basic concepts of optimization.
2. To develop foundational problem-solving skills using optimization techniques.
3. To understand linear and nonlinear optimization methods.
4. To apply optimization techniques to simple mechanical engineering problems.
5. To familiarize students with optimization algorithms.
6. To provide practical experience with optimization tools.

Course Outcomes:

On completion of the course, learner will be able to

CO1: Understand the fundamental principles of optimization.

CO2: Formulate and solve basic linear and nonlinear optimization problems.

CO3: Apply optimization techniques to real-world mechanical engineering problems.

CO4: Use basic optimization algorithms effectively.

CO5: Employ software tools for solving optimization problems.

CO6: Interpret and analyze optimization results.

Course Contents:

Unit 1 Introduction to Optimization **6 hrs.**

Definition and scope of optimization , Types of optimization problems, Applications in mechanical engineering ,Basic terminology

Unit 2 Linear Programming **7 hrs.**

Formulation of linear programming problems, Graphical method, Simplex method basics, Applications in mechanical engineering

Unit 3 Unconstrained Optimization **6 hrs.**

Introduction to unconstrained optimization, Gradient-based methods, Newton's method, Applications in mechanical engineering

Unit 4 Constrained Optimization **8 hrs.**

Introduction to constrained optimization, Lagrange multipliers, Simple constrained optimization techniques, Applications in mechanical engineering

Unit 5 Integer Programming and Dynamic Programming **7 hrs.**

Basics of integer programming, Simple integer programming methods ,Introduction to dynamic programming, Applications in mechanical engineering

Unit 6 Optimization Tools and Case Studies **8 hrs.**

Introduction to optimization software (MATLAB, Excel Solver, etc.), Simple case studies in mechanical engineering optimization, Practical sessions with optimization software , Analysis and interpretation of results

Textbooks

1. 'Engineering Optimization: Theory and Practice', by S.S. Rao, Wiley, 2009, 4th Edition.
2. 'Optimization for Engineering Design: Algorithms and Examples', by Kalyanmoy Deb, PHI Learning, 2012, 2nd Edition.
3. 'Introduction to Optimum Design', by Jasbir Arora, Elsevier, 2016, 4th Edition.
4. 'Linear Programming and Network Flows', by Mokhtar S. Bazaraa, John J. Jarvis, and Hanif D. Sherali, Wiley, 2009, 4th Edition.
5. 'Nonlinear Programming: Theory and Algorithms', by Mokhtar S. Bazaraa, Hanif D. Sherali, and C.M. Shetty, Wiley, 2006, 3rd Edition.
6. 'Optimization Techniques: An Introduction', by L.R. Foulds, Springer, 1981, 1st Edition.

Reference books

1. 'Practical Optimization', by Philip E. Gill, Walter Murray, and Margaret H. Wright, Academic Press, 1981, 1st Edition.
2. 'Optimization in Operations Research', by Ronald L. Rardin, Prentice Hall, 1997, 1st Edition.
3. 'Convex Optimization', by Stephen Boyd and Lieven Vandenberghe, Cambridge University Press, 2004, 1st Edition.
4. 'Applied Optimization with MATLAB Programming', by P. Venkataraman, Wiley, 2001, 1st Edition.
5. 'Optimization Techniques in Engineering', by R.S. Rao, New Age International Publishers, 1998, 1st Edition.

6. 'Operations Research: An Introduction', by Hamdy A. Taha, Pearson, 2016, 10th Edition**.**

E-content Links:

1. **https://nptel.ac.in/courses/111105039**

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M. Tech Mechanical Curriculum							
Course	**Modeling and Simulation**			**Code**	24PMEE302A		
Course Cadre	Elective V			**Semester**	III		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	4	-	-	**Marks**	25	25	50
Total Credits	4	-	-	**Total Marks**	100		

Prerequisites:

1. The learner should have understanding of Modeling and Simulation
2. The learner should be familiar with Modeling and Simulation

Course Objectives:

1. Define the basics of simulation modeling and replicating the practical situations in organizations
2. Generate random numbers and random variates using different techniques.
3. Develop simulation model using heuristic methods.
4. Analysis of Simulation models using input analyzer, and output analyzer
5. Explain Verification and Validation of simulation model.

Course Outcomes:

On completion of the course, learner will be able to

CO1: Describe the role of important elements of discrete event simulation and modeling paradigm.

CO2: Conceptualize real world situations related to systems development decisions, originating from source requirements and goals.

CO3: Develop skills to apply simulation software to construct and execute goal-driven system models.

CO4: Interpret the model and apply the results to resolve critical issues in a real world environment.

CO5: Understand the selection of correct software

CO6: Apply modeling & simulation Process on different manufacturing system & service oprations.

Course Contents:

Unit – I **06 Hrs**

Introduction to Simulation: Simulation, Advantages, Disadvantages, Areas of application, System environment, components of a system, Model of a system, types of models, steps in a simulation study.

Simulation Examples: Simulation of Queuing systems, Simulation of Inventory System, Other simulation examples.

Unit – II **07Hrs**

General Principles: Concepts in discrete - event simulation, event scheduling/ Time advance algorithm, simulation using event scheduling
Random Numbers: Properties, Generations methods, Tests for Random number- Frequency test, Runs test, Autocorrelation test.

Unit – III **07Hrs**
Random Variate Generation: Inverse Transform Technique- Exponential, Uniform, Weibull, Triangular distributions, Direct transformation for Normal and log normal Distributions, convolution methods- Erlang distribution, Acceptance Rejection Technique
Optimisation Via Simulation: Meaning, difficulty, Robust Heuristics, Random Search.

Unit – IV **07Hrs**
Analysis of Simulation Data
Input Modelling: Data collection, Identification and distribution with data, parameter estimation, Goodness of fit tests, Selection of input models without data, Multivariate and time series analysis. **Verification and Validation of Model –** Model Building, Verification, Calibration and Validation of Models.

Unit – V **07Hrs**
Output Analysis – Types of Simulations with Respect to Output Analysis, Stochastic Nature of output data, Measures of Performance and their estimation, Output analysis of terminating simulation, Output analysis of steady state simulations.

Unit – VI **06Hrs**
Simulation Softwares: Selection of Simulation Software, Simulation packages, Trend in Simulation Software. Simulation of Manufacturing process & Service Operation

REFERENCE BOOKS

1 Jerry Banks, John S Carson, II, Berry L Nelson, David M Nicol, Discrete Event system Simulation, Pearson Education, Asia, 4th Edition, 2007, ISBN: 81-203-2832-9.

2 Geoffrey Gordon, System Simulation, Prentice Hall publication, 2nd Edition, 1978, ISBN: 81-203-0140-4.

3. Averill M Law, W David Kelton, Simulation Modelling & Analysis, McGraw Hill International Editions – Industrial Engineering series, 4th Edition, ISBN: 0-07-100803-9.

4. Narsingh Deo, Systems Simulation with Digital Computer, PHI Publication (EEE), 3rd Edition, 2004, ISBN : 0-87692-028-8

E- Content link

https://youtu.be/AKhN-dBoBjM?feature=shared

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https://youtu.be/jyXgDUjBSio?feature=shared

https://youtu.be/6K2NCO8ufVY?feature=shared

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ME Mechanical Curriculum							
Course	**Computational Fluid dynamics**			**Code**	24PMEME302B		
Course Cadre	Elective V			**Semester**	III		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	3	-	-	**Marks**	25	25	50
Total Credits	3	-	-	**Total Marks**	100		

Prerequisites:
1. Heat transfer
2. Fluid mechanics.
3. Numerical Methods

Course Objectives:
1. To teach fundamentals of computational method for solving non-linear partial differential equations (PDE) primarily in complex geometry.
2. The emphasis of the course is to teach CFD techniques for solving incompressible N-S equation.
3. The emphasis of the course is to teach CFD techniques for solving Compressible N-S equation in primitive variables.
4. FVM equations for Heat Conduction & Convection.
5. Grid generation in complex geometry, transformation of N-S equation in curvilinear coordinate system.
6. Introduction to turbulence modelling

Course Outcomes:
On completion of the course, learner will be able to
CO1: Understand and use different discretization & iteration technique.
CO2: find solutions to Incompressible flow.
CO3: formulation of solution for Compressible flow.
CO4: Solve Heat Conduction & convection equation
CO5: Grid generation for any Geometry.
CO6: Understand to use turbulence models.

Course Contents:

Unit 1 Introduction to CFD Techniques 6 hrs.
Brief introduction of boundary layer flow, incompressible and compressible flows, finite difference and finite volume method, example of parabolic and hyperbolic systems and time discretization technique, explicit and implicit methods, upwind and central difference schemes, stability, dissipation and dispersion errors.
Point iterative/block iterative methods, Gauss-Seidel iteration (concept of central coefficient and residue, SOR), CGS, Bi-CGSTAB and GMRES (m) matrix solvers, different acceleration techniques.

Unit 2 Incompressible Flow 8 hrs.

Higher order upwind schemes: second order convective schemes, QUICK.
Solution of NS equations: Solution of incompressible N-S equation (Explicit time stepping, Semi–explicit time stepping).
SMAC method for staggered grid: Predictor - Corrector step, discretization of N-S and continuity equations, Pressure correction Poisson's equation, boundary conditions (no-slip, moving wall, slip boundary and inflow conditions), outflow (zero gradient/Orlanski) boundary conditions for unsteady flows, algorithm for the SMAC method, stability considerations for SMAC method.
SMAC method for collocated grid: Pressure–velocity coupling, N- S equations on a collocated grid, concept of momentum interpolation to avoid pressure velocity decoupling, discretization of governing equations using the concept of momentum interpolation.

Unit 3 Compressible flow 6 hrs.

N-S and energy equations, properties of Euler equation, linearization.
Solution of Euler equation: Explicit and implicit treatment such as Lax-Wendroff, MacCormark, Beam and Warming schemes, Upwind schemes for Euler equation: Steger and Warming, Van Leer's flux splitting, Roe's approximate Riemann solver, TVD schemes.
Solution of N-S equations: MacCormack, Jameson algorithm in finite volume formulation and transformed coordinate system.

Unit 4 Heat Conduction & Convection equation 6 hrs.

Finite volume discretization of Heat Conduction equation, Solving 2D Heat Equation with Dirichlet and Neumann boundary conditions. Finite volume discretization of Convection/diffusion equations. Solving 2D energy equation with prescribed velocity field

Unit 5 Grid System & Uncertainties. 6 hrs.

Historical aspects of the various grids, Body fitted grids in complex geometries, orthogonal grids, mapping functions, staggered/collocated and structured/unstructured, various methods of grid generations (Algebraic, Transfinite, Poisson equation methods).
Sources of uncertainties, studies on grid independence, time-step independence, domain independence, initial condition dependence.

Unit 6 Turbulence Modelling 6 hrs.

Introduction to Turbulence, scales of turbulence, Reynolds Averaged Navier Stokes (RANS) equation, closure problem, eddy viscosity model, k-ε and k-ω model, introduction to large eddy simulation (LES) and direct numerical simulation.

Textbooks

1. J. C. Tannehill, D. A. Anderson and R. H. Pletcher, Computational Fluid Mechanics and Heat Transfer, Taylor & Francis, 1997.
2. J. H. Ferziger and M. Peric, Computational Methods for Fluid Dynamics, Springer, 2002.
3. Zikanov. O., Essential Computational Fluid Dynamics, Wiley 2010

Reference books

1. J. D. Anderson, "Computational Fluid Dynamics", McGraw-Hill Inc. (1995).
2. S. V. Patankar, "Numerical Heat Transfer and Fluid Flow", Hemisphere Pub. (1980).
3. K. Muralidhar, and T. Sundarajan, "Computational Fluid Flow and Heat Transfer", Narosa (2003).
4. D. A. Anderson, J. C. Tannehill and R. H. Pletcher, "Computational Fluid Mechanics and Heat Transfer", Hemisphere Pub. (1984).
5. H. K. Versteeg and W. Malalaskera, "An Introduction to Computational Fluid Dynamics", Dorling Kindersley (India) Pvt. Ltd. (2008).
6. C. Hirsch, "Numerical Computation of Internal and External Flows", Butterworth-Heinemann, (2007).
7. K.Muralidhar and T. Sundararajan, Computational Fluid Flow and Heat Transfer, Narosa Publishing House, 1995.
8. Computational Fluid Dynamics, Chung T. J., Cambridge University Press, 2003.
9. S. B. Pope, Turbulent Flows, Cambridge University Press, 2000.
10. Pierre Sagaut, Large Eddy Simulation for Incompressible Flows, Springer, 1998.
11. Tapan K. Sengupta, Fundamentals of Computational Fluid Dynamics, Universities Press, 2004.
12. J. H. Ferziger, Numerical Methods for Engineering Application, John Wiley & Sons,1998

E-content Links:

1. https://onlinecourses.nptel.ac.in/noc20_ch05/preview
2. https://www.cranfield.ac.uk/courses/taught/computational-fluid-dynamics

E-books:

1. https://www.airloads.net/Downloads/Textbooks/Computational-Fluid-Dynamics-the-Basics-With-Applications-Anderson-J-D.pdf

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M. Tech Mechanical Curriculum							
Course	**Finite Element Method**			**Code**	24PMEME302C		
Course Cadre	Elective V			**Semester**	III		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	4	-	-	**Marks**	25	25	50
Total Credits	4	-	-	**Total Marks**	100		

Prerequisites: Proficiency in calculus, linear algebra, and differential equations, Basic knowledge of mechanics and numerical methods.

Course Objectives:

1. Understand the mathematical principles and theoretical foundations of the Finite Element Method (FEM).
2. Develop proficiency in formulating and solving engineering problems using FEA.
3. Explore advanced topics in finite element analysis, including nonlinearities and Multiphysics simulations.
4. Gain hands-on experience in using commercial FEA software for modeling and analysis.
5. Apply FEA techniques to solve practical engineering problems encountered in various disciplines.
6. Analyze and interpret finite element analysis results critically.

Course Outcomes:

On completion of the course the learner will be able to;

CO1: Demonstrate comprehension of the mathematical principles underlying the Finite Element Method, including variational principles and numerical integration techniques.

CO2: Develop skills in discretizing complex engineering domains into finite elements and generating quality meshes.

CO3: Explore advanced topics such as material nonlinearity, geometric nonlinearity, and Multiphysics simulations in FEA.

CO4: Develop proficiency in model setup, boundary conditions specification, and result interpretation using FEA software tools.

CO5: Demonstrate the ability to critically evaluate FEA results and make informed engineering decisions based on analysis outcomes.

CO6: Analyze and interpret finite element analysis results to assess the structural integrity, thermal performance, fluid flow behaviour, and other engineering parameters.

Unit No.1 Introduction to Finite Element Analysis 6 hrs.

Overview of FEA principles and applications, Mathematical foundations of the Finite Element Method (FEM), Variational principles and weak form formulation, Overview of commercial FEA software packages

Unit No. 2 Finite Element Modeling and Mesh Generation 6 hrs.

Discretization techniques and element types, Mesh generation strategies and quality assessment, Model setup, boundary conditions, and material properties

Unit No. 3 Advanced FEA Techniques **6 hrs.**
Nonlinear analysis: material and geometric nonlinearities, Contact mechanics and frictional contact modeling, Dynamic analysis: modal analysis and transient dynamics, Multiphysics simulations: thermal-structural, fluid-structure interaction

Unit No. 4 FEA Software Applications **6 hrs.**
Introduction to commercial FEA software (e.g., ANSYS, Abaqus, COMSOL), Hands-on sessions: software interface, model creation, and result interpretation, Case studies: modeling complex engineering systems and components

Unit No. 5 Practical Engineering Applications **6 hrs.**
Structural analysis: static and dynamic loading conditions, Thermal analysis: heat transfer and thermal stress analysis, Fluid flow analysis: steady-state and transient simulations, Case studies

Unit No. 6 Result Interpretation and Validation **6 hrs.**
Post-processing techniques: visualization and data analysis, Validation of finite element models: comparison with experimental data and analytical solutions, Sensitivity analysis and uncertainty quantification

Textbooks

1. "Finite Element Analysis: Theory and Application with ANSYS" by Saeed Moaveni.
2. "Introduction to Finite Element Analysis Using MATLAB and Abaqus" by Amar Khennane.
3. "Fundamentals of Finite Element Analysis" by David V. Hutton.
4. "Finite Element Procedures" by Klaus-Jürgen Bathe.
5. "Practical Finite Element Analysis" by Nitin S. Gokhale.

Reference Books:

1. J. N. Reddy, An introduction to the Finite Element Method, 3rd edition, McGraw-Hill, 2006.
2. R. D. Cook, D. S. Malkus and M. E. Plesha, Concepts and Applications of Finite Element Analysis, 4th edition, John Wiley, 2007.
3. K. J. Bathe, Finite Element Procedures in Engineering Analysis, 2nd edition (reprint), Prentice-Hall, 2009.
4. T. J. R. Hughes, The Finite Element Method, Prentice-Hall, 1986.
5. O. C. Zienkiewicz and R. L. Taylor, The Finite Element Method, 7th edition, Butterworth-Heinemann, 2013.

E-content Links:

1. https://archive.nptel.ac.in/courses/112/104/112104193/ NPTEL course
2. https://www.coursera.org/learn/finite-element-analysis

E-books:

1. https://link.springer.com/book/10.1007/978-981-19-7989-7-Introduction to Finite Element Analysis
2. https://www.engr.uvic.ca/~mech410/lectures/FEA_Theory.pdf- Introduction to Finite Element Analysis

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M. Tech Mechanical Curriculum							
Course	**Industrial Safety**			**Code**	24PMEO303A		
Course Cadre	Open Elective			**Semester**	III		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	4	-	-	**Marks**	25	25	50
Total Credits	4	-	-	**Total Marks**	100		

Prerequisites:

1. Basic knowledge of mechanical engineering concepts.
2. Understanding of workplace hazards and their potential consequences.
3. Familiarity with safety protocols and regulations.

Course Objectives:

1. To understand the importance of industrial safety in mechanical engineering practices.
2. To identify various workplace hazards and assess associated risks.
3. To implement preventive measures and safety protocols to mitigate workplace accidents.
4. To comprehend the legal and ethical aspects of industrial safety.
5. To promote a culture of safety awareness and proactive risk management.
6. To apply theoretical knowledge to real-world scenarios through case studies and practical exercises.

Course Outcomes:

On completion of the course, learner will be able to

CO1: Identify and analyze potential hazards in industrial environments.
CO2: Develop strategies to mitigate workplace risks and ensure employee safety.
CO3: Understand and comply with relevant safety regulations and standards.
CO4: Demonstrate effective communication skills in conveying safety protocols and procedures.
CO5: Implement risk assessment techniques to minimize the occurrence of accidents.
CO6: Evaluate and propose improvements to existing safety systems within industrial settings.

Course Contents:

Unit 1 Introduction to Industrial Safety **6 hr**

Overview of industrial accidents and their impact, Importance of safety regulations and standards, Role of mechanical engineers in ensuring workplace safety, Objectives and advantages of Industrial Safety

Unit 2: Hazard Identification and Risk Assessment **6 hr**

Types of workplace hazards (mechanical, electrical, chemical, etc.), Methods for identifying and evaluating workplace risks, Risk factors, Risk management strategies and control measures

Unit 3: Safety Management Systems **6 hr**

Concept and component of Management System, Development and implementation of safety policies and procedures, Roles and responsibilities of safety officers and management, Safety audits and inspections.

Unit 4: Emergency Preparedness and Response **6 hr**

Planning and preparedness for emergency situations, Emergency response protocols and procedures, Training in first aid and CPR, Phases of Emergency Management, Steps in emergency action plan

Unit 5: **Safety in Mechanical Engineering Processes** **6 hr**

Safe handling of machinery and equipment, Prevention of mechanical failures and accidents, Lockout/tag out procedures and machine guarding

Unit 6 : Case Studies and Best Practices **6 hr**

Analysis of real-life industrial accidents and their causes, Study of successful safety initiatives and programs, Application of best practices to improve workplace safety

Textbooks

1. "Introduction to Industrial and Systems Engineering" by Wayne C. Turner, Steve Schneider, and Robert A. Muenchen
2. "Industrial Safety and Health Management" by C. Ray Asfahl and David W. Rieske
3. "Safety and Health for Engineers" by Roger L. Brauer
4."Occupational Safety and Health for Technologists, Engineers, and Managers" by David L. Goetsch and Eugene R. Rinehart

Reference books

1. "Industrial Safety Management" by David Collins

2. "Industrial Safety and Health for Infrastructure Services" by Charles D. Reese
3. "Occupational Safety and Health for Technologists, Engineers, and Managers" by David L. Goetsch and Eugene R. Rinehart
4. "Safety Engineering Principles and Practices" by Frank R. Spellman and Revonna M. Bieber

E-content Links:

1. https://onlinecourses.nptel.ac.in/noc20_mg43
2. https://onlinecourses.nptel.ac.in/noc22_mg55

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M. Tech Mechanical Curriculum							
Course	**Business Analytics**			**Code**	24PMEO303B		
Course Cadre	Open Elective			**Semester**	III		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
	4	-	-	**Marks**	25	25	50
Total Credits	4	-	-	**Total Marks**	100		

Prerequisites:

4. The learner should have known basics of financial aspects.
5. The learner should be familiar with business processes and it's in and out.

Course Objectives:

Business Analysis for Engineers provides an opportunity for engineering students to understand the language of business both in financial and strategic dimensions. At the end of the course, a student will be able to

1. gain knowledge on basic concepts of accounting & costing,
2. introductory economics,
3. various corporate strategy tools
4. organizational behavior.
5. Stocks market analysis

Course Outcomes:

On completion of the course, learner will be able to

CO1: Understand business analytics in step by step approach

CO2: Understand and apply laws of economics.

CO3: Analyze the financial statements

CO4: Understand needs of different business functions

CO5: Evaluate the stocks and Bond market

CO6: Apply strategies in business analytics

Course Contents:

Unit 1 **Introduction to Economy** **7 hrs**

Macro and Microeconomics fundamentals, Demand & Supply, Pricing, Types of Markets
Macro/Micro economic indicators, Indian Budget - Overview

Unit 2 Introduction to Costing 8 hrs

Introduction to financial statements, Fundamental Accounting concepts – Dual entry concept and other accounting entries, Preparation of financial statements – B/S, I/S and Cash Flow, Analysis of financial statements, Types of costs – Economies of scale – Variances, Need for cost competitiveness – case studies for discussions

Unit 3 Business and Organization 7 hrs

Business functions, Role of each function, Organizations – Organizational structures
Types of organizations, Issues in handling complexities

Unit 4 Introduction to Strategy 8 hrs

What is strategy, Need for Strategy, Vision and Mission, Porter's Diamond framework
Porter's 5–forces, McKinsey's 7S Model, BCG Matrix, Value chain analysis
Case studies and discussions

Unit 5 Valuation of Bonds and Stocks 7 hrs

Bond Valuation-Bond Yields-Bond Market, Valuation of Preference Stock, Equity Valuation: Dividend Discount Model, The P/E Ratio Approach - The Relationship between Earnings-Price

Unit 6 Financial Analytics 7 hrs

Forecasting in Practice. Subjective Forecasting, Business Forecasting and Time Series
Introduction to Financial Analytics, Forecasting Performance Measurements: Distance
Forecasting Performance Measurements

Textbooks

1. Accounting Principles – Robert Anthony & James Reece, IR WIN, 2001
2. Competitive Strategy – Techniques for Analyzing Industries and
3. Competitors Michael E Porter, Free Press.
4. Competitive Advantage of Nations – Michael E. Porter, Free Press
5. Economics & Public Policy – Romulo Neri, AIM Publications, 2001

Reference books

1. Textbooks: Financial Analytics with R: Building a Laptop Laboratory for Data Science Book by Dirk L. Hugen and Mark Joseph Bennet
2. Quantitative Financial Analytics: The Path To Investment Profits Book by Edward E. Williams and John A. Dobelman
3. Financial Modeling and Valuation: A Practical Guide to Investment Banking and Private Equity, Book by Paul Pignataro

E-content Links:

3. https://archive.nptel.ac.in/courses/110/106/110106050/ Business Analytics for Engineers – AN NPTEL course
4. https://www.coursera.org/learn/business-analytics-bbva

E-books:

3. https://nibmehub.com/opac-service/pdf/read/Business%20Analysis.pdf - Business Analysis 3rd Edition by Paul and Cadle
4. https://www.simplilearn.com/business-analytics-basics-beginners-guide-pdf - Business Analytics Basics: A Beginner's Guide

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ME Mechanical Curriculum							
Course	**Operation Research**			**Code**	24PMEO303C		
Course Cadre	Open Elective			**Semester**	III		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	4	-	-	**Marks**	25	25	50
Total Credits	4	-	-	**Total Marks**	100		

Prerequisites:

1. Basic knowledge of calculus and algebra.
2. Familiarity with basic mechanical engineering concepts.
3. Understanding of probability and statistics.

Course Objectives:

1. To introduce the fundamental concepts and techniques of operations research.
2. To develop the ability to model complex mechanical engineering problems.
3. To provide students with the skills to apply optimization techniques to real-world scenarios.
4. To enhance problem-solving abilities through analytical and computational methods.
5. To familiarize students with the use of operations research tools in mechanical engineering.
6. To equip students with the knowledge to interpret and implement the results of operations research analyses.

Course Outcomes:

On completion of the course, learner will be able to
CO1: Understand and apply the basic concepts of operations research to mechanical engineering problems.
CO2: Develop and analyze mathematical models for optimization problems.
CO3: Use various operations research techniques to solve mechanical engineering problems.
CO4: Demonstrate the ability to use software tools for operations research.

Course Contents:

Unit 1 Introduction to Operations Research **6 hrs.**

Introduction to OR: Definition, scope, history, and importance, Phases of OR: Formulation, solution, and implementation., Applications in Mechanical Engineering: Case studies and examples. Tools and Techniques: Overview of linear programming, network models, decision analysis, etc.

Unit 2 Linear Programming and Nonlinear Programming 7. **hrs.**

Formulation of LP Problems: Objective function, constraints, feasible solutions. Graphical Method: Solving two-variable LP problems. Simplex Method: Basic feasible solutions, pivoting, optimality conditions. Applications: Manufacturing, transportation, allocation •

problems. Introduction to Nonlinear Optimization: Problem formulation, types of nonlinear problems. Unconstrained Optimization: Gradient methods, Newton's method, quasi-Newton methods.

Unit 3 Transportation and Assignment Problems **6 hrs.**

Transportation Problems: Formulation, initial feasible solution, optimization.
Methods: North-West Corner Rule, Least Cost Method, Vogel's Approximation Method.
Assignment Problems: Formulation, Hungarian method, applications in scheduling and resource allocation. Balancing and Degeneracy: Handling imbalanced problems and degeneracy in solutions.

Unit 4 Network Models **7 hrs.**

Introduction to Networks: Definitions, types, and applications. Shortest Path Problem: Dijkstra's algorithm, Bellman-Ford algorithm. Minimum Spanning Tree: Kruskal's and Prim's algorithms. Project Scheduling: PERT and CPM, critical path analysis, time-cost trade-offs.

Unit 5 Inventory and Queuing Models **7 hrs.**

Inventory Control: Basic EOQ model, production quantity model, safety stock, reorder levels. Queuing Theory: Characteristics, Kendall's notation, single-server and multi-server models. Applications: Inventory management in mechanical systems, queuing in manufacturing and maintenance.

Unit 6 Game Theory and Decision Analysis **7 hrs.**

Advanced Game Theory: Mixed strategies, Nash equilibrium in mechanical systems. Multi-Criteria Decision Making: Analytic Hierarchy Process (AHP), multi-attribute utility theory. Decision Making under Uncertainty: Bayesian analysis, risk assessment. Applications: Competitive strategy, resource management in engineering projects, and decision support systems in mechanical engineering.

Textbooks

1. "Operations Research: An Introduction" by Taha, H. A. - Comprehensive introduction with applications.
2. "Introduction to Operations Research" by Hillier, F. S., and Lieberman, G. J. - In-depth analysis with case studies.
3. "Nonlinear Programming: Theory and Algorithms" by Bazaraa, M. S., Sherali, H. D., and Shetty, C. M. - Advanced techniques for nonlinear problems.
4. "Dynamic Programming and Optimal Control" by Bertsekas, D. P. - Detailed treatment of dynamic programming.
5. "Network Flows: Theory, Algorithms, and Applications" by Ahuja, R. K., Magnanti, T. L., and Orlin, J. B. - Focus on network optimization.
6. "Queueing Systems: Volume 1: Theory" by Kleinrock, L. - Fundamental concepts in queuing theory.

Reference books

1. "Optimization in Operations Research" by Rardin, R. L. - Advanced optimization techniques.
2. "Operations Research: Applications and Algorithms" by Winston, W. L. - Broad coverage with practical applications.
3. "Linear Programming and Network Flows" by Bazaraa, M. S., Jarvis, J. J., and Sherali, H. D. - Techniques and applications in linear programming and networks.
4. "Handbook of Industrial Engineering" by Salvendy, G. - Comprehensive resource for operations research in industrial applications.
5. "Simulation Modeling and Analysis" by Law, A. M., and Kelton, W. D. - Detailed exploration of simulation techniques.
6. "Game Theory: An Introduction" by Tadelis, S. - Concepts and applications of game theory.

E-content Links:

1. NPTEL - Advanced Operations Research: Advanced topics and applications. https://archive.nptel.ac.in/courses/112/106/112106131/
2. https://www.youtube.com/watch?v=OQ5jsbhAv_M
3. https://www.youtube.com/playlist?list=PLCiQX8xL_7JwKi5NoAciRwS35vYyKeEv2

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M. Tech Mechanical Curriculum							
Course	**Cost Management & Engg. Projects**			**Code**	24PMEM303D		
Course Cadre	Open Elective			**Semester**	III		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
	4	-	-	**Marks**	25	25	50
Total Credits	4	-	-	**Total Marks**	100		

Prerequisites:

6. The learner should have understanding basic engineering principles
7. The learner should be familiar with basic cost computation
8. The learner should be familiar with budget and resource management

Course Objectives:

1. Understand how to develop and manage project budgets effectively
2. Develop skills to optimize resource allocation, including labor, materials, equipment, and subcontractors, to minimize costs
3. Implement cost control measures to monitor project expenditures, identify variances from the budget, and take corrective actions to keep costs on track.
4. Conduct cost-benefit analysis to evaluate the economic feasibility of engineering projects and support decision-making.

Course Outcomes:

On completion of the course, learner will be able to

CO1: Understand the concepts strategic cost management process.

CO2: Apply cost concepts in decision-making and cost management projects.

CO3: Implement various stages of project execution with a team project.

CO4: Analyze various decision-making problems.

CO5: Planning of profits for product and project

CO6: Evaluate different qualitative techniques and cost behavior

Course Contents:

Unit 1	Introduction	**2 hrs.**

Introduction and Overview of the Strategic Cost Management Process

Unit 2 Cost Concepts **8 hrs.**

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

Unit 3 Engineering Projects **8 hrs.**

Different types, why to manage, cost overruns centers, various stages of project execution: conception to commissioning. Detailed Engineering activities. Pre-project execution main clearances and documents Project team: Role of each member. Importance Project site: Data required with significance. Project contracts. Types and contents. Project execution Project cost control. Bar charts and Network diagram. Project commissioning: mechanical and process

Unit 4 Cost Behavior **6 hrs.**

Distinction between Marginal Costing and Absorption Costing; Break-even Analysis, Cost-Volume-Profit Analysis. Various decision-making problems. Standard Costing and Variance Analysis. Pricing strategies: Pareto Analysis.

Unit 5 Profit planning and Marginal costs **6 hrs.**

Target costing, Life Cycle Costing. Costing of service sector. Activity-Based Cost Management, Bench Marking; Balanced Score Card and Value-Chain Analysis. Budgetary Control; Flexible Budgets; Performance budgets; Zero-based budgets. Measurement of Divisional profitability pricing decisions including transfer pricing

Unit 6 Cost Management Techniques **6 hrs.**

Quantitative techniques for cost management, Linear Programming, PERT/CPM, Transportation problems, Assignment problems, Simulation, and Learning Curve Theory.

Textbooks & Reference books

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

E-content Links:

1. https://www.coursera.org/specializations/finance-for-technical-managers
2. https://www.coursera.org/specializations/real-world-engineering-management

E-book:

https://www.wiley.com/en-us/Cost+and+Value+Management+in+Projects%2C+2nd+Edition-p-9781119933564

https://www.everand.com/book/577059297/Project-Cost-Management-Principles-Tools-Techniques-and-Best-Practices-for-Project-Finance

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M. Tech Mechanical Curriculum							
Course	**Waste to Energy**			**Code**	24PMEO303E		
Course Cadre	Open Elective			**Semester**	III		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	4	-	-	**Marks**	25	25	50
Total Credits	4	-	-	**Total Marks**	100		

Prerequisites: Thermodynamics, Fluid Mechanics, Heat Transfer, Environmental Engineering

Course Objectives:

1. Understand the growing challenge of waste management and the role of WtE technologies in a sustainable future.
2. Analyze different types of waste and their suitability for energy conversion.
3. Explore various WtE conversion technologies including incineration, gasification, and pyrolysis.
4. Evaluate the design considerations for WtE plants, including boiler systems, air pollution control equipment, and ash management.
5. Assess the environmental and economic implications of WtE systems.

Course Outcomes: Upon successful completion of this course, students will be able to:

1. Classify different types of waste and their calorific values.
2. Explain the principles of operation of various WtE conversion technologies.
3. Select appropriate WtE technologies for specific waste streams.
4. Analyze the design aspects of key components in WtE plants.
5. Critically evaluate the environmental and economic impacts of WtE systems.
6. Propose sustainable waste management strategies with WtE integration.

Course Contents:

Unit 1 Introduction to Waste Management and WtE **6 hrs.**
Waste generation and characterization - Waste management hierarchy and WtE's role - Global WtE trends and future outlook

Unit 2 Waste Characterization and Feedstock Preparation **6 hrs.**
Classification of waste (municipal, industrial, hazardous) - Physical and chemical properties of waste - Feedstock preparation techniques (shredding, sorting, drying)

Unit 3 WtE Conversion Technologies **8 hrs.**
Incineration: Mass burn, grate technology, flue gas treatment - Gasification: Integrated gasification combined cycle (IGCC), syngas cleaning - Pyrolysis: Slow pyrolysis, bio-oil production - Comparison of WtE technologies

Unit 4 WtE Plant Design and Engineering **8 hrs.**
Boiler systems and steam generation - Air pollution control technologies (scrubbers, filters) - Ash management and utilization - Plant layout and material handling

Unit 5 Environmental and Economic Considerations **6 hrs**.
Environmental impacts of WtE (emissions, ash disposal) - Life cycle assessment and sustainability - Economic viability of WtE projects - Cost-benefit analysis

Unit 6 Case Studies and Future Trends **4 hrs.**
Case studies of operational WtE plants worldwide - Emerging WtE technologies and advancements - Future directions and policy considerations

Textbooks:

1. Waste to Energy: Conversion Technologies by Paul Tchobanoglous, Frank Kreith, and Francis Kreith (McGraw-Hill Education)
2. Introduction to Thermal and Fluid Power Systems by Alessandro Scaroni (Springer)

Reference Books:
1. Waste Management and Resource Recovery by Michael D. Witt (Cengage Learning)
2. Biomass Combustion and Co-firing by Brian Jenkins, Richard Baxter, Timothy R. Miles, and Thomas R. Miles (Elsevier)

E-Content:

1. The World Bank - Urban Development - What is Waste to Energy (WtE)? https://www.worldbank.org/en/topic/urbandevelopment/brief/solid-waste-management
2. International Energy Agency (IEA) - Bioenergy - Waste to Energy https://www.ieabioenergy.com/our-work-tasks/
3. American Society of Mechanical Engineers (ASME) - Waste-to-Energy Committee https://www.asme.org/about-asme/media-inquiries/press-releases/asme-introduces-committee-on-sustainability-to-strengthen-climate-initiatives-and-drive-global-impact

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ME Mechanical Curriculum							
Course	Composite Materials			**Code**	24PMEO303F		
Credits	Th	Pr	Tut	**Scheme**	TAE	CAE	ESE
Teaching hrs.	4	-	-	**Marks**	25	25	50
Total Credits	4	-	-	**Total Marks**	100		

Prerequisites:

1. The learner should know the basics of Engineering Materials, Metallurgy, Manufacturing Process & Basic Design aspects.

Course Objectives:

1. Describe what are composite materials and their differences with respect to conventional materials.
2. Comprehend the challenges associated with Polymer Matrix component
3. Understand the requirement of Metal Matrix Composites
4. Recognize design and properties aspect of composites
5. Understand the testing, inspection and standard in composites
6. Orient to the specific Application of Composites

Course Outcomes:

On completion of the course, learner will be able to

CO1: Use different types of manufacturing processes in the preparation of composite materials.
CO2: Analyze the problems on macro mechanical 88ehavior of composites.
CO3: Analyze the problems on micromechanical 88ehavior of Composites.
CO4: Determine stresses and strains relation in composites materials.

CO5: Understand and effective use of properties in design of composite structures.

CO6: Perform literature search on a selected advanced material topic.

Course Contents:

Unit 1 Introduction to Composite Materials **7 hrs.**

Definition, classification & brief history of composite materials. Constituent of composite materials: Reinforcements, Matrix, Coupling agents, coatings & fillers. Reinforcements: Introduction, Glass Fibers, Boron Fibers, Carbon Fibers, Organic Fibers, Ceramic Fibers, Whiskers, Other Non-oxide Reinforcements, Comparison of Fibers Polymers, Metals and Ceramic Matrix Materials. Wettability, Crystallographic nature of interface, types of bonding at the interface and optimum interfacial bond strength.

Unit 2 Polymer Matrix Composites (PMC) **6 hrs.**

Processing of PMC's; Processing of Thermoset Matrix Composites, Thermoplastic Matrix Composites, Sheet Moulding Compound and carbon reinforced polymer composites. Interfaces in PMC's, Structure & Properties of PMC's, applications Metal Matrix Composites: Types of metal matrix composites, Important Metallic Matrices, Processing, Interfaces in Metal Matrix Composites, Properties & Applications.

Unit 3 Ceramic Matrix Composites (CMC) **6 hrs.**

Processing of CMC's; Cold Pressing & Sintering, Hot Pressing, Reaction Bonding Processes, Infiltration, Directed Oxidation, In Situ Chemical Reaction Technique, Sol-Gel, Polymer Infiltration & Pyrolysis, Electrophoretic Deposition, Self-Propagating High Temperature Synthesis. Interfaces, properties and applications of CMC's.

Unit 4 Carbon Composition Process **8 hrs.**

Carbon Fiber/Carbon Matrix Composites: Processing of Carbon/Carbon Composites, Oxidation protection of Carbon/Carbon Composites, Properties of Carbon/Carbon Composites, and application of Carbon/Carbon Composites. Multi-filamentary Superconducting Composites: The Problem of Flux Pinning, Types of Super Conductor, Processing & structure of Multi filamentary superconducting composites. Applications of multi-filamentary superconducting composites.

Unit 5 Nonconventional Composites **7 hrs.**

Introduction, Nano composites; Polymer clay Nano composites, self-healing composites, self-reinforced composites. Bio composites, Laminates; Ceramic Laminates, Hybrid Composites. Performance/Characterization of Composites: Static Mechanical Properties; Tensile Properties, Compressive Properties, Flexural Properties, In-Plane Shear Properties, Interlinear Shear Strength. Fatigue Properties; Tension–Tension Fatigue, Flexural Fatigue. Impact Properties; Charpy, Izod, and Drop Weight Impact Test.

Unit 6 Micromechanics of Composites **8 hrs.**

Density, Mechanical Properties; Prediction of Elastic Constants, Micromechanical Approaches, Halpin-Tsai Equations, Transverse Stresses, Thermal properties. Numerical Problems. Macromechanics of Composites**:** Introduction, Elastic constants of an isotropic material, elastic constants of a lamina, relationship between engineering constants and reduced stiffnesses and compliances.

Textbooks

1. Composite Material Science and Engineering Krishan K. Chawla Springer Third Edition First Indian Reprint 2015
2. Fibre-Reinforced Composites, Materials, Manufacturing, and Design P.K. Mallick CRC Press, Taylor & Francis Group Third Edition
3. Mechanics of Composite Materials & Structures Madhijit Mukhopadhay Universities Press 2004

Reference books

1. Mechanics of Composite materials Autar K. Kaw CRC Taylor & Francis 2nd Ed, 2005.
2. Stress analysis of fiber Reinforced Composites Materials Michael W, Hyer Mc-Graw Hill International 2009.
3. Mechanics of Composite Materials .Robert M. Jones Taylor & Francis 1999.

E-content Links:

1. https://www.princeton.edu/~maelabs/hpt/materials/composites.htm
2. https://www.twi-global.com/technical-knowledge/faqs/what-is-a-composite-material
3. https://en.wikipedia.org/wiki/Composite_material

E-books:

1. http://www.ae.iitkgp.ac.in/ebooks/
2. https://www.routledge.com/engineering-technology/mechanical-engineering/mechanics-of-solids/composite-materials

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