JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
KAKINADA – 533 003, Andhra Pradesh, India
DEPARTMENT OF MECHANICAL ENGINEERING

COURSE STRUCTURE

For UG – R20

B. TECH - MECHANICAL ENGINEERING

(Applicable for batches admitted from 2020-2021)

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
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IV B.TECH I SEMESTER

S.No	Code	Course Title	Hours			Credits
			L	T	P	
1	PE-3	1. Mechanical Vibrations 2. Operations Research 3. Unconventional Machining Processes 4. Computational Fluid Dynamics 5. Gas Dynamics and Jet Propulsion 6. MOOCs (NPTEL/Swayam) Course (12 Week duration)	3	0	0	3
2	PE-4	1. Automation in Manufacturing 2. Power Plant Engineering 3. Big Data Analytics 4. Production Planning and Control 5.Condition Monitoring 6.MOOCs (NPTEL/Swayam) Course (12 Week duration)	3	0	0	3
3	PE-5	1. Advanced Manufacturing Processes 2. Mechatronics 3. Refrigeration & Air-Conditioning 4. Additive Manufacturing 5. Non Destructive Evaluation 6. MOOCs (NPTEL/Swayam) Course (12 Week duration)	3	0	0	3
4	OE-3	1. Additive Manufacturing 2. Mechatronics 3. Finite Element Methods 4. Introduction to Artificial Intelligence &Machine Learning	3	0	0	3
5	OE-4	1. Optimization Techniques 2. Smart Manufacturing 3. Safety Engineering 4. Operations Management	3	0	0	3
6	HSC-3	Universal Human Values: Understanding Harmony	3	0	0	3
7	SOC-5	Mechatronics Lab	0	0	4	2
Evaluation of Summer Internship which is completed at the end of III B.Tech II Semester						3
			Total credits			23
Honors/Minor courses			4	0	0	**4**

IV B.TECH II SEMESTER

S No.	Category	Code	Course Title	Hours per week			Credits
				L	T	P	
1	Major Project	PROJ	Project work*	0	4	16	12
			Total credits				**12**

*Students can complete Project work @ Industries/ Higher Learning Institutions/ APSSDC.

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SUBJECTS FOR B. Tech. (MINOR) in MECHANICAL ENGINEERING

B. Tech. (MINOR) in MECHANICAL ENGINEERING		Pre-requisites
1.	Basic Thermodynamics	NIL
2.	Manufacturing Processes	NIL
3.	Materials Science and Engineering	NIL
4.	Basic Mechanical Design	NIL
5.	Optimization Techniques	NIL
6.	Power Plant Engineering	Basic Thermodynamics
7.	Automobile Engineering	Basic Thermodynamics
8.	Industrial Engineering and Management	NIL
9.	Product Design & Development	NIL
10.	Smart Manufacturing	NIL
11.	Mechanical Measurements	NIL
12.	Industrial Robotics	Engineering Mechanics
13.	Mechatronics	NIL

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SUBJECTS FOR B. Tech. (HONORS) IN MECHANICAL ENGINEERING

HONORS IN MECHANICAL ENGINEERING		Pre-requisites
POOL – 1 (in II-II)		
1.	Advanced Mechanics of Fluids	Fluid Mechanics
2.	Green Manufacturing	Production Technology
3.	Analysis and Synthesis of Mechanisms	Kinematics of Machinery
4.	Alternative Fuels Technologies	Basic Thermodynamics
5.	Gear Engineering	Kinematics of Machinery
POOL-2 (in III-I)		
1.	Experimental Methods in Fluid Mechanics	Fluid Mechanics
2.	Advanced Optimization Techniques	Operations Research
3.	Micro Electro Mechanical Systems	Nil
4.	Tribology	Nil
5.	Statistical Design in Quality Control	Nil
POOL-3 (in III-II)		
1.	Advanced Computational Fluid Dynamics	Fluid Mechanics
2.	Material Characterization Techniques	Material Science and Metallurgy
3.	Product Design	Nil
4.	Electric & Hybrid Vehicles	Thermal Engineering
5.	Mechanical Vibrations & Acoustics	Nil
POOL-4 (in IV-I)		
1.	Advanced Thermodynamics	Nil
2.	Design for Manufacturing and Assembly	Production Technology
3.	Robotics and Control	Kinematics of Machinery
4.	Turbo Machines	FM&HM
5.	Materials Technology	Nil

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IV Year - I Semester		**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
	MECHANICAL VIBRATIONS (PE-3)				

Course Objectives:

1) To learn basic principles of mathematical modeling of vibrating systems
2) To learn the basic concepts free and forced multi degree freedom systems
3) To learn concepts involved in the torsional vibrations
4) To learn the principles involved in the critical speed of shafts
5) To learn the basic concepts of Laplace transformations response to different inputs

UNIT– I:
Relevance of and need for vibrational analysis – Basics of SHM - Mathematical modeling of vibrating systems - Discrete and continuous systems - single-degree freedom systems - free and forced vibrations, damped and undamped systems.

UNIT– II:
Free and forced vibrations of multi-degree freedom systems in longitudinal, torsional and lateral modes - Matrix methods of solution- normal modes - Orthogonality principle-Energy methods, Eigen values and Eigen vectors, modal analysis.

UNIT– III:
Torsional vibrations - Longitudinal vibration of rods - transverse vibrations of beams – Governing equations of motion - Natural frequencies and normal modes - Energy methods, Introduction to non-linear and random vibrations.

UNIT– IV:
Vibration Measuring Instruments and Critical Speeds Of Shafts:Vibrometers, Accelerometer, Frequency measuring instruments and Problems. Critical speed of a light shaft having a single disc without damping and with damping, critical speeds of shaft having multiple discs, secondary critical speed, critical speeds light cantilever shaft with a large heavy disc at its end.

UNIT– V:
Laplace transformations response to an impulsive input, response to a step input, response to pulse(rectangular and half sinusoidal pulse), phase plane method

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TEXT BOOKS:

1. S.S.Rao, "Mechanical Vibrations ", 5th Edition, Prentice Hall, 2011.
2. L.Meirovitch, "Elements of vibration Analysis", 2nd Edition, McGraw-Hill, New York, 1985.

REFERENCES:

1. W.T. Thomson, M.D. Dahleh and C Padmanabhan, "Theory of Vibration with Applications", 5th Edition,Pearson Education, 2008.
2. M.L.Munjal, "Noise and Vibration Control", World Scientific, 2013.
3. Beranek and Ver, "Noise and Vibration Control Engineering: Principles and Applications",JohnWiley and Sons, 2006.
4. Randall F. Barron, "Industrial Noise Control and Acoustics", Marcel Dekker, Inc., 2003.

Course Outcomes: At the end of the course, student will be able to

CO1: Understand the concepts of vibrational analysis
CO2: Understand the concepts of free and forced multi degree freedom systems
CO3: Summarize the concepts of torsional vibrations
CO4: Solve the problems on critical speed of shafts
CO5: Apply and Analyze the systems subjected to Laplace transformationsresponse to different inputs

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IV Year - I Semester		L	T	P	C
		3	0	0	3
	OPERATIONS RESEARCH (PE-3)				

Course Objectives:
1. Understand Linear Programming models
2. Interpret Transportation and sequencing problems
3. Solve replacement problems and analyze queuing models
4. Understand game theory and inventory problems
5. Interpret dynamic programming and simulation.

UNIT– I:
INTRODUCTION - definition– characteristics and phases – types of operation research models – applications.
ALLOCATION: Linear programming problem formulation – graphical solution – simplex method – artificial variables techniques -two–phase method, big-M method – duality principle.

UNIT– II:
TRANSPORTATION PROBLEM: Formulation – optimal solution, unbalanced transportation problem – degeneracy, assignment problem – formulation – optimal solution - variants of assignment problem- travelling salesman problem.
SEQUENCING – Introduction – flow –shop sequencing – n jobs through two machines – n jobs through three machines – job shop sequencing – two jobs through 'm' machines.

UNIT– III:
REPLACEMENT: Introduction – replacement of items that deteriorate with time – when money value is not counted and counted – replacement of items that fail completely, group replacement.
THEORY OF GAMES: Introduction – mini. max (max. mini) – criterion and optimal strategy – solution of games with saddle points – rectangular games without saddle points – 2 x 2 games – dominance principle – m x 2 & 2 x n games -graphical method.

UNIT– IV:
WAITING LINES: Introduction – single channel – poison arrivals – exponential service times – with infinite population and finite population models– multichannel – poison arrivals – exponential service times with infinite population single channel.
INVENTORY CONTROL : Introduction – single item – deterministic models – purchase inventory models with one price break and multiple price breaks – shortages are not allowed – stochastic models – demand may be discrete variable or continuous variable – instantaneous production. Instantaneous demand and continuous demand and no set up cost. ABC & VED Analysis.

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UNIT– V:
DYNAMIC PROGRAMMING: Introduction – Bellman's principle of optimality – applications of dynamic programming- capital budgeting problem – shortest path problem – linear programming problem.

SIMULATION: Definition – types of simulation models – phases of simulation– applications of simulation – inventory and queuing problems – advantages and disadvantages – simulation languages.

TEXT BOOKS:

1. Operations Research-An Introduction/Hamdy A Taha/Pearson publishers
2. Operations Research –Theory & publications / S.D.Sharma-Kedarnath/McMillan publishers India.

REFERENCES:

1. Introduction to O.R/Hiller & Libermann/TMH
2. Operations Research /A.M. Natarajan, P. Balasubramani, A. Tamilarasi /Pearson Education.
3. Operations Research: Methods & Problems / Maurice Saseini, Arhur Yaspan & Lawrence Friedman/Wiley

Course Outcomes: At the end of the course, student will be able to

CO1: Understand Linear Programming models.
CO2: Interpret Transportation and sequencing problems.
CO3: Solve replacement problems and analyze queuing models.
CO4: Understand game theory and inventory problems.
CO5: Interpret dynamic programming and simulation.

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IV Year - I Semester		L	T	P	C
		3	0	0	3
	UNCONVENTIONAL MACHINING PROCESSES (PE-3)				

Course Objectives:

1. To understand basic concepts of modern machining processes.
2. To explain the principles of ultrasonic machining.
3. To illustrate the elector chemical and chemical machining processes.
4. To apply the principles and procedure of thermal metal removal processes.
5. To illustrate the principles and procedure of electron beam machining, laser beam machining and plasma machining.

UNIT– I:
INTRODUCTION: Need for non-traditional machining methods-classification of modern machining processes considerations in process selection, applications.
ABRASIVE JET MACHINING: Abrasive Jet machining, Water jet machining and abrasive water jet machining: Basic principles, equipment's, process variables, mechanics of material removal, MRR, application and limitations, process capabilities, magnetic abrasive finishing, abrasive flow finishing.

UNIT– II:
ULTRASONIC MACHINING – Elements of the process, mechanics of material removal, effect of process parameters, tool feed mechanisms, economic considerations, recent developments, applications and limitations.

UNIT– III:
ELECTRO–CHEMICAL MACHINING: Fundamentals of electro chemical machining, electrochemical grinding, electro chemical honing and deburring process, metal removal rate in ECM, Tool design, Surface finish and accuracy, economic aspects of ECM – Simple problems for estimation of metal removal rate, Electro-stream drilling, shaped tube electrolytic machining.
Fundamentals of chemical machining, advantages and applications.

UNIT– IV:
THERMAL METAL REMOVAL PROCESSES: General principle and applications of Electric Discharge Machining, Electric Discharge Grinding and wire EDM – Power circuits for EDM, Mechanics of metal removal in EDM, Process parameters, selection of tool electrode and dielectric fluids, surface finish and machining accuracy, characteristics of spark eroded surface.

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UNIT– V:
ELECTRON BEAM MACHINING, LASER BEAM MACHINING - Basic principle and theory, mechanics of material removal, process parameters, efficiency & accuracy, applications
PLASMA ARC MACHINING: Application of plasma for machining, metal removal mechanism, process parameters, accuracy and surface finish and other applications of plasma in manufacturing industries.

TEXT BOOKS:
1. Fundamentals of Machining Processes-Conventional and non – conventional processes/Hassan Abdel – Gawad El-Hafy/CRCPress-2016.
2. Rapid prototyping: Principles and Applications /Chua C.K., Leong K.F. and LIM C.S/World Scientific publications

REFERENCES:
1. Modern Machining Process / Pandey P.C. and Shah H.S./TMH.
2. New Technology / Bhattacharya A/ the Institution of Engineers, India1984.
3. Non Traditional Manufacturing Processes / Benedict

Course Outcomes: At the end of the course, student will be able to
CO1: Understand the concepts of modern machining processes. .
CO2: Learn the principles of ultrasonic machining.
CO3: Apply the principles and procedure of electro chemical and chemical machining processes.
CO4: Apply the principles and procedure of thermal metal removal processes
CO5: Illustrate the principles and procedure of electron beam machining, laser beam machining and plasma machining.

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IV Year - I Semester		L	T	P	C
		3	0	0	3
COMPUTATIONAL FLUID DYNAMICS (PE-3)					

Course Objectives:

1.To explain elementary details and numerical techniques for solving various engineering problems involving fluid flow.
2. To study about finite difference applications in heat conduction and convection.
3. To use finite difference for flow modeling
4. To understand the concepts of finite volume method.
5. To understand the concepts of finite element method applied to heat transfer problems.

UNIT– I:
REVIEW OF EQUATIONS GOVERNING FLUID FLOW AND HEAT TRANSFER: Introduction, conservation of mass, Newton's second law of motion, expanded forms of Navier-stokes equations (Derivation), conservation of energy principle, and special forms of the Navier-stokes equations.
APPLIED NUMERICAL METHODS: Solution of a system of simultaneous linear algebraic equations, iterative schemes of matrix inversion, direct methods for matrix inversion, direct methods for banded matrices, TDMA – Algorithms.

UNIT– II:
FINITE DIFFERENCE APPLICATIONS: Steady flow, dimensionless form of momentum and energy equations, stokes equation, conservative body force fields, stream function -vorticity formulation.
Finite difference applications in heat conduction and convection –heat conduction, steady heat conduction in a rectangular geometry, transient heat conduction, finite difference application in convective heat transfer, closure.

UNIT– III:
FINITE DIFFERENCE FOR FLOW MODELING: Discretization, consistency, stability and fundamentals of fluid flow modelling: introduction, elementary finite difference quotients, implementation aspects of finite-difference equations, consistency, explicit and implicit methods.

UNIT– IV:
FLUID FLOW MODELING: Introduction to first order wave equation, stability of hyperbolic and elliptic equations, fundamentals of fluid flow modelling, conservative property, the upwind scheme.

FINITE VOLUME METHOD: Approximation of surface integrals, volume integrals, interpolation and differentiation practices, upwind interpolation, linear interpolation and quadratic interpolation.

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UNIT– V:
FINITE ELEMENT METHODS: Introduction – Weighted Residual and Variational Formulations – Rayleigh-Ritz Method – Interpolation – One dimensional and Two dimensional regions – Error Control – Applications of FEM to One dimensional Problems (Steady and Transient) – Two dimensional problems.

TEXT BOOKS:
1**.** Numerical heat transfer and fluid flow/Suhas V. Patankar/Butter-worth Publishers
2. Computational fluid dynamics-Basics with applications/John.D.Anderson/McGrawHill.

REFERENCES:
1. Computational Fluid Flow and Heat Transfer/ Niyogi /Pearson Publications
2. Introduction to CFD: Finite Volume Method – H. Versteeg and W. Malalasekahara
3. Fundamentals of Computational Fluid Dynamics /Tapan K. Sengupta/Universities Press.
4.Computational fluid dynamics: An introduction, 3rd edition/John.F Wendt/Springer publishers

Course Outcomes: At the end of the course, student will be able to
CO1: Explain elementary details and numerical techniques for solving various engineering problems involving fluid flow.
CO2: Study about finite difference applications in heat conduction and convection.
CO3: Apply finite difference for flow modeling.
CO4: Understand the concepts of finite volume method.
CO5: Understand the concepts of finite element method applied to heat transfer problems.

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IV Year - I Semester		L	T	P	C
		3	0	0	3
GAS DYNAMICS AND JET PROPULSION (PE-3)					

Course Objectives:

1. To learn basic concepts of compressible fluid flow
2. To learn the isentropic flow of an ideal gas and effects of back pressure on nozzles
3. To learn the simple frictional flow in constant area duct of adiabatic and isothermal flows
4. To learn the conditions to form the shock waves due to the effect of heat transfer in convergent-divergent nozzle
5. To learn the basic concepts of jet propulsions systems and working of liquid propellant engines and Rockets.

UNIT– I:
INTRODUCTION TO GAS DYNAMICS: control volume and system approaches acoustic waves and sonic velocity -Mach number - classification of fluid flow based on Mach number - Mach cone-compressibility factor - general features of one dimensional flow of a compressible fluid - continuity and momentum equations for a control volume.

UNIT– II:
ISENTROPIC FLOW OF AN IDEAL GAS: basic equation - stagnation enthalpy, temperature, pressure and density stagnation, acoustic speed - critical speed of sound- dimensionless velocity-governing equations for isentropic flow of a perfect gas - critical flow area - stream thrust and impulse function.
Steady one dimensional isentropic flow with area change-effect of area change on flow parameters chocking- convergent nozzle - performance of a nozzle under decreasing back pressure -De Lavel nozzle - optimum area ratio effect of back pressure - nozzle discharge coefficients - nozzle efficiencies.

UNIT– III:
SIMPLE FRICTIONAL FLOW: adiabatic flow with friction in a constant area duct-governing equations – Fanno line limiting conditions - effect of wall friction on flow properties in an Isothermal flow with friction in a constant area duct-governing equations - limiting conditions.
Steady one dimensional flow with heat transfer in constant area ducts- governing equations – Rayleigh line entropy change caused by heat transfer - conditions of maximum enthalpy and entropy.

UNIT– IV:
EFFECT OF HEAT TRANSFER ON FLOW PARAMETERS: Intersection of Fanno and Rayleigh lines. Shock waves in perfect gas- properties of flow across a normal shock - governing equations - Rankine Hugoniat equations - Prandtl velocity relationship - converging diverging nozzle flow with shock thickness - shock strength.

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UNIT– V:

PROPULSION: Aircraft propulsion - energy flow through jet engines, thrust, thrust power and propulsive efficiency turbojet components- diffuser, compressor, combustion chamber, turbines, exhaust systems (Performance Matching).

Performance of turbo propeller engines, ramjet and pulsejet, scramjet engines. Rocket propulsion – Basic theory of equations - thrust equation - effective jet velocity - specific impulse–rocket engine performance - solid and liquid propellant rockets - comparison of various propulsion systems.

TEXT BOOKS:

1. Compressible fluid flow /A. H. Shapiro / Ronald Press Co., 1953
2. Fundamentals of compressible flow with aircraft and rocket propulsion/S. M. Yahya/New Age international Publishers
3. Fundamental of Gas dynamics-2nd edition/ M J Zucker/ Wiley publishers

REFERENCES:

1. Elements of gas dynamics / HW Liepman &A Roshko/Wiley
2. Aircraft & Missile propulsion /MJ Zucrow/Wiley
3. Gas dynamics / M.J. Zucrow & Joe D.Holfman / Krieger Publishers

Course Outcomes: At the end of the course, student will be able to

CO1: Explain elementary details and numerical techniques for solving various engineering problems involving fluid flow.

CO2: Study about finite difference applications in heat conduction and convection.

CO3: Apply finite difference for flow modeling.

CO4: Understand the concepts of finite volume method.

CO5: Understand the concepts of finite element method applied to heat transfer problem

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IV Year - I Semester		L	T	P	C
		3	0	0	3
	AUTOMATION IN MANUFACTURING (PE-4)				

Course Objectives:

1. To understands the types and strategies and various components in Automated Systems
2. To classify the types of automated flow lines and analyze automated flow lines
3. To solve the line balancing problems in the various flow line systems with and without buffer storage
4. To interpret different automated material handling systems, storage and retrieval systems and automated inspection systems
5. To understand the principles of Adaptive Control systems and recognize the types of automated inspection techniques and their applications.

UNIT– I:
INTRODUCTION: Types and strategies of automation, pneumatic and hydraulic components, circuits, automation in machine tools, power transmission in CNC machines, optical encoders, other sensors, mechanical feeding and tool changing and machine tool control.

UNIT– II:
AUTOMATED FLOW LINES: Methods of part transport, transfer mechanism, buffer storage, control function, design and fabrication considerations, Analysis of automated flow lines - General terminology and analysis of transfer lines without and with buffer storage, partial automation, implementation of automated flow lines.

UNIT– III:
ASSEMBLY SYSTEM AND LINE BALANCING: Assembly process and systems, assembly line, line balancing methods, ways of improving line balance, flexible assembly lines.
AUTOMATED INSPECTION: Fundamentals, types of inspection methods and equipment, Coordinate Measuring Machines, Machine Vision

UNIT– IV:
AUTOMATED MATERIAL HANDLING AND STORAGE SYSTEMS:
Types of equipment, functions, analysis and design of material handling systems, conveyor systems, automated guided vehicle systems. Automated storage and retrieval systems; work in process storage, interfacing handling and storage with manufacturing.

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UNIT– V:
ADAPTIVE CONTROL SYSTEMS: Introduction, adaptive control with optimization, adaptive control with constraints, application of adaptive control in machining operations. Consideration of various parameters such as cutting force, temperatures, vibration and acoustic emission in the adaptive controls systems.

TEXT BOOK:
1.Automation, Production Systems and Computer Integrated Manufacturing: M.P. Groover/ PE/PHI.
2.Automation by W. Buekinsham.

REFERENCES:
1. Computer Control of Manufacturing Systems by YoramCoren.
2. CAD / CAM/ CIM by Radhakrishnan.

Course Outcomes: At the end of the course, student will be able to

CO1: Understands the types and strategies and various components in Automated Systems.
CO2: Classify the types of automated flow lines and analyze automated flow lines
CO3: Solves the line balancing problems in the various flow line systems with and without buffer storage
CO4: Interpret different automated material handling systems, storage and retrieval systems and automated inspection systems.
CO5: Understand the principles of Adaptive Control systems and recognize the types of automated inspection techniques and their applications

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IV Year - I Semester		L	T	P	C
		3	0	0	3
	POWER PLANT ENGINEERING (PE-4)				

Course Objectives:

1) To learn the working of different components of the steam power plant.
2) To learn the components of the diesel and gas power plants.
3) To learn the different elements in the hydroelectric and nuclear power plants.
4) To learn the basic concepts for power production in combined plants and usage of different instrument to measure the operating parameters of the power plant.
5) To learn the concepts of power plant economics and pollution standards to be observed in the power plants.

UNIT– I:
STEAM POWER PLANT: Plant layout, working of different circuits, fuel and handling equipments, types of coals, coal handling, choice of handling equipment, coal storage, ash handling systems. Combustion: properties of coal – overfeed and underfeed fuel beds, traveling grate stokers, spreader stokers, retort stokers, pulverized fuel burning system and its components, combustion needs and draught system, cyclone furnace, design and construction, dust collectors, cooling towers and heat rejection, corrosion and feed water treatment.

UNIT– II:
INTERNAL COMBUSTION AND GAS TURBINE POWER PLANTS:
DIESEL POWER PLANT: Plant layout with auxiliaries – fuel supply system, air starting equipment, super charging.
GAS TURBINE PLANT: Introduction – classification - construction – layout with auxiliaries, combined cycle power plants and comparison.

UNIT– III:
HYDRO ELECTRIC POWER PLANT: Water power – hydrological cycle / flow measurement – drainage area characteristics – hydrographs – storage and pondage – classification of dams and spill ways.
HYDRO PROJECTS AND PLANT: Classification – typical layouts – plant auxiliaries – plant operation pumped storage plants.
NUCLEAR POWER STATION: Nuclear fuel – breeding and fertile materials – nuclear reactor – reactor operation.
TYPES OF REACTORS: Pressurized water reactor, boiling water reactor, sodium-graphite reactor, fast breeder reactor, homogeneous reactor, gas cooled reactor, radiation hazards and shielding – radioactive waste disposal.

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UNIT– IV:
COMBINED OPERATIONS OF DIFFERENT POWER PLANTS: Introduction, advantages of combined working, load division between power stations, storage type hydro-electric plant in combination with steam plant, run-of-river plant in combination with steam plant, pump storage plant in combination with steam or nuclear power plant, co-ordination of hydro-electric and gas turbine stations, co-ordination of hydro-electric and nuclear power stations, co-ordination of different types of power plants.
POWER PLANT INSTRUMENTATION AND CONTROL: Importance of measurement and instrumentation in power plant, measurement of water purity, gas analysis, O_2 and CO_2 measurements, measurement of smoke and dust, measurement of moisture in carbon dioxide circuit, nuclear measurements.

UNIT– V:
POWER PLANT ECONOMICS AND ENVIRONMENTAL CONSIDERATIONS: Capital cost, investment of fixed charges, operating costs, general arrangement of power distribution, load curves, load duration curve, definitions of connected load, maximum demand, demand factor, average load, load factor, diversity factor – energy audit-related exercises. effluents from power plants and Impact on environment – pollutants and pollution standards – methods of pollution control.

TEXT BOOKS:
1. A course in Power Plant Engineering /Arora and Domkundwar/Dhanpatrai & Co.
2. Power Plant Engineering /P.C.Sharma / S.K.Kataria Pub

REFERENCES:
1. Power Plant Engineering: P.K.Nag/ II Edition /TMH.
2. Power station Engineering – ElWakil / McGraw-Hill.
3. An Introduction to Power Plant Technology / G.D. Rai/Khanna Publishers

Course Outcomes: At the end of the course, student will be able to

CO1: Identify the different components of the steam power plant for power production.
CO2: Illustrate the component used in the diesel and gas power plant for power production
CO3: Understand how the power is produced by hydro-electric and nuclear power plants
CO4: Interpret the power production by combined power plants and operating principles of different instruments used in power plants.
CO5: Analyze power plant economics and implementation of pollution standards and control of pollution caused by the power plants.

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IV Year - I Semester		L	T	P	C
		3	0	0	3
	BIG DATA ANALYTICS (PE-4)				

Course Objectives:

1) To understand the Big Data Platform and its Use cases
2) To Provide an overview of Apache Hadoop
3) To configure and set the environment with MapReduce
4) To Understand the concepts of Scala programming
5) To understand NoSQL database

UNIT– I:
Introduction to BigData
Introduction: Big Data - Characteristics of Big Data(7Vs) - Big data management architecture - Examining Big Data Types - Big Data Technology Components - Big data analytics- Big data analytics applications and examples- Industries leveraging Big Data, Comparison of Data Characteristics by Industry, Comparison of various Big Data tools, Web Data Overview-Web Data in Action

UNIT– II:
Hadoop
Introduction: History of Hadoop - Hadoop Ecosystem - Analyzing data with Hadoop - Hadoop Distributed File System - Design - HDFS concepts - Hadoop file system - Data flow - Hadoop I / O - Data integrity - Serialization -Setting up a Hadoop cluster-Cluster specification-cluster setup and installation-YARN.

UNIT– III:
MapReduce
Introduction: Understanding MapReduce functions - Scaling out - Anatomy of a MapReduce Job Run - Failures -Shuffle and sort - MapReduce types and formats - features - counters - sorting - MapReduce Applications –Configuring and setting the environment-Unit test with MRunit-localtest.

UNIT– IV:
Spark
Installing spark - Spark applications - Jobs - Stages and Tasks - Resilient Distributed databases - Anatomy of a Spark Job Run - Spark on YARN - SCALA: Introduction - Classes and objects - Basic types and operators - built-in control structures –functions and closures-inheritance.

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UNIT– V:
NoSQL Databases
Introduction to NoSQL - MongoDB: Introduction - Data types - Creating - Updating and deleing documents -Querying - Introduction to indexing - Capped collections - Hbase: Concepts - Hbase Vs RDBMS – Creating records-Accessing data-Updating and deleting data-Modifying data-exporting and importing data.

USECASES: Call detail log analysis – Credit fraud alert-Weather forecast.

TEXTBOOKS

1. EMCEducationServices,"DataScienceandBigDataAnalytics:Discovering,Analyzing,Visualizing and Presenting Data",Wiley Publishers, 2015.
2. ImonWalkowiak,"BigDataAnalyticswithR",PackTPublishers,2016.

REFERENCEBOOKS

1. David Loshin,"BigDataAnalytics:FromStrategicPlanningtoEnterpriseIntegrationwithTools,Techniques,NoSQL, and Graph", Morgan Kaufmann/Elsevier Publishers, 2013.
2. BartBaesens,"AnalyticsinaBigDataWorld:TheEssentialGuidetoDataScienceanditsApplications",WileyPublishers,2015.
3. Kim H.Pries, Robert Dunnigan,"Big Data Analytics: APracticalGuideforManagers",CRCPress,2015.

Course Outcomes: At the end of the course, student will be able to

CO1: Understand the characteristics of big data and concepts of Hadoop ecosystem.
CO2: Design programs for big data applications using Hadoop components.
CO3: Apply Map reduce programming model to process big data.
CO4: Analyze Spark and its uses for big data processing.
CO5: Apply the concepts of NOSQL databases.

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IV Year - I Semester		L	T	P	C
		3	0	0	3
PRODUCTION PLANNING AND CONTROL (PE-4)					

Course Objectives:

1) To understand the different types of production systems and the internal organization of production planning and control
2) To estimate forecasts in the manufacturing and service sectors using selected quantitative and qualitative techniques
3) To understands the importance and function of inventory and to be able to apply for its control and management
4) To apply routing procedures and differentiate schedule and loading and interpret scheduling policies and aggregate planning
5) To understand dispatching procedure and applications of computers in production planning and control

UNIT– I:
Introduction: Definition – objectives and functions of production planning and control – elements of production control – types of production – organization of production planning and control department – internal organization of department.

UNIT– II:
Forecasting – Importance of forecasting –types of forecasting, their uses – general principles of forecasting – forecasting techniques – qualitative methods and quantitative methods.

UNIT– III:
Inventory management – functions of inventories – relevant inventory costs – ABC analysis – VED analysis – EOQ model – Inventory control systems – P–Systems and Q-Systems Introduction to MRP I, MRP II, ERP, LOB (Line of Balance), JIT and KANBAN system.

UNIT– IV:
Routing –definition – routing procedure –route sheets – bill of material – factors affecting routing procedure, schedule –definition – difference with loading. Scheduling policies – techniques, standard scheduling methods.
Line Balancing, aggregate planning, chase planning, expediting, controlling aspects.

UNIT– V:
Dispatching – activities of dispatcher – dispatching procedure – follow up – definition – reason for existence of functions – types of follow up, applications of computer in production planning and control.

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TEXT BOOKS:

1. Elements of Production Planning and Control / Samuel Eilon/Universal Book Corp.
2. Manufacturing, Planning and Control/Partik Jonsson Stig- Arne Mattsson/TataMcGrawHill

REFERENCES:

1. Inventory Control Theory and Practice / Martin K. Starr and David W.Miller/Prentice-Hall
2. Production Planning andControl/Mukhopadyay/PHI.
3. Production Control A Quantitative Approach / John E.Biegel/Prentice-Hall
4. Production Control / Franklin G Moore & Ronald Jablonski/Mc-GrawHill
5. Production and Operations Management/Shailendra Kale/McGraw-Hill
6. Production and Operations Management/Ajay K Garg/McGraw-Hill

Course Outcomes: At the end of the course, student will be able to

CO1: To understand the different types of production systems and the internal organization of production planning and control.
CO2: To estimate forecasts in the manufacturing and service sectors using selected quantitative and qualitative techniques.
CO3: To understands the importance and function of inventory and to be able to apply for its control and management.
CO4: To apply routing procedures and differentiate schedule and loading and interpret scheduling policies and aggregate planning.
CO5: To understand dispatching procedure and applications of computers in production planning and control.

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IV Year -I Semester		L	T	P	C
		3	0	0	3
	CONDITION MONITORING (PE-4)				

Course Objectives:
1) To introduce the basics of vibration
2) To analyze vibration measurement and analysis using transducers and mounting methods
3) To understand fault diagnosis and interpret vibration measurements
4) To understand oil and wear debris analysis
5) To interpret Ultrasonic monitoring and analysis

UNIT– I:
BASICS OF VIBRATION: Basic motion: amplitudes, period, frequency, basic parameters: displacement, velocity, acceleration, units (including dB scales) and conversions, Mass, spring and damper concept, Introduction to SDOF and MDOF systems, Natural frequencies and resonance, Forced response.

UNIT– II:
VIBRATION MEASUREMENTS AND ANALYSIS: Transducers and mounting methods, data acquisition using instrumentation recorders/data loggers, time domain signal analysis, orbit analysis, Filters, Frequency domain analysis (Narrow band FFT analysis), Nyquist criteria, Sampling, aliasing, windowing and averaging.

UNIT– III:
FAULT DIAGNOSIS: Interpreting vibration measurements for common machine faults, imbalance, and misalignment, mechanical looseness, bearing and gearing faults, faults in induction motors, resonances, some case studies, static and dynamic balancing, and international standards for vibration condition monitoring.
THERMOGRAPHY: The basics of infrared thermography, differences in equipment and specific wave length limitations, application of IR to: electrical inspection, mechanical inspection, energy conservation, how to take good thermal images, hands-on demonstrations focusing on proper camera settings and image interpretation, analysis of thermal images and report generation, study of thermography applications.

UNIT– IV:
OIL AND WEAR DEBRIS ANALYSIS: Basics of oil analysis, monitoring condition of oil, lubricant analysis, physio – chemical properties, moisture, tan tbn, wear debris analysis, particle counting, spectroscopy, uses & limitations, ferrography wear particle analysis, concept of ferrography, principle particle classification, size, shape, composition, concentration, analysis procedure, sampling & analytical ferrography equipment's, severity rating.

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UNIT– V: DEPARTMENT OF MECHANICAL ENGINEERING
ULTRASONIC MONITORING AND ANALYSIS: Ultrasonic monitoring (leak, crack and thickness) basics of ultrasonic monitoring , ultrasonic theory, test taking philosophy, ultrasonic theory, mathematics of ultrasound, equipment and transducers, inspection parameters and calibration, immersion theory, equipment quality control, flaw origins and inspection methods, UT Procedure familiarization, and study recommendations, application of ultrasound to: air leaks, steam trap testing, bearing lubrication, electrical inspection, case studies.

TEXT BOOKS:
1. The Vibration Analysis Handbook/J I Taylor (1994)/Vibration consultants Incorporate Publishers
2. Mohanty, A.R. (2014). Machinery Condition Monitoring: Principles and Practices (1st Ed.). CRC Press.

REFERENCES:
1. Machinery Vibration: Measurement and Analysis/Victor Wowk/Mc GrawHill Professional
2. Mechanical fault diagnosis and condition monitoring/RA Collacott(1977) /Chapman and Hall
3. The Vibration Monitoring Handbook/Charles W Reeves/Coxmoor publishing company

Course Outcomes: At the end of the course, student will be able to

CO1: Understand the basics of vibration.
CO2: Analyze vibration measurement and analysis using transducers and mounting methods.
CO3: Understand fault diagnosis and interpret vibration measurements.
CO4: Understand oil and wear debris analysis.
CO5: Interpret Ultrasonic monitoring and analysis.

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IV Year - I Semester		**L**	**T**	**P**	**C**
		3	**0**	**0**	**3**
ADVANCED MANUFACTURING PROCESSES (PE-5)					

Course Objectives:
1) To understand the principles of various coating techniques and fabrication methods for MEMS devices
2) To make the students understand the properties, processing and design of ceramic and composite materials
3) To understand the fabrication methods for MEMS devices.
4) To understand the concepts and principles of nano manufacturing methods.
5) To learn various Rapid Prototyping (RP) processes and their applications.

UNIT– I:
COATING TECHNIQUES: Scope, Cleaners, Methods of cleaning, Surface coating types, ceramic and organic methods of coating, and economics of coating. Electro forming, Chemical vapor deposition, Physical vapor deposition, thermal spraying, Ion implantation, diffusion coating, Diamond coating and cladding.

UNIT– II:
PROCESSING OF CERAMICS: Applications, characteristics, classification, Processing of particulate ceramics, Powder preparations, consolidation, hot compaction, drying, sintering, and finishing of ceramics, Areas of application.
PROCESSING OF COMPOSITES: Composite Layers, Particulate and fiber reinforced composites, Elastomers, Reinforced plastics, MMC, CMC, Polymer matrix composites.

UNIT– III:
FABRICATION OF MICROELECTRONIC DEVICES: Crystal growth and wafer preparation, Film Deposition oxidation, lithography, bonding and packaging, reliability and yield, Printed Circuit boards, computer aided design in micro-electronics, surface mount technology, Integrated circuit economics.

UNIT– IV:
NANOMANUFACTURING: Nanotubes, Nanoparticles, nanowires, Lithography, Electro-spinning, mechanical milling, Inert gas condensation, sputtering, laser ablation, Arc discharge, Sol-gel methods, working, applications, advantages.

UNIT– V:
RAPID PROTOTYPING: Working Principles, Methods, Stereo Lithography, Laser Sintering, Fused Deposition Method, Applications and Limitations, Rapid tooling, Techniques of rapid manufacturing.

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TEXT BOOKS:
1. Manufacturing Engineering and Technology*I*Kalpakijian / Adisson Wesley, 1995.
2. Process and Materials of Manufacturing / R. A. Lindburg / 1th edition, PHI 1990.

REFERENCES:
1. Microelectronic packaging handbook / Rao. R. Thummala and Eugene, J. Rymaszewski / VanNostrand Renihold,
2. MEMS & Micro Systems Design and manufacture / Tai — Run Hsu / TMGH
3. Advanced Machining Processes / V.K.Jain / Allied Publications.
4. Introduction to Manufacturing Processes / John A Schey*I*Mc Graw Hill.

Course Outcomes: At the end of the course, student will be able to
CO1: Understand the working principles of various surface coating methods.
CO2: Discuss novel and promising techniques in the processing of ceramics and composites.
CO3: Select suitable fabrication methods for MEMS components.
CO4: Learn the concepts and principles of nano manufacturing methods.
CO5: Illustrate the working principles of RP and select appropriate RP process for the application.

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IV Year - I Semester		L	T	P	C
		3	0	0	3
	MECHATRONICS (PE-5)				

Course Objectives:
1) To understand the use the various mechatronics systems, measurement systems, sensors and transducers.
2) To apply the concepts of solid state electronic devices.
3) To identify the components in the design of elector mechanical systems.
4) To apply the concepts of digital electronics and applications of PLCs for control.
5) To understand system interfacing, data acquisition and design of mechatronics systems.

UNIT– I:
Mechatronics systems – elements & levels of mechatronics system, Mechatronics design process, system, measurement systems, control systems, microprocessor-based controllers, advantages and disadvantages of mechatronics systems. Sensors and transducers, types, displacement, position, proximity, velocity, motion, force, acceleration, torque, fluid pressure, liquid flow, liquid level, temperature and light sensors.

UNIT– II:
Solid state electronic devices - PN junction diode, BJT, FET, DIAC, TRIAC and LEDs. Analog signal conditioning, operational amplifiers, noise reduction, filtering

UNIT– III:
Hydraulic and pneumatic actuating systems - Fluid systems, Hydraulic systems, and pneumatic systems, components, control valves, electro-pneumatic, hydro-pneumatic, electro-hydraulic servo systems. Mechanical actuating systems and electrical actuating systems – basic principles and elements.

UNIT– IV:
Digital electronics and systems, digital logic control, microprocessors and micro controllers, programming, process controllers, programmable logic controllers, PLCs versus computers, application of PLCs for control.

UNIT– V:
System and interfacing and data acquisition – Data Acquisition Systems, Analog to Digital and Digital to Analog conversions; Digital Signal Processing – data flow in DSPs, block diagrams, typical layouts, Interfacing motor drives. Design of mechatronics systems & future trends.

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TEXT BOOKS:

1. Mechatronics Integrated Mechanical Electronics Systems/KP Ramachandran, GK Vijaya Raghavan & MS Balasundaram/WILEY India Edition

REFERENCES:

1. Mechatronics /Smaili A, Mrad F/ Oxford Higher Education, Oxford UniversityPress
2. Mechatronics Source Book / Newton C Braga/ThomsonPublications,Chennai.
3. Mechatronics – N. Shanmugam / Anuradha Agencies Publishers.
4. Mechatronics System Design / Devdas shetty/Richard/Thomson.
5. Mechatronics/M.D.Singh/J.G.Joshi/PHI.
6. Mechatronics – Electronic Control Systems in Mechanical and Electrical Engg. 4th Edition / W. Bolton/ Pearson,2012
7. Mechatronics – Principles and Application / Godfrey C. Onwubolu/Elsevier, Indianprint

Course Outcomes: At the end of the course, student will be able to

CO1: Understand the use the various mechatronics systems, measurement systems, sensors and transducers.

CO2: Apply the concepts of solid state electronic devices.

CO3: Identify the components in the design of electro mechanical systems.

CO4: Apply the concepts of digital electronics and applications of PLCs for control.

CO5:Understand system interfacing, data acquisition and design of mechatronics systems.

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IV Year - I Semester		L	T	P	C
		3	0	0	3
	REFRIGERATION & AIR-CONDITIONING (PE) **(Refrigeration and Psychrometric tables and charts allowed)**				

Course Objectives:
1) To illustrate the operating cycles and different systems of refrigeration
2) To analyze cooling capacity and coefficient of performance of vapour compression refrigeration systems and understand the fundamentals of cryogenics
3) To calculate coefficient of performance by conducting test on vapour absorption and steam jet refrigeration system and understand the properties refrigerants.
4) To calculate cooling load for air conditioning systems and identify the requirements of comfort air conditioning
5) To describe different component of refrigeration and air conditioning systems

UNIT– I:
INTRODUCTION TO REFRIGERATION: Necessity and applications – unit of refrigeration and C.O.P. – Mechanical refrigeration – types of ideal cycles of refrigeration. air refrigeration: Bell Coleman cycle - open and dense air systems – refrigeration systems used in air crafts and problems.

UNIT– II:
VAPOUR COMPRESSION REFRIGERATION SYSTEM &COMPONENTS: Working principle and essential components of the plant – simple vapour compression refrigeration cycle – COP – representation of cycle on T-S and p-h charts – effect of sub cooling and super heating – cycle analysis – actual cycle influence of various parameters on system performance – use of p-h charts – numerical problems.
INTRODUCTION TO CRYOGENICS: Joule-Thomson expansion, refrigerant mixtures**,** multi stage vapour compression refrigeration.

UNIT– III:
REFRIGERANTS – Desirable properties – classification - refrigerants –green refrigerants - nomenclature – ozone depletion – global warming.
VAPOR ABSORPTION SYSTEM: Calculation of maximum COP – description and working of NH_3 – water system and Li Br –water (Two shell & Four shell) System, principle of operation three fluid absorption system, salient features.
STEAM JET REFRIGERATION SYSTEM: Working Principle and basic components, principle and operation of thermoelectric refrigerator and vortex tube.

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UNIT– IV:
INTRODUCTION TO AIR CONDITIONING: Psychometric properties & processes – characterization of sensible and latent heat loads — need for ventilation, consideration of infiltration – load concepts of RSHF, GSHF- problems, concept of ESHF and ADP temperature.
Requirements of human comfort and concept of effective temperature- comfort chart –comfort air conditioning – requirements of industrial air conditioning, air conditioning load calculations.

UNIT– V:
AIR CONDITIONING SYSTEMS: Classification of equipment, cooling, heating humidification and dehumidification, filters, grills and registers, fans and blowers. heat pump – heat sources – different heat pump circuits.

TEXT BOOKS:
1. A Course in Refrigeration and Air conditioning / SC Arora &Domkundwar / Dhanpatrai
2. Refrigeration and Air Conditioning / CP Arora / TMH.

REFERENCES:
1. Refrigeration and Air Conditioning / Manohar Prasad / New Age.
2. Principles of Refrigeration /Dossat / Pearson Education.
3. Basic Refrigeration and Air-Conditioning / Ananthanarayanan / TMH

Course Outcomes: At the end of the course, student will be able to
CO1: Illustrate the operating cycles and different systems of refrigeration.
CO2: Analyze cooling capacity and coefficient of performance of vapour compressionrefrigeration systems and understand the fundamentals of cryogenics
CO3: Calculate coefficient of performance by conducting test on vapour absorption and steam jet refrigeration systems and understand the properties of refrigerants.
CO4: Solve cooling load for air conditioning systems and identify the requirements of comfort air conditioning.
CO5:Demonstrate different components of refrigeration and air conditioning systems.

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IV Year - I Semester		L	T	P	C
		3	0	0	3
	ADDITIVE MANUFACTURING (PE-5)				

Course Objectives:
1) To understand the principles of prototyping, classification of RP processes and liquid-based RP systems
2) To understand and apply different types of solid-based RP systems.
3) To understand and apply powder-based RP systems.
4) To understand and apply various rapid tooling techniques.
5) To understand different types of data formats and to explore the applications of AM processes in various fields.

UNIT– I:
INTRODUCTION: Prototyping fundamentals, historical development, fundamentals of rapid prototyping, advantages and limitations of rapid prototyping, commonly used terms, classification of RP process.
LIQUID-BASED RAPID PROTOTYPING SYSTEMS: Stereo lithography Apparatus (SLA): models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages, case studies. Solid Ground Curing (SGC): models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

UNIT– II:
SOLID-BASED RAPID PROTOTYPING SYSTEMS: Laminated object manufacturing (LOM) - models and specifications, process, working principle, applications, advantages and disadvantages, case studies. Fused deposition modelling (FDM) - models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

UNIT– III:
POWDER BASED RAPID PROTOTYPING SYSTEMS: Selective laser sintering (SLS): models and specifications, process, working principle, applications, advantages and disadvantages, case studies. three dimensional printing (3DP): models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

UNIT– IV:
RAPID TOOLING: Introduction to rapid tooling (RT), conventional tooling Vs RT, Need for RT. rapid tooling classification: indirect rapid tooling methods: spray metal deposition, RTV epoxy tools, Ceramic tools, investment casting, spin casting, die casting, sand casting process. Direct rapid tooling: Direct AIM, LOM Tools, and Direct Metal Tooling using 3DP.

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UNIT– V:

RAPID PROTOTYPING DATA FORMATS: STL Format, STL File Problems, consequence of building valid and invalid tessellated models, STL file Repairs: Generic Solution, other Translators, and Newly Proposed Formats.

RP APPLICATIONS: Application in engineering, analysis and planning, aerospace industry, automotive industry, jewelry industry, coin industry, GIS application, RP medical and bioengineering applications: customized implants and prosthesis, forensic sciences.

TEXT BOOKS:
1.Rapid prototyping: Principles and Applications /Chua C.K., Leong K.F. and LIM C.S/WorldScientific publications

REFERENCES:
1. Rapid Manufacturing / D.T. Pham and S.S. Dimov/Springer
2. Wohlers Report 2000 /Terry T Wohlers/Wohlers Associates
3. Rapid Prototyping & Manufacturing / Paul F.Jacobs/ASME Press
4. Rapid Prototyping / Chua and Liou

Course Outcomes: At the end of the course, student will be able to
CO1: Understand the principles of prototyping, classification of RP processes and liquid-based RP systems.
CO2: Understand and apply different types of solid-based RP systems.
CO3: Apply powder-based RP systems.
CO4: Analyze and apply various rapid tooling techniques.
CO5:Understand different types of data formats and explore the applications of AM processes in various fields.

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IV Year - I Semester		L	T	P	C
		3	0	0	3
NON DESTRUCTIVE EVALUATION (PE-5)					

Course Objectives:
1) To learn basic concepts of non-destructive testing and industrial applications
2) To learn the elements of ultrasonic test and limitations of ultrasonic test
3) To learn the concepts involved in the liquid penetrant test and eddy current test
4) To learn the basic principles and operating procedures of magnetic particle testing
5) To learn the basic concepts involved in the infrared and thermal testing

UNIT– I:
Introduction to non-destructive testing and industrial Applications of NDE: Span of NDE Activities Railways, Nuclear, Non-nuclear and Chemical Industries, Aircraft and Aerospace Industries, Automotive Industries, Offshore Gas and Petroleum Projects, Coal Mining Industry, NDE of pressure vessels, castings, welded constructions.
Radiographic test**,** Sources of X and Gamma Rays and their interaction with Matter, Radiographic equipment, Radiographic Techniques, Safety Aspects of Industrial Radiography, neutron ray radiography

UNIT– II:
Ultrasonic test: Principle of Wave Propagation, Reflection, Refraction, Diffraction, Mode Conversion and Attenuation, Sound Field, Piezo-electric Effect, Ultrasonic Transducers and their Characteristics, Ultrasonic Equipment and Variables Affecting Ultrasonic Test, Ultrasonic Testing, Interpretations and Guidelines for Acceptance, Rejection - Effectiveness and Limitations of Ultrasonic Testing.

UNIT– III:
Liquid Penetrant Test: Liquid Penetrant Test, Basic Concepts, Liquid Penetrant System, Test Procedure, Effectiveness, DPI, FPI, Limitations of Liquid Penetrant Testing**.**
Eddy Current Test: Principle of Eddy Current, Eddy Current Test System, Applications of Eddy Current Testing Effectiveness of Eddy Current Testing

UNIT– IV:
Magnetic Particle Test: Magnetic Materials, Magnetization of Materials , Demagnetization of Materials, Principle of Magnetic Particle Test, Magnetic Particle Test Equipment, Magnetic Particle Test Procedure, Standardization and Calibration, Interpretation and Evaluation, Effective Applications and Limitations of the Magnetic Particle Test

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UNIT– V:
Infrared And Thermal Testing: Introduction and fundamentals to infrared and thermal testing–Heat transfer –Active and passive techniques –Lock in and pulse thermography, tomography-Contact and non-contact thermal inspection methods–Heat sensitive paints –Heat sensitive papers –-thermally quenched phosphors liquid crystals –techniques for applying liquid crystals –other temperature sensitive coatings –Inspection methods –Infrared radiation and infrared detectors–thermo mechanical behaviour of materials–IR imaging in aerospace applications, electronic components, Honey comb and sandwich structures–Case studies.

TEXTBOOKS:

1. Nondestructive test and evaluation of Materials/J Prasad, GCK Nair/TMH Publishers
2. Ultrasonic testing of materials/ H Kraut Kramer/Springer
3. Nondestructive testing/Warren, J Mc Gonnagle / Godan and Breach Science publishers
4. Nondestructive evaluation of materials by infrared thermography / X. P. V. Maldague, Springer-Verlag, 1st edition, (1993)

REFERENCES:

1. Ultrasonic inspection training for NDT/E.A.Gingel/PrometheusPress,
2. ASTMStandards,Vol3.01,Metalsandalloys
3. Non-destructive, Hand Book – R. HamChand

Course Outcomes: At the end of the course, student will be able to

CO1: Understand the concepts of various NDE techniques and the requirements of radiographytechniques and safety aspects.
CO2: Interpret the principles and procedure of ultrasonic testing (BL-2).
CO3: Understand the principles and procedure of Liquid penetration and eddy current testing.
CO4: Illustrate the principles and procedure of Magnetic particle testing.
CO5:Interpret the principles and procedure of infrared testing and thermal testing.

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IV Year - I Semester		L	T	P	C
		3	0	0	3
	ADDITIVE MANUFACTURING (OE-3)				

Course Objectives:
1) To understand the principles of prototyping, classification of RP processes and liquid-based RP systems
2) To understand and apply different types of solid-based RP systems.
3) To understand and apply powder-based RP systems.
4) To understand and apply various rapid tooling techniques.
5) To understand different types of data formats and to explore the applications of AM processes in various fields.

UNIT– I:
INTRODUCTION: Prototyping fundamentals, historical development, fundamentals of rapid prototyping, advantages and limitations of rapid prototyping, commonly used terms, classification of RP process.
LIQUID-BASED RAPID PROTOTYPING SYSTEMS: Stereo lithography Apparatus (SLA): models and specifications, process, working principle, photopolymers, photo polymerization, layering technology, laser and laser scanning, applications, advantages and disadvantages, case studies. Solid Ground Curing (SGC): models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

UNIT– II:
SOLID-BASED RAPID PROTOTYPING SYSTEMS: Laminated object manufacturing (LOM) - models and specifications, process, working principle, applications, advantages and disadvantages, case studies. Fused deposition modelling (FDM) - models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

UNIT– III:
POWDER BASED RAPID PROTOTYPING SYSTEMS: Selective laser sintering (SLS): models and specifications, process, working principle, applications, advantages and disadvantages, case studies. three dimensional printing (3DP): models and specifications, process, working principle, applications, advantages and disadvantages, case studies.

UNIT– IV:
RAPID TOOLING: Introduction to rapid tooling (RT), conventional tooling Vs RT, Need for RT. rapid tooling classification: indirect rapid tooling methods: spray metal deposition, RTV epoxy tools, Ceramic tools, investment casting, spin casting, die casting, sand casting process. Direct rapid tooling: Direct AIM, LOM Tools, and Direct Metal Tooling using 3DP.

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UNIT– V:
RAPID PROTOTYPING DATA FORMATS: STL Format, STL File Problems, consequence of building valid and invalid tessellated models, STL file Repairs: Generic Solution, other Translators, and Newly Proposed Formats. RP **APPLICATIONS**: Application in engineering, analysis and planning, aerospace industry, automotive industry, jewelry industry, coin industry, GIS application, RP medical and bioengineering applications: customized implants and prosthesis, forensic sciences.

TEXT BOOKS:
1. Rapid prototyping: Principles and Applications /Chua C.K., Leong K.F. and LIM C.S/World Scientific publications

REFERENCES:
1. Rapid Manufacturing / D.T. Pham and S.S. Dimov/Springer
2. Wohlers Report 2000 /Terry T Wohlers/Wohlers Associates
3. Rapid Prototyping & Manufacturing / Paul F.Jacobs/ASME Press
4. Rapid Prototyping / Chua & Liou

Course Outcomes: At the end of the course, student will be able to
CO1: Understand the principles of prototyping, classification of RP processes and liquid-based RP systems.
CO2: Understand and apply different types of solid-based RP systems.
CO3: Apply powder-based RP systems
CO4: Analyze and apply various rapid tooling techniques.
CO5: Understand different types of data formats and explore the applications of AM processes in various fields.

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY KAKINADA
KAKINADA–533003, Andhra Pradesh, India
DEPARTMENT OF MECHANICAL ENGINEERING

IV Year - I Semester		L	T	P	C
		3	0	0	3
	MECHATRONICS (OE-3)				

Course Objectives:
1. To understand the use the various mechatronics systems, measurement systems, sensors and transducers.
2. To apply the concepts of solid state electronic devices.
3. To identify the components in the design of electro mechanical systems.
4. To apply the concepts of digital electronics and applications of PLCs for control.
5. To understand system interfacing, data acquisition and design of mechatronics systems.

UNIT– I:
Mechatronics systems – elements & levels of mechatronics system, Mechatronics design process, system, measurement systems, control systems, microprocessor-based controllers, advantages and disadvantages of mechatronics systems. Sensors and transducers, types, displacement, position, proximity, velocity, motion, force, acceleration, torque, fluid pressure, liquid flow, liquid level, temperature and light sensors.

UNIT– II:
Solid state electronic devices - PN junction diode, BJT, FET, DIAC, TRIAC and LEDs. Analog signal conditioning, operational amplifiers, noise reduction, filtering

UNIT– III:
Hydraulic and pneumatic actuating systems - Fluid systems, Hydraulic systems, and pneumatic systems, components, control valves, electro-pneumatic, hydro-pneumatic, electro-hydraulic servo systems. Mechanical actuating systems and electrical actuating systems – basic principles and elements.

UNIT– IV:
Digital electronics and systems, digital logic control, microprocessors and micro controllers, programming, process controllers, programmable logic controllers, PLCs versus computers, application of PLCs for control.

UNIT– V:
System interfacing and data acquisition – Data Acquisition Systems, Analog to Digital and Digital to Analog conversions; Digital Signal Processing – data flow in DSPs, block diagrams, typical layouts, Interfacing motor drives. Design of mechatronics systems & future trends.

TEXT BOOKS:
1. MECHATRONICS Integrated Mechanical Electronics Systems/KP Ramachandran, GK Vijaya Raghavan & MS Balasundaram/WILEY India Edition

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REFERENCES:
1. Mechatronics /Smaili A, Mrad F/ Oxford Higher Education, Oxford UniversityPress
2. Mechatronics Source Book / Newton C Braga/ThomsonPublications,Chennai.
3. Mechatronics – N. Shanmugam / Anuradha AgenciesPublishers.
4. Mechatronics System Design / Devdasshetty/Richard/Thomson.
5. Mechatronics/M.D.Singh/J.G.Joshi/PHI.
6. Mechatronics – Electronic Control Systems in Mechanical and Electrical Engg. 4th Edition / W. Bolton/ Pearson,2012
7. Mechatronics – Principles and Application / Godfrey C. Onwubolu/Elsevier, Indianprint

Course Outcomes: At the end of the course, student will be able to

CO1: Understand the use the various mechatronics systems, measurement systems, sensors and transducers

CO2: Apply the concepts of solid state electronic devices.

CO3: Identify the components in the design of electro mechanical systems.

CO4: Apply the concepts of digital electronics and applications of PLCs for control.

CO5: Understand system interfacing, data acquisition and design of mechatronics systems.

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IV Year - I Semester		L	T	P	C
		3	0	0	3
	FINITE ELEMENT METHODS (OE-3)				

Course Objectives:
1) To learn basic principles of Variational methods
2) To learn the principles of Weighted residual methods
3) To understand the basic procedure of finite element method
4) To learn finite element modeling of two dimensional analysis
5) To learn the finite modeling using high order and isoparametric elements

UNIT– I:
Introduction to finite element method, variational methods-principles-establishment of natural variational principles, Rayleigh-Ritz method, least squares method.

UNIT– II:
Weighted residual methods, Galerkins method, weighted residual forms, piecewise trail functions, weak formulation, solving differential equations using weighted residual methods, one dimensional problems.

UNIT– III:
Discretization of domain, element shapes, discretization procedures, assembly of stiffness matrix, band width, node numbering, mesh generation, interpolation functions, local and global coordinates, convergence requirements, treatment of boundary conditions.

UNIT– IV:
Finite element modeling of two dimensional analysis and treatment of boundary conditions. Finite element modeling of four node rectangular element.

UNIT– V:
Higher order and iso-parametric elements: One dimensional, quadratic and cubic elements in natural coordinates, two dimensional four node iso-parametric elements and numerical integration.

TEXTBOOKS:
1. An introduction to Finite Element Method /JNReddy/McGraw-Hill

References:
1. Finite Element Method with applications in Engineering / YM Desai, Eldho& Shah /Pearson publishers
2. An introduction to Finite Element Method /JNReddy/McGraw-Hill
3. The Finite Element Method for Engineers–KennethH.Huebner, Donald L. Dewhirst, Douglas E. Smith and TedG. Byrom/John Wiley & sons (ASIA)Pvt Ltd.
4. The Finite Element Methods in Engineering /S.S.Rao/Pergamon.

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5. Finite Element Analysis: Theory and Application with Ansys, Saeed Moaveniu, Pearson Education
6. Finite Element Methods / Chen
7. Finite Element Analysis: for students & Practicing Engineers / G.Lakshmi Narasaiah / BSP Books Pvt. Ltd.

Course Outcomes: At the end of the course, student will be able to
CO1: Learn basic principles of variational methods
CO2: Learn the principles of Weighted residual methods.
CO3: Understand the basic procedure of finite element method
CO4: Learn finite element modeling of two dimensional analysis
CO5: Learn the finite modeling using high order and isoparametric elements

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DEPARTMENT OF MECHANICAL ENGINEERING

IV Year - I Semester		L	T	P	C
		3	0	0	3
INTRODUCTION TO ARTIFICIAL INTELLIGENCE & MACHINE LEARNING (OE-3)					

Course objectives:
1) To understand the basic concepts of artificial intelligence, neural networks and genetic algorithms.
2) To understand the principles of knowledge representation and reasoning.
3) To gain knowledge about bayesian and computational learning and machine learning.
4) To explore various machine learning techniques.
5) To understand the machine learning analytics and deep learning techniques.

UNIT– I:
Introduction: Definition of Artificial Intelligence, Evolution, Need, and applications in real world. Intelligent Agents, Agents and environments; Good Behavior-The concept of rationality, the nature of environments, structure of agents.
Neural Networks and Genetic Algorithms: Neural network representation, problems, perceptrons, multilayer networks and back propagation algorithms, Genetic algorithms.

UNIT– II:
Knowledge–Representation and Reasoning: Logical Agents: Knowledge based agents, the Wumpus world, logic. Patterns in Propositional Logic, Inference in First-Order Logic-Propositional vs first order inference, unification and lifting.

UNIT– III:
Bayesian and Computational Learning: Bayes theorem , concept learning, maximum likelihood, minimum description length principle, Gibbs Algorithm, Naïve Bayes Classifier, Instance Based Learning- K-Nearest neighbour learning
Introduction to Machine Learning (ML): Definition, Evolution, Need, applications of ML in industry and real world, classification; differences between supervised and unsupervised learning paradigms.

UNIT– IV:
Basic Methods in Supervised Learning: Distance-based methods, Nearest-Neighbors, Decision Trees, Support Vector Machines, Nonlinearity and Kernel Methods.
Unsupervised Learning: Clustering**,** K-means, Dimensionality Reduction, PCA and kernel.

UNIT– V:
Machine Learning Algorithm Analytics: Evaluating Machine Learning algorithms, Model, Selection, Ensemble Methods (Boosting, Bagging, and Random Forests).
Modeling Sequence/Time-Series Data and Deep Learning: Deep generative models, Deep Boltzmann Machines, Deep auto-encoders, Applications of Deep Networks.

TEXT BOOKS:

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1. Stuart Russell, Peter Norvig, Artificial Intelligence: A Modern Approach, 2/e, Pearson Education, 2010.
2. Tom M. Mitchell, Machine Learning, McGraw Hill, 2013.
3. Ethem Alpaydin, Introduction to Machine Learning (Adaptive Computation and Machine Learning), The MIT Press, 2004.

REFERENCE BOOKS:
1. Elaine Rich, Kevin Knight and Shivashankar B. Nair, Artificial Intelligence, 3/e, McGraw Hill Education, 2008.
2. Dan W. Patterson, Introduction to Artificial Intelligence and Expert Systems, PHI Learning, 2012.
3. T. Hastie, R. Tibshirani, J. H. Friedman, The Elements of Statistical Learning, 1/e, Springer, 2001.
4. Bishop, C. M., Pattern Recognition and Machine Learning, Springer, 2006.
5. M. Narasimha Murty, Introduction to Pattern Recognition and Machine Learning, World Scientific Publishing Company, 2015.

Course outcomes: At the end of the course, student will be able to
CO1: Discuss basic concepts of artificial intelligence, neural networks and genetic algorithms.
CO2: Apply the principles of knowledge representation and reasoning.
CO3: Learn about bayesian and computational learning and machine learning.
CO4: Utilize various machine learning techniques.
CO5: Apply the machine learning analytics and deep learning techniques.

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IV Year - I Semester		L	T	P	C
		3	0	0	3
	OPTIMIZATION TECHNIQUES (OE-4)				

Course Objectives:
1) To understand classification of optimization problem and apply classical optimization techniques
2) To apply unconstrained optimization techniques using various methods
3) To understand the characteristics and approaches of constrained optimization techniques
4) To obtain optimized solutions using constrained and unconstrained geometric programming
5) To understand integer programming methods

UNIT– I:
INTRODUCTION TO OPTIMIZATION: Engineering applications of optimization- statement of an optimization problem- classification of optimization problem- optimization techniques.
CLASSICAL OPTIMIZATION TECHNIQUES: Single variable optimization- multivariable optimization with equality constraints- multivariable optimization with inequality constraints.

UNIT– II:
UNCONSTRAINED OPTIMIZATION TECHNIQUES: Pattern search method- Rosenbrock's method of rotating coordinates- Simplex method- Descent methods- Gradient of function- Steepest Descent method.

UNIT– III:
CONSTRAINED OPTIMIZATION TECHNIQUES: Characteristics of constrained problem methods of feasible directions - basic approach in the penalty function method- interior penalty function method- convex programming problem- exterior penalty function method.

UNIT– IV:
GEOMETRIC PROGRAMMING (G.P): Solution of an unconstrained geometric programming, differential calculus method and arithmetic method. primal dual relationship and sufficiency conditions. Solution of a constrained geometric programming problem (G.P.P). Complimentary geometric programming (C.G.P)

UNIT– V:
INTEGER PROGRAMMING (I.P): Graphical representation. Gomory's cutting plane method. Algorithm for zero-one programming problem. Integer non-linear programming.

TEXT BOOK:
1. Optimization Theory and Applications/ S.S.Rao/Wiley Eastern Limited, New Delhi.

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IV Year - I Semester		L	T	P	C
		3	0	0	3
	SMART MANUFACTURING (OE-4)				

Course objectives:
1) To apply knowledge of smart manufacturing systems' components in the context of Industry 4.0
2) To understand the concepts of smart machines and smart sensors
3) To understand and apply the concepts of IoT connectivity to Industry 4.0
4) To understand the concepts of Digital Twin and apply Machine Learning and Artificial Intelligence concepts in Manufacturing
5) To understand the concepts of Metaverse.

UNIT– I:
Concepts of Smart Manufacturing: Definition and key characteristics of smart manufacturing, Corporate adaptation processes, manufacturing challenges, challenges vs technologies, Stages in smart manufacturing. Minimizing Six big losses in manufacturing with Industry 4.0, and their benefits

UNIT– II:
Smart Machines and Smart Sensors: Concept and Functions of a Smart, Machine Salient features and Critical Subsystems of a Smart Machine, Smart sensors; smart sensors ecosystem, need, benefits and applications of sensors in industry, Introduction to IoT, IIoT, and Cyber physical systems, Sensing for Manufacturing Process in IIoT, Block Diagram of an IoT Sensing Device, Sensors in IIoT Applications, Smart Machine Interfaces,

UNIT– III:
IoT connectivity for Industry 4.0: Industrial communication requirement and its infrastructure, an overview of different types of networks, mesh network in industrial IoT, IoT protocols and the internet, TCP/IP (transmission control protocol/internet protocol) model, IoT connectivity standards: common protocols, application layer protocols, internet/network layer protocols, physical layer IoT protocols, choosing the right IoT connectivity protocol.

UNIT– IV:
Digital Twin: Introduction, applications of digital twins, impact zones of digital twins in manufacturing (factories/plants and OEMs), advantages of digital twins, basic steps of digital twin technology
Machine Learning (ML) and Artificial Intelligence (AI) in Manufacturing: Introduction, benefits and applications of ML in industries, common approaches of ML; supervised and unsupervised, semi-supervised and reinforced ML.

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UNIT– V:
Metaverse – Basic concepts, AR/VR, Social Metaverse, Industrial Metaverse, How Web 3.0 is changing the Internet, Asset Classes Inside the Metaverse, Land, Coins, Characters/ Avatars, Skins, Utility, Industries Disrupted by the Metaverse, Smart wearables.

TEXT BOOKS:
1. Industry 4.0, The Industrial Internet of Things by Alasdair Gilchrist, Apress
2. Industrial Internet of Things, Cyber Manufacturing System by Sabina Jeschke, Christian Brecher, Houbing Song Danda B. Rawat, Springer

REFERENCES:
1. The Metaverse: And how it will revolutionize everything/Matthew Ball/Liveright Publishers

Course Outcomes: At the end of the course, student will be able to
CO1: Learn about smart manufacturing systems' components and can handle it more effectively in context of Industry 4.0
CO2: Learn about the smart machines and smart sensors
CO3: Apply IoT to Industry 4.0 and they are able to make a system tailor-made as per requirement of the industry
CO4: Learn about concepts of Digital Twin and able to apply Machine Learning and Artificial Intelligence concepts in Manufacturing
CO5: Learn the concepts of AR/VR and Metaverse platform

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IV Year - I Semester		L	T	P	C
		3	0	0	3
	SAFETY ENGINEERING (OE-4)				

Course objectives:
1) To understand the concepts of industrial safety and management.
2) To demonstrate the accident preventions and protective equipment.
3) To understand and apply the knowledge of safety acts
4) To have the knowledge about fire prevention and protection systems
5) To understand and apply fire safety principles in buildings

UNIT - I
INTRODUCTION TO THE DEVELOPMENT OF INDUSTRIAL SAFETY AND MANAGEMENT: History and development of Industrial safety: Implementation of factories act, Safety and productivity, Safety organizations. Safety committees and structure, Role of management and role of Govt. in industrial safety.

UNIT - II
ACCIDENT PREVENTIONS AND PROTECTIVE EQUIPMENT: Personal protective equipment, Survey the plant for locations, Part of body to be protected, Education and training in safety, Prevention causes and cost of accident, Housekeeping, First aid, Accident reporting, Investigations. Industrial psychology in accident prevention, Safety trials, Safety related to operations.

UNIT - III
SAFETY ACTS: Features of Factory Act, Introduction of Explosive Act, Boiler Act, ESI Act, Workman's compensation Act, Industrial hygiene, Occupational safety, Diseases prevention, Ergonomics, Occupational diseases, stress, fatigue, health, safety and the physical environment, Engineering methods of controlling chemical hazards, safety and the physical environment, Control of industrial noise and protection against it, Code and regulations for worker safety and health, codes for safety of systems.

UNIT - IV
FIRE PREVENTION AND PROTECTION: Sources of ignition – fire triangle – principles of fire extinguishing – active and passive fire protection systems – various classes of fires – A, B, C, D, E- Fire extinguishing agents- Water, Foam, Dry chemical powder, Carbon-dioxide Halon alternatives Halocarbon compounds-Inert gases, dry powders – types of fire extinguishers – fire stoppers – hydrant pipes – hoses – monitors – fire watchers – layout of stand pipes – fire station- fire alarms and sirens – maintenance of fire trucks – foam generators – escape from fire rescue operations – fire drills – first aid for burns.

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UNIT- V
BUILDING FIRE SAFETY: Objectives of fire safe building design, Fire load, fire resistant material and fire testing – structural fire protection – structural integrity – concept of egress design - exit – width calculations - fire certificates – fire safety requirements for high rise buildings.

TEXT BOOKS:
1) Industrial Maintenance Management Srivastava, S.K. - S. Chand and Co.
2) Occupational Safety Management and Engineering Willie Hammer – Prentice Hall
3) Purandare D.D & Abhay D.Purandare, "Hand book on Industrial Fire Safety" P & A publications, New Delhi, 2006.
4) McElroy, Frank E., "Accident Prevention Manual for Industrial Operations", NSC, Chicago, 1988.
5) Green, A.E., "High Risk Safety Technology", John Wiley and Sons, 1984.

REFERENCE BOOKS:
1) Installation, Servicing and Maintenance Bhattacharya, S.N. - S. Chand andCo.
2) Jain V K "Fire Safety in Building" New Age International 1996.
3) Occupational Safety Management and Engineering Willie Hammer – Prentice Hall
4) Reliability, Maintenance and Safety Engineering by Dr. A. K. Guptha
5) A Textbook of Reliability and Maintenance Engineering by Alakesh Manna

Course outcomes:
CO1: Students learn the concepts of industrial safety and management.
CO2: Learn about the smart machines and smart sensors
CO3: Apply IoT to Industry 4.0 and they are able to make a system tailor-made as per requirement of the industry
CO4: Students learn about fire prevention and protection systems.
CO5: Students learn and apply the fire safety principles in buildings

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IV Year - I Semester		L	T	P	C
		3	0	0	3
	OPERATIONS MANAGEMENT (OE-4)				

Course Objectives:
1) To develop the skills of forecasting, production systems and Aggregate Planning.
2) To provide the knowledge of materials management and scheduling policies
3) To understand the principles of inventory control, MRP and contemporary management techniques.
4) To guide in learning the key concepts and issues of quality management in both manufacturing and service organizations.
5) To develop the knowledge and skill to find out the optimum solutions for a given situation using optimization techniques.

UNIT – I:
Forecasting: Introduction, types of forecasting and their uses, General principles of forecasting, forecasting techniques: qualitative and quantitative methods of Forecasting.
Production Systems: Types of production systems: job, batch, mass and flow type production.
Aggregate Planning: Introduction, aggregate planning strategies, aggregate planning methods, problems

UNIT – II:
Scheduling: Introduction, difference with loading, scheduling policies, techniques, standard scheduling methods.
Materials Management: Introduction, functions of materials management, inventory, inventory management, types of inventories, Selective inventory control techniques: ABC analysis, VED analysis.

UNIT – III:
Inventory Control: P and Q Systems, Basic Economic Order Quantity model, Price break model, assumptions and problems
Material Requirement Planning: Introduction, Inputs, outputs and MRP logic.
Contemporary management techniques: Introduction to Lean, JIT, ERP and Supply chain Management.

UNIT – IV:
Quality Management: Quality engineering, Taguchi Principles, SQC – X bar, p and c charts, problems, Juran's principles Introduction to quality acceptance sampling.
Deming's Philosophy, Introduction to Total quality management, Quality Function Deployment, Introduction to six sigma and ISO 9000 2015 standards.

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UNIT – V:
Optimization: Linear Programming – Graphical and simplex method – problems, Demonstration of Transportation and Assignment Models, Travelling Salesman problem.

TEXT BOOKS:
1. Modern Production/ operations managements / Baffa & Rakesh Sarin
2. Operations Management – an Integrated Approach, International student Version, R. Dan Reid and Nada R. Sanders, John Wiley & Sons
3. Production and Operations management by K. C. Jain, Wiley
4. Operations Management by William J. Stevenson, McGraw-Hill Companies 2015
5. SOperations Management by Jay Heizer , Barry Render, Chuck Munson , Amit Sachan Twelfth Edition, Pearson, 2017

REFERENCES:
1. Maynard's Industrial Engineering Handbook, Kjell B. Zandin, Fifth Edition 2001, The McGraw-Hill Companies, Inc.
2. Operations Management S.N. Chary.
3. Inventory Control Theory and Practice / Martin K. Starr and David W. Miller.

Course Outcomes: At the end of the course, student will be able to
CO1: Apply appropriate forecasting techniques & Aggregate planning methods
CO2: Learn Materials management analysis and scheduling policies
CO3: Learn about the inventory control techniques, MRP and contemporary management techniques.
CO4: Apply quality management principles proposed by Taguachi, Juran & Demigs
CO5: Apply optimization to LP model & transportation and assignment problems

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IV Year - I Semester		L	T	P	C
		3	0	0	3
Universal Human Values: Understanding Harmony					

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IV Year -I Semester		L	T	P	C
		0	0	4	2
MECHATRONICS LAB					

Course Objectives:
1) Measure load, displacement and temperature using analogue and digital sensors.
2) Develop PLC programs for control of traffic lights, water level, lifts and conveyor belts.
3) Simulate and analyze PID controllers for a physical system using MATLAB.
4) Develop pneumatic and hydraulic circuits using Automation studio.

List of Experiments

1. DYNA 1750 Transducers Kit :-
    a. Characteristics of LVDT
    b. Principle & Characteristics of Strain Gauge
    c. Characteristics of Summing Amplifier
    d. Characteristics of Reflective Opto Transducer
2. PLC PROGRAMMING & Simulation of Allen Bradley, Siemens or IEC Ladder Using Automation Studio
    a. Ladder programming on Logic gates ,Timers (TON,TOFF) &counters (UP,DOWN)
    b. Ladder Programming for digital &Analogy sensors
    c. Ladder programming & Simulations of Virtual System such as Traffic Light control, Washing machine, Garage Door, Water level control, Lift control, Conveyor Belt etc.
    d. Ladder programming to control circuits such as single solenoid spring return latch circuit, double solenoid Hydraulic / Pneumatic circuits, Self-Reciprocating Hydraulic / Pneumatic Circuit.
3. AUTOMATION STUDIO SOFTWARE (Design, Simulate & Analyze)
    a. Introduction to Automation studio & its control.
    b. Draw & Simulate Hydraulic circuits for series &parallel cylinders connection, Accumulator circuit, Pressure intensifier circuit, Simple Electro- Hydraulic Electro - Pneumatic circuits (Plot Waveforms for different parameters).
    c. Design & Simulate Meter-in, Meter-out, Regenerative circuit, sequencing circuit, traverse and feed hydraulic circuit, hydraulic press and clamping.
    d. Position Control of Proportional Servo Valve Circuit using PID Feedback controller.
4. MATLAB Programming
    a. Sample programs on Mat lab
    b. Simulation and analysis of PID controller using SIMULINK

Course Outcomes: At the end of the course, student will be able to .
CO1: Understand the Characteristics of LVDT
CO2: Measure load, displacement and temperature using analogue and digital sensors.
CO3: Develop PLC programs for control of traffic lights, water level, lifts and conveyor belts.
CO4: Simulate and analyze PID controllers for a physical system using MATLAB.
CO5: Develop pneumatic and hydraulic circuits using Automaton studio.

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SUBJECTS FOR B.Tech (MINOR) in MECHANICAL ENGINEERING

MINOR		**L**	**T**	**P**	**C**
		4	**0**	**0**	**4**
	BASIC THERMODYNAMICS				

Course Objectives:
1) To understand the basic concepts like thermodynamic system, its boundary, related fundamental definitions and distinguish between point function and path function.
2) To understand and learn the energy conservation principle, concept of equality of temperature, principle of operation of various temperature measuring devices and applications of various flow systems.
3) To understand and apply the thermodynamics principles to heat engines & refrigerator/ heat pump and analyze the concepts of Carnot cycle, entropy, availability and irreversibility, Maxwells relations and thermodynamic functions.
4) To understand the process of steam formation and its representation on property diagrams with various phase changes and should be able to calculate the quality of steam after its expansion in a steam turbine, with the help of standard steam tables and charts.
5) To understand and apply Psychrometric chart and calculate various psychrometric properties of air.

UNIT – I
Introduction: Basic Concepts : System, boundary, Surrounding, control volume, Universe, Types of Systems, Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic Equilibrium, State, Property, Process - Reversible, Quasi static & Irreversible Processes, cycle, Energy in State and in Transition - Types, Work and Heat, Point and Path function

UNIT II
Zeroth Law of Thermodynamics – Concept of Temperature - Joule's Experiments – First law of Thermodynamics – Corollaries – First law applied to a Process – applied to a flow system – Steady Flow Energy Equation. PMM-I, throttling and free expansion processes.

UNIT – III
Limitations of the First Law – Thermal Reservoir, Heat Engine, Heat pump, Parameters of performance, Second Law of Thermodynamics, Kelvin-Planck and Clausius Statements and their Equivalence, Corollaries, PMM of Second kind, Carnot's principle, Carnot cycle and its specialties, Thermodynamic scale of Temperature, Clausius Inequality, Entropy, Principle of Entropy Increase.

UNIT IV
Pure Substances, P-V-T- surfaces, T-S and h-s diagrams, Mollier Charts, Phase Transformations – Triple point and critical point, properties during change of phase, Dryness Fraction – Clausius – Clapeyron Equation, Property tables. Various Thermodynamic processes and energy Transfer.

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UNIT – V

Mixtures of perfect Gases – Mole Fraction, Mass friction Gravimetric and volumetric Analysis – Dalton's Law of partial pressure, Avogadro's Laws of additive volumes – Mole fraction , Volume fraction and partial pressure, Equivalent Gas const. And Molecular Internal Energy, Enthalpy, sp. Heats and Entropy of Mixture of perfect Gases and Vapour, Atmospheric air - Psychrometric Properties – Dry bulb Temperature, Wet Bulb Temperature, Dew point Temperature, Thermodynamic Wet Bulb Temperature, Specific Humidity, Relative Humidity, saturated Air, Vapour pressure, Degree of saturation – Adiabatic Saturation , Carrier's Equation – Psychrometric chart.

TEXT BOOKS:

1. Engineering Thermodynamics, PK Nag 4th Edn, TMH.
2. Treatise on Heat Engineering (MKS and SI units), VP Vasandani, DS Kumar, Metropolitan books.

REFERENCES:

1. Engineering Thermodynamics – Jones & Dugan PHI
2. Thermodynamics – J.P.Holman, McGraw-Hill
3. Basic Engineering Thermodynamics – A.Venkatesh – Universities press.
4. An Introduction to Thermodynamics - Y.V.C.Rao – Universities press.
5. Thermodynamics – W.Z.Black & J.G.Hartley, 3rd Edn Pearson Publ.
6. Engineering Thermodynamics – D.P.Misra, Cengage Publ.
7. Engineering Thermodynamics – P.Chattopadhyay – Oxford Higher Edn Publ.

Course Outcomes: After undergoing the course the student is expected to learn

CO1: Basic concepts like thermodynamic system, its boundary, related fundamental definitions and distinguish between point function and path function.

CO2: Energy conservation principle, concept of equality of temperature, principle of operation of various temperature measuring devices and applications of various flow systems.

CO3: Thermodynamics principles to heat engines & refrigerator/ heat pump and analyse the concepts of Carnot cycle, entropy, availability and irreversibility, Maxwells relations and thermodynamic functions.

CO4: Process of steam formation and its representation on property diagrams with various phase changes and should be able to calculate the quality of steam after its expansion in a steam turbine, with the help of standard steam tables and charts.

CO5:To calculate various psychrometric properties of air using psychrometric charts.

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MINOR		L	T	P	C
		4	0	0	4
	MANUFACTURING PROCESSES				

Course objectives:
1) To understand the basic concepts and principles of casting of different casting techniques
2) To learn the principles of metal cutting and different machine tools
3) To understand the principles of various welding processes
4) To understand the various metal forming process.
5) To understand the fundamentals of sheet metal forming with force and power requirements

UNIT-1
CASTING: Steps involved in making a casting – Advantage of casting and its applications, Patterns and Pattern making – Types of patterns – Materials used for patterns, pattern allowances Basic principles and applications of casting processes - Centrifugal casting – True, semi and centrifuging, Die casting, Investment casting and shell molding, Casting defects.

UNIT- II
MACHINING PROCESSES: Elementary treatment of metal cutting theory – element of cutting process – Principles of turning, drilling, milling, planning, slotting, shaping, grinding, and broaching and machine tools

UNIT– III
WELDING: Classification of welding processes, types of welded joints and their characteristics, Gas welding, Different types of flames and uses, Oxy – Acetylene Gas cutting. Basic principles of Arc welding, power characteristics, Manual metal arc welding, submerged arc welding, TIG & MIG welding. Electro – slag welding-Soldering & Brazing.

UNIT – IV
Metal FORMING PROCESS: Forging - Types of Forging, Smith forging, Drop Forging, Roll forging, forging hammers, Rotary forging, forging defects; Rolling – fundamentals, types of rolling mills and products, Forces in rolling and power requirements. Extrusion and its characteristics. Types of extrusion, Impact extrusion, Hydrostatic extrusion; Wire drawing and Tube drawing.

UNIT – V
SHEET METAL FORMING: Blanking and piercing, Forces and power requirement in these operations, Deep drawing, Stretch forming, Bending, Spring back and its remedies, Coining, Spinning, Types of presses and press tools.

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TEXT BOOK(S):
1. Manufacturing Technology (Foundation Forming & Welding)- P.N. Rao, Tata McGraw Hill.
2. Principles of manufacturing materials and processes- J.S.Campbell, Tata McGraw Hill.
3. Basic Manufacturing Process- D. Mishra IndiaTech Publisher, New Delhi.

REFERENCE(S):
1. Principles of manufacturing materials and processes- J.S.Campbell, Tata McGraw Hill.
2. Manufacturing Engineering and Technology, 4th Edition- S.Kalpakjian and S.R. Scsimid, Pearson Education.
3. Materials and processes in manufacturing- DeGarmo, Black and Kohser, Prentice Hall of India.
4. Principle of Metal Casting- Heine, Loper and Rosenthal, Tata McGraw Hill.

Course Outcomes: At the end of the course, student will be able to
CO1: Learn about the basic concepts of casting
CO2: Design the gating system for different metallic components
CO3: Understand the working principles of arc and gas welding processes.
CO4: Understand principles of Forging, rolling, extrusion and drawing processes.
CO5: Illustrate the various sheet metal forming processes for a specific application.

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DEPARTMENT OF MECHANICAL ENGINEERING

MINOR		L	T	P	C
		4	0	0	4
MATERIALS SCIENCE AND ENGINEERING					

Course Objective:
1) To understand the structure of metals and the necessity of alloying.
2) To understand the equilibrium diagrams and properties of alloys.
3) To obtain the knowledge about the ferrous alloys.
4) To understand the structure and properties of non-ferrous metals and alloys.
5) To understand the principles of heat treatment of alloys.

UNIT – I
Structure of Metals and Constitution of alloys: Bonds in Solids, Metallic bond, crystallization of metals, Packing Factor - SC, BCC, FCC& HCP-line density, plane density. Grain and grain boundaries, effect of grain boundaries on the Properties of metal / alloys – determination of grain size. Imperfections – point, line, surface and volume- Slip and Twinning.
Necessity of alloying, types of solid solutions, Hume Rotherys rules, intermediate alloy phases, and electron compounds

UNIT –II
Equilibrium Diagrams : Experimental methods of construction of equilibrium diagrams, Isomorphous alloy systems, equilibrium cooling and heating of alloys, Lever rule, coring miscibility gaps, eutectic systems, congruent melting intermediate phases, peritectic reaction. Transformations in the solid state – allotropy, eutectoid, peritectoid reactions, phase rule, relationship between equilibrium diagrams and properties of alloys. Study of binary phase diagrams such as Cu-Ni and Fe-Fe$_3$C.

UNIT – III
Ferrous Alloys: Structure and properties of White Cast iron, Malleable Cast iron, grey cast iron, Spheroidal graphite cast iron, Alloy cast irons. Classification of steels, structure and properties of plain carbon steels, Low alloy steels, Hadfield manganese steels, tool and die steels.

UNIT – IV
Non-ferrous Metals and Alloys: Structure and properties of Copper and its alloys, Aluminium and its alloys, Titanium and its alloys, Magnesium and its alloys, Super alloys.

UNIT – V
Heat treatment of Alloys: Effect of alloying elements on Fe-Fe$_3$C system, Annealing, normalizing, hardening, TTT diagrams, tempering, hardenability, surface - hardening methods, Age hardening treatment, Cryogenic treatment of alloys.

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TEXT BOOKS:
1. Introduction to Physical Metallurgy - Sidney H. Avner -McGraw-Hill
2. Essential of Materials science and engineering - Donald R.Askeland -Cengage.

REFERENCES:
1. Material Science and Metallurgy – Dr. V.D.kodgire- Everest PublishingHouse
2. Materials Science and engineering – Callister&Baalasubrahmanyam- Wiley Publications
3. Material Science for engineering students – Fischer – ElsevierPublishers
4. Material science and Engineering - V. Rahghavan – PHIPublishers
5. Introduction to Material Science and Engineering – Yip-Wah Chung CRCPress
6. Material Science and Metallurgy – A V K Suryanarayana – B SPublications
7. Material Science and Metallurgy – U. C. Jindal – PearsonPublications

Course Outcomes: At the end of the course, students will be able
CO1: To learn the structure of metals and the necessity of alloying.
CO2: To learn the equilibrium diagrams and properties of alloys.
CO3: To learn about the ferrous alloys.
CO4: To learn the structure and properties of non-ferrous metals and alloys.
CO5: To learn the principles of heat treatment of alloys.

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DEPARTMENT OF MECHANICAL ENGINEERING

MINOR		L	T	P	C
		4	0	0	4
	BASIC MECHANICAL DESIGN				

Course Objectives:
1) To understand the design procedure of engineering problems with constraints.
2) To measure the stress concentration and strength of machine elements
3) To understand the principles and apply to design the riveted and welded joints.
4) To understand design principles to design shafts and shaft couplings under different loading conditions.
5) To have knowledge of mechanical springs and apply principles to design springs for different loading conditions.

UNIT-I
INTRODUCTION: General considerations in the design of Engineering Materials and their properties – selection –Manufacturing consideration in design, tolerances and fits –BIS codes of steels- ASHBY Charts.
STRESSES IN MACHINE MEMBERS: Simple stresses – combined stresses – torsional and bending stresses – impact stresses – stress strain relation – various theories of failure – factor of safety – design for strength and rigidity – preferred numbers-concept of stiffness in tension, bending, torsion and combined situations – static strength design based on fracture toughness.

UNIT-II
STRENGTH OF MACHINE ELEMENTS: Stress concentration – theoretical stress concentration factor – fatigue stress concentration factor notch sensitivity – design for fluctuating stresses – endurance limit – estimation of endurance strength – Goodman's line – Soderberg's line – modified Goodman's line

UNIT-III
RIVETED AND WELDED JOINTS – design of joints with initial stresses – eccentric loading. Bolted joints – design of bolts with pre-stresses – design of joints under eccentric loading – locking devices – both of uniform strength, different seals.

UNIT-IV
SHAFTS: Design of solid and hollow shafts for strength and rigidity – design of shafts for combined bending and axial loads – shaft sizes – BIS code- Use of internal and external circlips-gaskets and seals (stationary & rotary).
SHAFT COUPLINGS: Rigid couplings – muff, split muff and flange couplings.

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UNIT-V   DEPARTMENT OF MECHANICAL ENGINEERING
MECHANICAL SPRINGS:
Stresses and deflections of helical springs – extension -compression springs – springs for fatigue loading, energy storage capacity – helical torsion springs – co-axial springs, leaf springs.
Note: Design data book is NOT Permitted for examination.

TEXT BOOKS:
1. Machine design / NC Pandya & CS Shah/Charotar Publishing House Pvt. Limited
2. Machine Design/V.B.Bhandari/ McGraw-Hill Education

REFERENCES:
1. Design of Machine Elements / V.M. Faires/McMillan
2. Machine design / Schaum Series/McGraw-Hill Professional
3. Machine Design/ Shigley, J.E/McGraw Hill.
4. Design data handbook/ K.Mahadevan& K. Balaveera Reddy/ CBS publishers.
5. Machine Design –Norton/ Pearson publishers

Course outcomes: At the end of course, students will be able to
CO1: Learn the design procedure of engineering problems with constraints.
CO2: Measure the stress concentration and strength of machine elements
CO3: Learn the principles and apply to design the riveted and welded joints.
CO4: Learn the design principles to design shafts and shaft couplings under different loading conditions.
CO5: Know about mechanical springs and apply the principles to design springs for different loading conditions.

MINOR		**L**	**T**	**P**	**C**
		4	**0**	**0**	**4**
	OPTIMIZATION TECHNIQUES				

Course Objectives:

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1) To understand the fundamentals of unconstrained and constrained optimization techniques.
2) To understand and apply unconstrained optimization techniques to solve problems.
3) To understand and apply constrained optimization techniques to solve problems.
4) To obtain optimized solutions using constrained and unconstrained geometric programming
5) To understand the principles of dynamic programming and its applications.

UNIT – I
INTRODUCTION TO OPTIMIZATION: Engineering applications of optimization- statement of an optimization problem- classification of optimization problem- optimization techniques.
CLASSICAL OPTIMIZATION TECHNIQUES: Single variable optimization- multivariable optimization with equality constraints- multivariable optimization with inequality constraints.

UNIT – II
UNCONSTRAINED OPTIMIZATION TECHNIQUES: Pattern search method- Rosenbrock's method of rotating coordinates- Simplex method- Descent methods- Gradient of function- Steepest Descent method.

UNIT – III
CONSTRAINED OPTIMIZATION TECHNIQUES: Characteristics of constrained problem methods of feasible directions - basic approach in the penalty function method- interior penalty function method- convex programming problem- exterior penalty function method.

UNIT – IV
GEOMETRIC PROGRAMMING (G.P): Solution of an unconstrained geometric programming, differential calculus method and arithmetic method. Primal dual relationship and sufficiency conditions. Solution of a constrained geometric programming problem (G.P.P). Complimentary geometric programming (C.G.P)

UNIT – V
DYNAMIC PROGRAMMING:
Introduction – Bellman's principle of optimality – applications of dynamic programming-shortest path problem – linear programming problem.

TEXT BOOK:
1. Optimization Theory and Applications/ S.S.Rao/Wiley Eastern Limited, New Delhi.

REFERENCES:
1. Engineering Optimization / Kalyanmanai Deb/Prentice Hall of India, New Delhi.
2. Optimization Techniques-Theory and applications/C.Mohan&Kusum Deep/New Age International
3. Operations Research /S.D.Sharma / MacMillan Publishers

Course outcomes: At the end of course, students will be able to
CO1: Learn the classification of optimization problems and classical optimization techniques.
CO2: Learn and apply unconstrained optimization techniques to solve problems.
CO3: Learn and apply constrained optimization techniques to solve problems.
CO4: Learn to obtain optimized solutions using constrained and unconstrained geometric
        programming.

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CO5: Learn the applications of micro and nano manufacturing.

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DEPARTMENT OF MECHANICAL ENGINEERING

MINOR		L	T	P	C
		4	0	0	4
POWER PLANT ENGINEERING					

Course Objectives:
1) To understand the sources of energy and concepts of steam power plant.
2) To design of components of steam, gas and diesel power plants.
3) To explain the principles of hydro power plant and nuclear power station.
4) To apply the concepts of nuclear reactors and understand the operations of different power plants.
5) To understand the principles and concepts relevant to power plant instrumentation, control, economics and environmental considerations.

UNIT – I
Introduction to the sources of energy – resources and development of power in India.
STEAM POWER PLANT: Plant layout, working of different circuits, fuel handling equipments, types of coals, coal handling, choice of handling equipment, coal storage, ash handling systems. Combustion: properties of coal – overfeed and underfeed fuel beds, traveling grate stokers, spreader stokers, retort stokers, pulverized fuel burning system and its components,

UNIT – II
STEAM POWER PLANT: Combustion needs and draught system, cyclone furnace, design and Construction, dust collectors, cooling towers and heat rejection. Corrosion and feed water treatment.
INTERNAL COMBUSTION AND GAS TURBINE POWER PLANTS:
DIESEL POWER PLANT: Plant layout with auxiliaries – fuel supply system, air starting equipment, super charging.
GAS TURBINE PLANT: Introduction – classification - construction – layout with auxiliaries, combined cycle power plants and comparison.

UNIT – III
HYDRO ELECTRIC POWER PLANT: Water power – hydrological cycle / flow measurement – drainage area characteristics – hydrographs – storage and pondage – classification of dams and spillways.
HYDRO PROJECTS AND PLANT: Classification – typical layouts – plant auxiliaries – plantoperation pumped storage plants.
NUCLEAR POWER STATION: Nuclear fuel – breeding and fertile materials – nuclear reactor – reactor operation.

UNIT – IV
TYPES OF NUCLEAR REACTORS: Pressurized water reactor, boiling water reactor, sodium-graphite reactor, fast breeder reactor, homogeneous reactor, gas cooled reactor, radiation hazards and shielding – radioactive waste disposal.

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COMBINED OPERATIONS OF DIFFERENT POWER PLANTS: Introduction, advantages of combined working, load division between power stations, storage type hydro-electric plant in combination with steam plant, run-of-river plant in combination with steam plant, pump storage plant in combination with steam or nuclear power plant, co-ordination of hydro-electric and gas turbine stations, co-ordination of hydro-electric and nuclear power stations, co-ordination of different types of power plants.

UNIT – V
POWER PLANT INSTRUMENTATION AND CONTROL: Importance of measurement and instrumentation in power plant, measurement of water purity, gas analysis, O_2 and CO_2 measurements, measurement of smoke and dust, measurement of moisture in carbon dioxide circuit, nuclear measurements, smart grids, power plant control room.
POWER PLANT ECONOMICS AND ENVIRONMENTAL CONSIDERATIONS: Capital cost, investment of fixed charges, operating costs, general arrangement of power distribution, load curves, load duration curve, definitions of connected load, maximum demand, demand factor, average load, load factor, diversity factor – related exercises. Effluents from power plants and Impact on environment –pollutants and pollution standards – methods of pollution control.

TEXT BOOKS:
1. A course in Power Plant Engineering /Arora and Domkundwar/Dhanpatrai & Co.
2. Power Plant Engineering /P.C.Sharma / S.K.Kataria Pub

REFERENCES:
1. Power Plant Engineering: P.K.Nag/ II Edition /TMH.
2. Power station Engineering – ElWakil / McGraw-Hill.
3. An Introduction to Power Plant Technology / G.D. Rai/Khanna Publishers

Course outcomes: At the end of the course, students will be able to
CO1:   Illustrate the functions of different components of steam power plant
CO2:   Describe basic working principles, performance characteristics and components of gas turbine and diesel power plants
CO3:   Illustrate basic working principles of hydroelectric power plants and analyze the importance of hydrological cycles, measurements and drainage characteristics
CO4:   Learn about the principal components and types of nuclear reactors
CO5:   Analyze the working of power plant instrumentation and estimate the economics of power plants

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DEPARTMENT OF MECHANICAL ENGINEERING		T	P	C
MINOR		4	0	0	4
AUTOMOBILE ENGINEERING				

Course Objectives:
1) To learn basic components and functions of automobile
2) To learn the various elements and working of transmission system of automobile
3) To learn the working of braking system and suspension system of automobile
4) To learn the concepts involved in the electrical system of automobile, engine.
5) To learn the concepts involved in the automobile electronic systems and engine service of different Parts

UNIT – I
INTRODUCTION: Components of four wheeler automobile – chassis and body – power unit – power transmission – rear wheel drive, front wheel drive, 4 wheel drive – types of automobileengines, engine construction, oil filters, oil pumps – crank case ventilation – engine service,reboring, decarbonisation, Nitriding of crank shaft.
STEERING SYSTEM: Steering geometry – camber, castor, king pin rake, combined angle train, center point steering. Types of steering mechanism – Ackerman steering mechanism, Davissteering mechanism, steering gears – types, steering linkages.

UNIT-II
TRANSMISSION SYSTEM: Clutches, principle, types, cone clutch, single plate clutch, multiplate clutch, magnetic and centrifugal clutches, fluid fly wheel – gear boxes, types, sliding mesh,construct mesh, synchro mesh gear boxes, epicyclic gear box, over drive torque converter. Propeller shaft – Hotch – Kiss drive, Torque tube drive, universal joint, differential rear axles –
Types – wheels and tyres.

UNIT – III
SUSPENSION SYSTEM: Objects of suspension systems – rigid axle suspension system, torsion bar, shock absorber, Independent suspension system.
BRAKING SYSTEM: Mechanical brake system, hydraulic brake system, master cylinder, and wheel cylinder tandem master cylinder requirement of brake fluid, pneumatic and vacuum brakes.

UNIT – IV
ELECTRICAL SYSTEM: Charging circuit, generator, current – voltage regulator – starting system, Bendix drive mechanism, solenoid switch, lighting systems, horn, wiper, fuel gauge – oil pressure gauge, engine temperature indicator etc.
ENGINE SPECIFICATION AND SAFETY SYSTEMS: Introduction- engine specifications with regard to power, speed, torque, no. of cylinders and arrangement, lubrication and cooling etc. Safety: Introduction, safety systems - seat belt, air bags, bumper, anti-lock brake system (ABS), wind shield, suspension sensors, traction control, mirrors, central locking and electric windows, speed control.

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UNIT-V
ENGINE EMISSION CONTROL: Introduction – types of pollutants, mechanism of formation, concentration measurement, methods of controlling-engine modification, exhaust gas treatment-thermal and catalytic converters-use of alternative fuels for emission control – National and International pollution standards
ENGINE SERVICE: Introduction, service details of engine cylinder head, valves and valve mechanism, piston-connecting rod assembly, cylinder block, crank shaft and main bearings, engine reassembly-precautions.

TEXT BOOKS:
1. Automotive Mechanics – Vol. 1 & Vol. 2 / Kirpal Singh/standard publishers
2. Automobile Engineering / William Crouse/TMH Distributors
3. Automobile Engineering/P.S Gill/S.K. Kataria& Sons/New Delhi.

REFERENCES:
1. Automotive Engines Theory and Servicing/James D. Halderman and Chase D. Mitchell Jr., / Pearson education Inc.
2. Automotive Engineering / K Newton, W.Steeds& TK Garrett/SAE
3. Automotive Mechanics: Principles and Practices/ Joseph Heitner/Van Nostrand Reinhold
4. Automobile Engineering / C Srinivasan/McGraw-Hill

Course Outcomes: Upon successful completion of this course the student should be able to:
CO1: Acquire the basic knowledge of anatomy of an automobile and realize the functions of various steering systems.
CO2: Understand the systems of automobile transmission systems
CO3: Understand various braking and suspension systems used in automobiles
CO4: Acquire the knowledge of engine specifications and safety systems and its components
CO5: Explain the systems of engine servicing and emission control systems

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DEPARTMENT OF MECHANICAL ENGINEERING	0	0	4
INDUSTRIAL ENGINEERING AND MANAGEMENT			

Course Objectives:
1) To understand the scientific principles of management to improve productivity.
2) To impart the knowledge of financial management.
3) To understand the types of plant layout and principles of statistical quality control
4) To explain the concepts of human resources management
5) To apply project management techniques in solving project related issues.

UNIT-I
Introduction: Definition of Industrial Engineering, development, applications, Role of an industrial engineer, Quantitative tools of IE, and productivity measurement, Concepts of Management, Importance, Functions of management, Scientific management, Taylor's principles, theory X and theory Y, Fayol's principles of management.

UNIT-II
Financial Management: Concept, meaning and functions of financial management, shares, bonds, debentures, time value of money, evaluation of financial alternatives, numerical problems. Capital budgeting - Marketing Management- Functions, strategies, channels of distributions. Operations Management: Importance, types of production, applications, work study, method study and time study, work sampling, PMTS, micro-motion study, rating techniques, MTM, work factor system, principles of Ergonomics, flow process charts, string diagrams and Therbligs.

UNIT-III
Plant layout: Definition, types and principles of plant layouts. Statistical Quality Control: Control charts and its applications- X, R and σ charts and their applications, numerical examples.

UNIT-IV
Human Resource management: Concept and functions of Human Resource Management, Industrial relations, Job-evaluation and merit rating, wage and salary administration. Value analysis: Value engineering, implementation procedure.

UNIT-V
Project management: PERT, CPM – differences, applications, critical path, determination of floats, importance, project crashing, smoothing and numerical examples.

TEXT BOOKS:
1. Industrial Engineering and Management by O.P Khanna, Khanna Publishers.
2. Industrial Engineering and Production Management, Martand Telsang, S.ChandCompany Ltd. New Delhi.

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REFERENCES:
1. Operations Management by J.G Monks, McGraw-Hill Publishers.
2. Production and Operations Management – R.Panneerselvam- PHI- 3rd Edition
3. Industrial Engineering by Banga & Sharma.
4. Principles of Management by Koontz O' Donnel, McGraw Hill Publishers.
5. PERT/CPM by L.S Srinath, East west Press.
6. Production and operations management by K.C Arora.
7. Statistical Quality Control by Gupta.
8. Manufacturing Organization and Management, Harold T. Amrine, John A. Ritchey, Colin L. Moodie &Joseph F. Kmec, Pearson
9. Essentials of HRM and IR: P.Subba Rao, Himalaya Publishing House, Hyderabad,2015.
10. Introduction to Management Science: Kumar, Rao, Chhalill, Cengage Learning, New Delhi, 2012.

Course outcomes: At the end of course, students will be able to
CO1: Learn the scientific principles of management to improve productivity.
CO2: Gain the knowledge of financial management.
CO3: Learn the types of plant layout and principles of statistical quality control.
CO4: Apply the concepts of human resources management.
CO5: Analyze project related issues and solve through project management techniques.

MINOR		L	T	P	C

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DEPARTMENT OF MECHANICAL ENGINEERING	0	0	4
PRODUCT DESIGN AND DEVELOPMENT			

Course Objectives:
1) To understand the basic concepts of product design process
2) To interpret the operations of product management and impact of manufacturing processes on product decisions
3) To understand concepts of risks and reliability of the products design.
4) To interpret the various testing procedure of the product design.
5) To understand the concepts of maintenance concepts and procedures of product design

UNIT-I
Product Design Process: Design Process Steps, Morphology of Design. Problem Solving and Decision Making: Problem-Solving Process, Creative Problem Solving, Invention, Brainstorming, Morphological Analysis, Behavioral Aspects of Decision Making, Decision Theory, Decision Matrix, Decision Trees. Modelling and Simulation: Triz, Role of Models in Engineering Design, Mathematical Modelling, Similitude and Scale Models, Computer Simulation, Geometric Modelling on Computer, Finite-Element Analysis.

UNIT-II
Product management: The operation of product management: Customer focus of product management, product planning process, Levels of strategic planning, Wedge analysis, Opportunity search, Product life cycle theory, assessment and practice.
Product development: Managing new products, Generating ideas, Sources of product innovation, selecting the best ideas, the political dimension of product design, Managing the product launch and customer feedback.
Product managers and manufacturing: The need for effective relationships, the impact of manufacturing processes on product decisions, Prototype planning, Productivity potentials, Management of product quality, Customer service levels.

UNIT-III
Risk and Reliability: Risk and Society, Hazard Analysis, Fault Tree Analysis. Failure Analysis and Quality: Causes of Failures, Failure Modes, Failure Mode and Effect Analysis, FMEA Procedure, Classification of Severity, Computation of Criticality Index, Determination of Corrective Action, Sources of Information, Copyright and Copying. Patent Literature

UNIT-IV
Product Testing; Thermal, vibration, electrical, and combined environments, temperature testing, vibration testing, test effectiveness. Accelerated testing and data analysis, accelerated factors. Weibull probability plotting, testing with censored data

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UNIT-V
Design For Maintainability: Maintenance Concepts and Procedures, Component Reliability, Maintainability and Availability, Fault Isolation in design and Self-Diagnostics. Product Design for Safety, Product Safety and User Safety Concepts, Examples of Safe Designs. Design Standardization and Cost Reduction: Standardization Methodology, Benefits of Product Standardization; International, National, Association and Company Level Standards; Parts Modularization

TEXT BOOKS:
1. Engineering Design, George E. Dieter, McGraw-Hill
2. Product Integrity and Reliability in Design, John W. Evans and Jillian Y. Evans, Springer

REFERENCES:
1. The Product Management Handbook, Richard S. Handscombe, McGraw-Hill
2. New Product Design, Ulrich Eppinger,
3. Product Design, Kevin Otto.

Course Outcomes: At the end of the course, student will be able to
CO1: Understand the basic concepts of product design process
CO2: Identify the operations of product management and impact of manufacturing processes on product decisions
CO3: Understand concepts of risks and reliability of the products design
CO4: Interpret the various testing procedure of the product design.
CO5: Illustrate the concepts of maintenance concepts and procedures of product design

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DEPARTMENT OF MECHANICAL ENGINEERING

MINOR		L	T	P	C
		4	0	0	4
SMART MANUFACTURING					

Course objectives:
1) To understand concepts of smart manufacturing.
2) To gain knowledge about smart machines and sensors.
3) To understand the principles of IoT connectivity to industry 4.0.
4) To acquire knowledge about digital twin and its applications and machine learning and artificial intelligence in manufacturing.
5) To understand the basic concepts of metaverse.

UNIT-I
Concepts of Smart Manufacturing: Definition and key characteristics of smart manufacturing, Corporate adaptation processes, manufacturing challenges, challenges vs technologies, Stages in smart manufacturing. Minimizing Six big losses in manufacturing with Industry 4.0, and their benefits

UNIT-II
Smart Machines and Smart Sensors: Concept and Functions of a Smart, Machine Salient features and Critical Subsystems of a Smart Machine, Smart sensors; smart sensors ecosystem, need, benefits and applications of sensors in industry, Introduction to IoT, IIoT, and Cyber physical systems, Sensing for Manufacturing Process in IIoT, Block Diagram of an IoT Sensing Device, Sensors in IIoT Applications, Smart Machine Interfaces.

UNIT-III
IoT connectivity for Industry 4.0: Industrial communication requirement and its infrastructure, an overview of different types of networks, mesh network in industrial IoT, IoT protocols and the internet, TCP/IP (transmission control protocol/internet protocol) model, IoT connectivity standards: common protocols, application layer protocols, internet/network layer protocols, physical layer IoT protocols, choosing the right IoT connectivity protocol.

UNIT-IV
Digital Twin: Introduction, applications of digital twins, impact zones of digital twins in manufacturing (factories/plants and OEMs), advantages of digital twins, basic steps of digital twin technology

Machine Learning (ML) and Artificial Intelligence (AI) in Manufacturing: Introduction, benefits and applications of ML in industries, common approaches of ML; supervised and unsupervised, semi-supervised and reinforced ML

UNIT-V

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Metaverse –DEPARTMENT OF MECHANICAL ENGINEERING verse, How Web 3.0 is
changing the Internet, Asset Classes Inside the Metaverse, Land, Coins, Characters/ Avatars, Skins,
Utility, Industries Disrupted by the Metaverse, Smart wearables,

TEXT BOOKS:
1) Stuart Russell and Peter Norvig, Artificial Intelligence: A Modern Approach, 2/e, Pearson Education, 2010.
2) Tom M. Mitchell, Machine Learning, McGraw Hill, 2013.
3) Ethem Alpaydin, Introduction to Machine Learning (Adaptive Computation and Machine Learning), The MIT Press, 2004.
4) AurélienGéron, Hands on Machine Learning with Scikit-Learn and TensorFlow [Concepts, Tools, and Techniques to Build Intelligent Systems], Published by O'Reilly Media, 2017.
5) Artificial Intelligence and Machine Learning, Principles and applications by Vinod Chandra S.S., Anand Hareendran S., PHI.

REFERENCE BOOKS:
1) Elaine Rich, Kevin Knight and Shivashankar B. Nair, Artificial Intelligence, 3/e, McGraw Hill Education, 2008.
2) Dan W. Patterson, Introduction to Artificial Intelligence and Expert Systems, PHI Learning, 2012.
3) MACHINE LEARNING: A PRACTITIONER'S APPROACH, by Vinod Chandra S.S., Anand Hareendran S., PHI.
4) M.C. Trivedi, A Classical Approach to Artifical Intelligence, Khanna Publishing House,New Delhi, 2018.
5) S. Kaushik, Artificial Intelligence, Cengage Learning India, 2011.

Course Outcomes: At the end of the course, student will be able to
CO1: Apply the basic concepts of smart manufacturing.
CO2: Analyze about smart machines and sensors.
CO3: Utilize the principles of IoT connectivity to industry 4.0.
CO4: Perceive about digital twin and its applications and machine learning and artificial intelligence in manufacturing.
CO5: Learn the basic concepts of metaverse.

MINOR		L	T	P	C

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DEPARTMENT OF MECHANICAL ENGINEERING	0	0	4
MECHANICAL MEASUREMENTS			

Course objectives:
1) To understand the principles of measurement systems and measurement of displacement.
2) To understand the measurement concepts of temperature and pressure.
3) To understand the concepts of measurement of level and the measurement of flow and speed.
4) To know the concepts of measurement of stress and strain.
5) To apply the concepts in measuring the humidity, force, torque and power.

UNIT – I:
Definition – Basic principles of measurement – measurement systems, generalized configuration and functional descriptions of measuring instruments – examples. Static and dynamic performance characteristics – sources of error, classification and elimination of error.
MEASUREMENT OF DISPLACEMENT: Theory and construction of various transducers to measure displacement – Piezo electric, inductive, capacitance, resistance, ionization and photo electric transducers, calibration procedures.

UNIT – II:
MEASUREMENT OF TEMPERATURE: Classification – ranges – various principles of measurement – expansion, electrical resistance – thermistor – thermocouple – pyrometers – temperature indicators.
MEASUREMENT OF PRESSURE: Units – classification – different principles used, manometers, piston, bourdon pressure gauges, and bellows – diaphragm gauges. Low pressure measurement – thermal conductivity gauges – ionization pressure gauges, Mcleod pressure gauge.

UNIT – III:
MEASUREMENT OF LEVEL: Direct method – indirect methods – capacitive, ultrasonic, magnetic,cryogenic fuel level indicators – bubbler level indicators.
FLOW MEASUREMENT: Rotameter, magnetic, ultrasonic, turbine flow meter, hot – wire anemometer, laser doppler anemometer (LDA).
MEASUREMENT OF SPEED: Mechanical tachometers – electrical tachometers – stroboscope,
Non-contact type of tachometer Measurement of Acceleration and Vibration: Different simple instruments – principles of seismic instruments – vibrometer and accelerometer using this principle.

UNIT – IV:
STRESS STRAIN MEASUREMENTS: Various types of stress and strain measurements – electrical strain gauge – gauge factor – method of usage of resistance strain gauge for bending compressive and tensile strains – usage for measuring torque, strain gauge rosettes.

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UNIT – V:
MEASUREMENT OF HUMIDITY – Moisture content of gases, sling psychrometer, absorption Psychrometer, dew point meter.
MEASUREMENT OF FORCE, TORQUE AND POWER- Elastic force meters, load cells, torsionmeters, dynamometers.

TEXT BOOKS:
1. Measurement Systems: Applications & design / D.S Kumar/
2. Mechanical Measurements / BeckWith, Marangoni,Linehard, Pearson

REFERENCES:
1. Measurement systems: Application and design/Doeblin Earnest. O. Adaptation/ TMH
2. Experimental Methods for Engineers / J.P.Holman/McGraw Hill
3. Mechanical and Industrial Measurements / R.K. Jain/ Khanna Publishers.
4. Instrumentation, measurement & analysis / B.C.Nakra & K.K.Choudhary/TMH

Course outcomes: At the end of the course, student will be able to
CO 1: Learn the principles of measurement systems and measurement of displacement.
CO 2: Learn the measurement concepts of temperature and pressure.
CO 3: Apply the concepts of measurement of level and the measurement of flow and speed.
CO 4: Learn the concepts of measurement of stress and strain.
CO 5: Apply the concepts in measuring the humidity, force, torque and power.

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MINOR		L	T	P	C
		4	0	0	4
	INDUSTRIAL ROBOTICS				

Course Objectives:
1) Discuss various applications and components of industrial robot systems
2) Learn about the types of actuators used in robotics
3) Calculate the forward kinematics and inverse kinematics.
4) Learn about programming principles and languages for a robot control system
5) Discuss the applications of image processing and machine vision in robotics.

UNIT – I:
INTRODUCTION: Automation and Robotics, CAD/CAM and Robotics – An overview of Robotics – present and future applications – classification by coordinate system and control system.
COMPONENTS OFTHE INDUSTRIAL ROBOTICS: Robot anatomy, work volume, components, number of degrees of freedom - robot drive systems, function line diagram representation of robot arms, common types of arms – requirements and challenges of end effectors, determination of the end effectors.

UNIT – II:
ROBOT ACTUATORS AND FEEDBACK COMPONENTS:
Actuators: Pneumatic, Hydraulic actuators, electric & stepper motors. Comparison of Electric, Hydraulic and Pneumatic types of actuation devices Feedback components: position sensors–potentiometers, resolvers, encoders–Velocity sensors.

UNIT – III:
MOTION ANALYSIS: Homogeneous transformations as applicable to rotation and translation – problems.
MANIPULATOR KINEMATICS: Specifications of matrices, D-H notation joint coordinates and world coordinates, Forward and inverse kinematics – problems.

UNIT – IV:
GENERAL CONSIDERATIONS IN PATH DESCRIPTION AND GENERATION: Trajectory planning and avoidance of obstacles, path planning, Skew motion, joint integrated motion – straight line motion –Robot programming, languages and software packages-description of paths with a robot programming language.

UNIT – V:
IMAGE PROCESSING AND MACHINE VISION: Introduction to Machine Vision, Sensing and Digitizing function in Machine Vision, Training and Vision System, Robotic Applications.

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TEXTBOOKS:

1. Industrial Robotics/GrooverMP/Pearson Edu.
2. Robotics and Control /MittalR K & Nagrathi J /TMH.

REFERENCES:

1. Robotics/Fu KS/ McGrawHill.
2. Robotic Engineering /RichardD. Klafter, PrenticeHall
3. Robot Analysis and Control/ H. Asada and J.J.E. Slotine/BSP Books Pvt.Ltd.
4. Introduction to Robotics/John JCraig/PearsonEdu.

Course Outcomes: At the end of the course, student will be able to

CO 1: Discuss various applications and components of industrial robot systems
CO 2: Learn about the types of actuators used in robotics
CO 3: Calculate the forward kinematics and inverse kinematics.
CO 4: Learn about programming principles and languages for a robot control system
CO 5: Discuss the applications of image processing and machine vision in robotics.

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DEPARTMENT OF MECHANICAL ENGINEERING

MINOR		L	T	P	C
		4	0	0	4
MECHATRONICS					

Course Objectives:
1) To understand the use the various mechatronics systems, measurement systems, sensors and transducers.
2) To apply the concepts of solid state electronic devices.
3) To identify the components in the design of electro mechanical systems.
4) To apply the concepts of digital electronics and applications of PLCs for control.
5) To understand system interfacing, data acquisition and design of mechatronics systems.

UNIT – I:
Mechatronics systems – elements & levels of mechatronics system, Mechatronics design process, system, measurement systems, control systems, microprocessor-based controllers, advantages and disadvantages of mechatronics systems. Sensors and transducers, types, displacement, position, proximity, velocity, motion, force, acceleration, torque, fluid pressure, liquid flow, liquid level, temperature and light sensors.

UNIT – II:
Solid state electronic devices - PN junction diode, BJT, FET, DIAC, TRIAC and LEDs. Analog signal conditioning, operational amplifiers, noise reduction, filtering

UNIT – III:
Hydraulic and pneumatic actuating systems - Fluid systems, Hydraulic systems, and pneumatic systems, components, control valves, electro-pneumatic, hydro-pneumatic, electro-hydraulic servo systems. Mechanical actuating systems and electrical actuating systems – basic principles and elements.

UNIT – IV:
Digital electronics and systems, digital logic control, microprocessors and micro controllers, programming, process controllers, programmable logic controllers, PLCs versus computers, application of PLCs for control.

UNIT – V:
System interfacing and data acquisition – Data Acquisition Systems, Analog to Digital and Digital to Analog conversions; Digital Signal Processing – data flow in DSPs, block diagrams, typical layouts, Interfacing motor drives. Design of mechatronics systems & future trends.

TEXT BOOKS:
1. MECHATRONICS Integrated Mechanical Electronics Systems/KP Ramachandran, GK Vijaya Raghavan& MS Balasundaram/WILEY India Edition

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REFERENCES:
1. Mechatronics /Smaili A, Mrad F/ Oxford Higher Education, Oxford UniversityPress
2. Mechatronics Source Book / Newton C Braga/ThomsonPublications,Chennai.
3. Mechatronics – N. Shanmugam / Anuradha AgenciesPublishers.
4. Mechatronics System Design / Devdasshetty/Richard/Thomson.
5. Mechatronics/M.D.Singh/J.G.Joshi/PHI.
6. Mechatronics – Electronic Control Systems in Mechanical and Electrical Engg. 4th Edition / W.Bolton/ Pearson,2012
7. Mechatronics – Principles and Application / Godfrey C. Onwubolu/Elsevier, Indianprint

Course Outcomes: At the end of the course, student will be able to
CO 1: Understand the use the various mechatronics systems, measurement systems, sensors and transducers.
CO 2: Apply the concepts of solid state electronic devices.
CO 3: Identify the components in the design of electro mechanical systems.
CO 4: Apply the concepts of digital electronics and applications of PLCs for control.
CO 5: Understand system interfacing, data acquisition and design of mechatronics systems.

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HONORS IN MECHANICAL ENGINEERING

HONORS		L	T	P	C
		4	0	0	4
ADVANCED MECHANICS OF FLUIDS					

Course Objectives:
1) To understand the general concepts of in viscid flow of incompressible fluids.
2) To apply the concepts of viscous flow.
3) To analyze the boundary layer concepts and expressions for local and mean drag coefficients for different velocity profiles.
4) To understand fundamental concept of turbulence.
5) To illustrate the compressible fluid flow and supersonic wave drag

UNIT – I:
Introduction: Basics of Fluid Mechanics – Continuity Equation – Euler's Equation – Bernoulli's equation
Viscous Flow: Derivation of Navier-Stoke's Equations for viscous compressible flow – Exact solutions to certain simple cases: Plain Poiseuille flow, Couette flow with and without pressure gradient, Hagen Poiseuille flow

UNIT – II:
Boundary Layer Concepts: Prandtl contribution to real fluid flows – Prandtl boundary layer theory, Boundary layer thickness for flow over a flat plate – Blasius solution. Von-Karman momentum integral equation for laminar boundary layer — Expressions for local and mean drag coefficients for different velocity profiles.

UNIT – III:
Introduction to Turbulent Flow: Fundamental concept of turbulence – Time Averaged Equations – Boundary Layer Equations, Prandtl Mixing Length Model - Universal Velocity Distribution Law - Van Driest Model – k-epsilon model, boundary layer separation and form drag – Karman Vortex Trail, Boundary layer control, lift on circular cylinders.

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UNIT – IV:

Internal Flow: Smooth and rough boundaries – Equations for Velocity Distribution and frictional Resistance in smooth and rough Pipes – Roughness of Commercial Pipes – Moody's diagram.
Compressible Fluid Flow – I: Thermodynamic basics – Equations of continuity, Momentum and Energy , Acoustic Velocity, Derivation of Equation for Mach Number – Flow Regimes – Mach Angle – Mach Cone – Stagnation State.

UNIT – V:

Compressible Fluid Flow – II: Area Variation, Property Relationships in terms of Mach number, Nozzles, Diffusers – Fanno and Rayleigh Lines, Property Relations – Isothermal Flow in Long Ducts – Normal Compressible Shock, Oblique Shock: Expansion and Compressible Shocks – Supersonic Wave Drag.

TEXT BOOKS:
1. Fluid Mechanics / L. Victor Streeter / TMH
2. Fluid Mechanics / Frank M. White / MGH

REFERENCES:
1. Fluid Mechanics and Machines/ Modi and Seth/Standard Book House
2. Fluid Mechanics/Cohen and Kundu/Elsevier/5th edition
3. Fluid Mechanics/Potter/Cengage Learning
4. Fluid Mechanics/William S Janna/CRC Press
5. Fluid Mechanics / Y.A Cengel and J.M Cimbala/MGH
6. Boundary Layer Theory/ Schlichting H /Springer Publications
7. Dynamics & Theory and Dynamics of Compressible Fluid Flow/ Shapiro.
8. Fluid Dynamics/ William F. Hughes & John A. Brighton/TMH
9. Fluid Mechanics / K.L Kumar /S Chand & Co.

Course Outcomes: At the end of the course, student will be able to
CO 1: Understand the general concepts of in viscid flow of incompressible fluids.
CO 2: Apply the concepts of viscous flow.
CO 3: Analyse the boundary layer concepts and expressions for local and mean drag coefficients for different velocity profiles.
CO 4: Understand fundamental concept of turbulence.
CO 5: Illustrate the compressible fluid flow and supersonic wave drag.

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HONORS		L	T	P	C
		4	0	0	4
	GREEN MANUFACTURING				

Course Objectives:
1) To understand concepts of green manufacturing
2) To illustrate various recycling techniques.
3) To apply concepts of green design methods.
4) To understand the concepts of eco design and emission less manufacturing.
5) To apply concepts of the sustainable economic environment.

UNIT – I:
Environmental effects and environmental damage – In efficient energy use – Concepts of Green Manufacturing. Waste – Collection, sorting, cleaning –Characterization of waste streams.

UNIT – II:
Recycling Techniques: Recycling rate, material recovery facilities – Integrating recycling with landfills – Processing equipments, Processing facilities for recyclable materials

UNIT – III:
Green design methods: Mass balance analysis – Green indicate – Design for disassembly design for recycle – Risk analysis – Material selection

UNIT – IV:
Eco design – Industrial Ecology – Pollution prevention – Reduction of toxic emissions and Emission less manufacturing.

UNIT – V:
Sustainable economic environment: Solar energy devices – wind energy resources – Full cost accounting methodology – Selection of natural friendly materials for green manufacturing.

TEXT BOOKS:
1. Dornfield David, Green Manufacturing, Springer, 2012
2. Davim.J.Pauls, Green Manufacturing Processes and Systems, Springer, 2013

REFERENCES:
1. Cairncrss and Francis – Costing the earth – Harvard Business School Press – 2009
2. Gradel.T.E. and B.R. Allenby – Industrial Ecology – Prentice Hall – 2010
3. World Commission on Environment and Development (WCED), Our Common Future, Oxford University Press 2005.

Course Outcomes: At the end of the course, student will be able to

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CO 1: Understand green manufacturing.
CO 2: Illustrate various recycling techniques.
CO 3: Apply concepts of green design methods.
CO 4: Understand the concepts of eco design and emission less manufacturing.
CO 5: Apply concepts of the sustainable economic environment.

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HONORS		L	T	P	C
		4	0	0	4
ANALYSIS AND SYNTHESIS OF MECHANISMS					

Course Objectives:
1) To understand the general concepts of advanced kinematics of plane motion-I.
2) To apply the concepts of advanced kinematics of plane motion-II.
3) To understand the introduction to synthesis-graphical methods – I with function and path generation
4) To analyze the synthesis-graphical methods with Velocity – pole method and Roberts's theorem.
5) To illustrate the synthesis of four-bar mechanisms for prescribed extreme values of the angular velocity of driven link.

UNIT – I:
ADVANCED KINEMATICS OF PLANE MOTION- I: Introduction to plane motion. The Inflection circle, Euler – Savary Equation, Bobillier's Construction , Collinear axis , Hartmann's Construction ,Inflection circle for the relative motion of two moving planes, Application of the Inflection circle to kinematic analysis.

UNIT – II:
ADVANCED KINEMATICS OF PLANE MOTION – II: Polode curvature, Hall's Equation, Polode curvature in the four bar mechanism, coupler motion, relative motion of the output and input links, Determination of the output angular acceleration and its Rate of change, Freudenstein's collineation –axis theorem, Carter –Hall circle, The circling – point curve for the Coupler of a four bar mechanism.

UNIT – III:
INTRODUCTION TO SYNTHESIS-GRAPHICAL METHODS – I: The Four bar linkage ,Guiding a body through Two distinct positions, Guiding a body through Three distinct positions, The Roto center triangle , Guiding a body through Four distinct positions, Burmester's curve.

UNIT – IV:
INTRODUCTION TO SYNTHESIS-GRAPHICAL METHODS – II: Function generation-General discussion, Function generation: Relative – Roto center method, Overlay's method, Function generation- Velocity – pole method, Path generation: Hrones's and Nelson's motion Atlas, Roberts's theorem.

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UNIT – V:
INTRODUCTION TO SYNTHESIS – ANALYTICAL METHODS: Function Generation: Freudenstien's equation, Precision point approximation, Precision – derivative approximation, Path Generation: Synthesis of Four-bar Mechanisms for specified instantaneous condition, Method of components, Synthesis of Four-bar Mechanisms for prescribed extreme values of the angular velocity of driven link, Method of components.

TEXT BOOKS:
 1. Kinematics and Dynamics of plane mechanisms/ Jeremy Hirsch horn/McGraw-Hill.
 2. Theory of Machines and Mechanisms/ J. E Shigley and J.J. Uicker Jr. / McGraw-Hill.

REFERENCES:
 1. Design of machinery / Robert L Norton third edition/ McGraw-Hill 2004
 2. Theory of Mechanisms and Machines/ Amitabh Ghosh and Ashok Kumar Mallik/ E. W. P. Publishers.
 3. Kinematic Linkage Design/ Allen S.Hall Jr. / PHI.
 4. Kinematics and Dynamics of Machinery/Charles E Wilson/Pearson/3rd Edition

Course Outcomes: At the end of the course, student will be able to
CO 1: Understand the general concepts of advanced kinematics of plane motion-I.
CO 2: Apply the concepts of advanced kinematics of plane motion-II.
CO 3: Understand the introduction to synthesis-graphical methods – I with function and path generation..
CO 4: Analyze the synthesis-graphical methods with Velocity – pole method and Roberts's theorem.
CO 5: Illustrate the synthesis of four-bar mechanisms for prescribed extreme values of the angular velocity of driven link.

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HONORS		L	T	P	C
		4	0	0	4
	ALTERNATIVE FUELS TECHNOLOGIES				

Course Objectives: The Students will acquire the knowledge

1) To understand significance of fossil fuels and their limitations.
2) To apply the concepts of Methods of production of various liquid alternative fuels.
3) To identify different ways of using alternative liquid fuels in engines.
4) To illustrate the concepts of usage of gaseous fuels in alternative fuels technologies.
5) To understand principles of duel fuel combustion, hybrid power plants and fuel cell.

UNIT – I:
Fossil fuels and their limitations Engine requirements; Potential alternative liquid and gaseous fuels.

UNIT – II:
Methods of production; Properties, safety aspects, handling and distribution of various liquid alternative fuels like alcohols, vegetable oils, Di-methyl and Di-ethyl ether etc.

UNIT – III:
Different ways of using alternative liquid fuels in engines, performance and emission characteristics; Conversion of vegetable oils to their esters and effect on engine performance.

UNIT – IV:
Use of gaseous fuels like biogas, LPG, hydrogen, CNG, producer gas etc. in SI/CI engines; Production, storage, distribution and safety aspects of gaseous fuels

UNIT – V:
Different approaches like duel fuel combustion and surface ignition to use alternative fuels in engines; Use of additives to improve the performance with alternative fuels; Hybrid power plants and fuel cell.

TEXT BOOK:
1. Alternative Fuels: The Future of Hydrogen, Second Edition**,** Michael Frank Hordeski, CRC Press

REFERENCES:
1. Alternative Fuels for Transportation, A S Ramadhas, CRC Press
2. Alternative Fuels & Advanced Technology Vehicles: Incentives & Considerations, Thomas Huber, Jack Spera, Nova Science Publishers.

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Course Outcomes: At the end of the course, student will be able to

CO 1: Understand significance of fossil fuels and their limitations.

CO 2: Apply the concepts of methods of production of various liquid alternative fuels.

CO 3: Analyze different ways of using alternative liquid fuels in engines.

CO 4: Illustrate the concepts of usage of gaseous fuels in alternative fuels technologies.

CO 5: Understand principles of duel fuel combustion, hybrid power plants and fuel cell.

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HONORS		L	T	P	C
		4	0	0	4
GEAR ENGINEERING					

Course Objectives:
1) To understand the Principles of gear tooth action and spur gears.
2) To illustrate the concepts of helical and bevel gears.
3) To interpret the design considerations and methodology of worm gear teeth and gear failures.
4) To analyze design of gear trains for various applications.
5) To understand the optimization of gear design parameters

UNIT – I:
Introduction: Principles of gear tooth action, Generation of Cycloid and Involute gears, Involutometry, gear manufacturing processes and inspection, gear tooth failure modes, stresses, selection of right kind of gears.
Spur Gears: Tooth loads, Principles of Geometry, Design considerations and methodology, Complete design of spur gear teeth considering Lewis beam strength, Buckingham's dynamic load and wear load, Design of gear shaft and bearings, AGMA standards.

UNIT – II:
Helical Gears: Tooth loads, Principles of Geometry, Design considerations and methodology, Complete design of helical gear teeth considering Lewis beam strength, Buckingham's dynamic load and wear load, Design of gear shaft and bearings, AGMA standards.
Bevel Gears: Tooth loads, Principles of Geometry, Design considerations and methodology, Complete design of bevel gear teeth considering Lewis beam strength, Buckingham's dynamic load and wear load, Design of gear shaft and bearings.

UNIT – III:
Worm Gears: Tooth loads, Principles of Geometry, Design considerations and methodology, Complete design of worm gear teeth considering Lewis beam strength, Buckingham's dynamic load and wear load, Heat dissipation considerations. Design of gear shaft and bearings.
Gear failures: Analysis of gear tooth failures, Nomenclature of gear tooth wear and failure, tooth breakage, pitting, scoring, wear, overloading, gear-casing problems, lubrication failures

UNIT – IV:
Gear trains: Simple, compound and epicycle gear trains, Ray diagrams, Design of a gear box of an automobile, Design of gear trains from the propeller shafts of airplanes for auxiliary systems.

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UNIT – V:
Optimal Gear design: Optimization of gear design parameters, Weight minimization, Constraints in gear train design-space, interference, strength, dynamic considerations, rigidity etc. Compact design of gear trains, multi objective optimization of gear trains. Application of Traditional and non-traditional optimization techniques

TEXT BOOKS:
1. Maleev and Hartman, Machine Design, C.B.S. Publishers, India.
2. Henry E.Merrit, Gear engineering, Wheeler publishing, Allahabad, 1992.

REFERENCES:
1. Practical Gear design by Darle W. Dudley, McGraw-Hill
2. Earle Buckingham, Analytical mechanics of gears, Dover publications, New York, 1949.
3. G.M.Maitha, Hand book of gear design, Tata McGraw Hill publishing company Ltd., New Delhi.

Course Outcomes: At the end of the course, student will be able to
CO 1: To understand the Principles of gear tooth action and spur gears.
CO 2: To illustrate the concepts of helical and bevel gears.
CO 3: To interpret the design considerations and methodology of worm gear teeth and gear failures.
CO 4: To analyze design of gear trains for various applications.
CO 5: To understand the optimization of gear design parameters.

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DEPARTMENT OF MECHANICAL ENGINEERING

HONORS		L	T	P	C
		4	0	0	4
EXPERIMENTAL METHODS IN FLUID MECHANICS					

Course Objectives:
1) To understand the general concepts of measurement systems and analysis of first order and second order measurement systems
2) To understand the operating principles and design considerations of various pressure measurement systems
3) To understand the operating principles and design considerations of various temperature measurement systems
4) To understand the operating principles and design considerations of various flow and velocity measurement systems
5) To understand working of different voltage indicating, recording and data acquisition systems

UNIT – I:
GENERAL CONCEPTS: Basic concepts of measurement methods, Sensing elements and transducers, Errors in instruments, Processing of experimental data, curve fitting and regression analysis.
ANALYSIS OF MEASUREMENT SYSTEMS
Analysis of First & Second order systems with examples of mechanical and thermal systems.

UNIT – II:
MEASUREMENT OF PRESSURE – Principles of pressure measurement, static and dynamic pressure, vacuum and high pressure measurement –Manometers- Analysis of liquid manometer, dynamics of variable area and inclined manometer, Pressure transducers- Bellow gauges, Diaphragm gauges- Measurement of low pressure, Calibration methods, Dynamic characteristics, design principles.

UNIT – III:
TEMPERATURE MEASUREMENT: Different principles of Temperature Measurement, use of bimetallic thermometers ,Measurement Design, Construction and Analysis of liquid and gas thermometers, resistance thermometer with wheat stone bridge, Thermo-electric effect, Construction, testing and calibration of thermocouples and thermopiles, Thermistors, Pyrometers, measurement of heat flux, Calibration of temperature measuring instruments. Design of temperature measuring instruments

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UNIT – IV:
FLOW AND VELOCITY MEASUREMENT: Positive displacement methods, Obstruction meters, variable area meters, Ultrasonic flow meter, Vortex –shedding flow meters, Turbine meters, Thermal anemometers, Laser application in flow measurement calibration of flow measuring instruments. Introduction to design of flow measuring instruments. Velocity measurements- pitot tubes, yaw tubes, pitot static tubes, Laser Based Techniques.

UNIT – V:
VOLTAGE INDICATING, RECORDING AND DATA ACQUISITION SYSTEMS:
Standards and calibration, Analog volt meters and potentiometers. Electrical instruments. Digital voltmeters and multimeters. Signal generation. Electro mechanical servo type XT and XY recorders, Thermal array recorders and data acquisition systems. Analog and digital CROs. Displays and liquid crystals flat panel displays. Displays. Virtual instruments. Magnetic tape and disk recorders/reproducers. Fiber optic sensors.

TEXT BOOK:
Measurement System, Application & Design – E.O. Doeblin, MGH

REFERENCES:
1. Mechanical and Industrial Measurements – R.K. Jain – Khanna Publishers.
2. Mechanical Measurements – Buck & Beckwith – Pearson.
3. Control Systems, Principles & Design, 2nd Edition – M. Gopal – TMH.
4. Mechanical Measurements – J.P Holman

Course Outcomes: At the end of the course, student will be able to
CO 1: Understand general concepts of measurement systems and analysis of first order and second order measurement systems
CO 2: Identify the operating principles and design considerations of various pressure measurement systems.
CO 3: Understands the operating principles and design considerations of various temperature measurement systems.
CO 4: Apply the operating principles and design considerations of various flow and velocity measurement systems
CO 5: Illustrate the working of different voltage indicating, recording and data acquisition systems.

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HONORS		L	T	P	C
		4	0	0	4
ADVANCED OPTIMIZATION TECHNIQUES					

Course Objectives:
1) To understand the Engineering applications of optimization.
2) To apply the concepts of unconstrained optimization techniques.
3) To understand the concepts of constrained optimization techniques.
4) To solve geometric programming problems.
5) To solve multistage decision processes and dynamic programming problems.

UNIT – I:
INTRODUCTION TO OPTIMIZATION: Engineering applications of optimization- statement of an optimization problem- classification of optimization problem- optimization techniques.
CLASSICAL OPTIMIZATION TECHNIQUES: Single variable optimization- multivariable optimization with equality constraints - multivariable optimization with inequality constraints..

UNIT – II:
UNCONSTRAINED OPTIMIZATION TECHNIQUES: pattern search method - Rosenbrock's method of rotating coordinates- the simplex method - Descent methods- gradient of function- steepest descent method.

UNIT – III:
CONSTRAINED OPTIMIZATION TECHNIQUES: characteristics of a constrained problem-methods of feasible directions - basic approach in the penalty function method- interior penalty function method- convex programming problem- exterior penalty function method.

UNIT – IV:
GEOMETRIC PROGRAMMING (G.P): Solution of an unconstrained geometric programming, differential calculus method and arithmetic method. Primal dual relationship and sufficiency conditions. Solution of a constrained geometric programming problem (G.P.P).Complimentary geometric programming (C.G.P).

UNIT – V:
DYNAMIC PROGRAMMING (D.P): Multistage decision processes. Concepts of sub optimization, computational procedure in dynamic programming calculus method and tabular methods. Linear programming as a case of D.P., Continuous D.P.

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TEXT BOOK:
1. Optimization Theory and Applications, by S.S.Rao, Wiley Eastern Limited, New Delhi.

References:
1. Engineering Optimization by Kalyanmanai Deb, Prentice Hall of India, New Delhi.
2. Optimization Techniques, C.Mohan, Kusum Deep.
3. Operations Research by S.D.Sharma.

Course Outcomes: At the end of the course, student will be able to
CO 1: Understand the Engineering applications of optimization.
CO 2: Apply the concepts of unconstrained optimization techniques.
CO 3: Understand the concepts of constrained optimization techniques.
CO 4: Apply concepts of geometric programming problems.
CO 5: Analyze multistage decision processes and dynamic programming problems.

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HONORS		L	T	P	C
		4	0	0	4
MICRO ELECTRO MECHANICAL SYSTEMS					

Course Objectives:
1) To understand basics of Micro Electro Mechanical Systems (MEMS), mechanical sensors and actuators
2) To illustrate thermal sensors and actuators used in MEMS.
3) To apply the principle and various devices of Micro-Opto-Electro Mechanical Systems (MOEMS), magnetic sensors and actuators.
4) To analyze applications and considerations on micro fluidic systems.
5) To illustrate the principles of chemical and bio medical micro systems.

UNIT – I:
INTRODUCTION: Definition of MEMS, MEMS history and development, micro machining, lithography principles & methods, structural and sacrificial materials, thin film deposition, impurity doping, etching, surface micro machining, wafer bonding, LIGA.
MECHANICAL SENSORS AND ACTUATORS: Principles of sensing and actuation: beam and cantilever, capacitive, piezo-electric, strain, pressure, flow, pressure measurement by micro phone, MEMS gyroscopes, shear mode piezo actuator, gripping piezo actuator, Inchworm technology.

UNIT – II:
THERMAL SENSORS AND ACTUATORS: Thermal energy basics and heat transfer processes, thermistors, thermo devices, thermo couple, micro machined thermo couple probe, Peltier effect heat pumps, thermal flow sensors, micro hot plate gas sensors, MEMS thermo vessels, pyro electricity, shape memory alloys (SMA), U-shaped horizontal and vertical electro thermal actuator, thermally activated MEMS relay, micro spring thermal actuator, data storage cantilever.

UNIT – III:
MICRO-OPTO-ELECTRO MECHANICAL SYSTEMS: Principle of MOEMS technology, properties of light, light modulators, beam splitter, micro lens, micro mirrors, digital micro mirror device (DMD), light detectors, grating light valve (GLV), optical switch, wave guide and tuning, shear stress measurement.
MAGNETIC SENSORS AND ACTUATORS: Magnetic materials for MEMS and properties, magnetic sensing and detection, magneto resistive sensor, more on hall effect, magneto diodes, magneto transistor, MEMS magnetic sensor, pressure sensor utilizing MOKE, mag MEMS actuators, by directional micro actuator, feedback circuit integrated magnetic actuator, large force reluctance actuator, magnetic probe based storage device.

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UNIT – IV:
MICRO FLUIDIC SYSTEMS: Applications, considerations on micro scale fluid, fluid actuation methods, dielectro-phoresis (DEP), electro wetting, electro thermal flow, thermo capillary effect, electro osmosis flow, opto electro wetting (OEW), tuning using micro fluidics, typical micro fluidic channel, micro fluid dispenser, micro needle, molecular gate, micro pumps. RADIO FREQUENCY (RF) MEMS: RF – based communication systems, RF MEMS, MEMS inductors, tuner/filter, resonator, clarification of tuner, filter, resonator, MEMS switches, phase shifter.

UNIT – V:
CHEMICAL AND BIO MEDICAL MICRO SYSTEMS: Sensing mechanism & principle, membrane-transducer materials, chem.-lab-on-a-chip (CLOC) chemo-resistors, chemo-capacitors, chemo-transistors, electronic nose (E-nose), mass sensitive chemo-sensors, fluorescence detection, calorimetric spectroscopy.

TEXT BOOK:
1.MEMS, Nitaigour Premchand Mahalik, TMH

REFERENCE BOOKS:
1. Foundation of MEMS, Chang Liu, Prentice Hall Ltd.
2. MEMS and NEMS, Sergey Edward Lyshevski, CRC Press, Indian Edition.
3. MEMS and Micro Systems: Design and Manufacture, Tai-Ran Hsu, TMH Publishers.
4. Introductory MEMS, Thomas M Adams, Richard A Layton, Springer International Publishers.

Course Outcomes: At the end of the course, student will be able to
CO 1: To understand basics of Micro Electro Mechanical Systems (MEMS), mechanical sensors and actuators.
CO 2: Illustrate thermal sensors and actuators used in MEMS.
CO 3: To apply the principle and various devices of Micro-Opto-Electro Mechanical Systems (MOEMS), magnetic sensors and actuators.
CO 4: Analyze applications and considerations on micro fluidic systems.
CO 5: Illustrate the principles of chemical and bio medical micro systems.

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HONORS		L	T	P	C
		4	0	0	4
TRIBOLOGY					

Course objectives:
1) To explain the contact of solid surfaces and types of lubrication
2) To understand the genesis of friction, the theories/laws of sliding and rolling friction
3) To apply the principles and design procedures for hydrostatic bearings.
4) To understand and analyze the principles of hydrodynamic and mixed/ boundary lubrication
5) To gain knowledge about the types of seals and failure of tribological components.

UNIT – I
Introduction: Nature of surfaces and contact-Surface topography-friction and wear mechanisms, wear maps, effect of lubricants- methods of fluid film formation.
Lubrication: Choice of lubricants, types of oil, Grease and solid lubricants- additives- lubrication systems and their selection.

UNIT – II
Selection of rolling element bearings: Nominal life, static and dynamic capacity-Equivalent load, probabilities of survival- cubic mean load- bearing mounting details, pre loading of bearings, conditioning monitoring using shock pulse method.

UNIT – III
Hydrostatic Bearings: Thrust bearings – pad coefficients- restriction- optimum film thickness- journal bearings – design procedure –Aerostatic bearings; Thrust bearings and Journal bearings – design procedure.

UNIT – IV
Hydrodynamic bearings: Fundamentals of fluid formation – Reynold's equation; Hydrodynamic journal bearings – Sommerfield number- performance parameters – optimum bearing with maximum load capacity – Friction – Heat generated and Heat dissipated. Hydrodynamic thrust bearings; Raimondi and Boyd solution for hydrodynamic thrust bearings- fixed tilting pads, single and multiple pad bearings-optimum condition with largest minimum film thickness.

UNIT – V
Seals: different type-mechanical seals, lip seals, packed glands, soft piston seals, Mechanical piston rod packing, labyrinth seals and throttling bushes, oil flinger rings and drain grooves – selection of mechanical seals.
Failure of Tribological components: Failure analysis of plain bearings, rolling bearings, gears and seals, wear analysis using soap and Ferrography.
Dry rubbing Bearings: porous metal bearings and oscillatory journal bearings – qualitative approach only.

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TEXT BOOKS:
1.Rowe WW& O' Dionoghue,"Hydrostatic and Hybrid bearing design " Butterworths & Co.Publishers Ltd,1983.
2.Collacott R.A," Mechanical Fault diagnosis and condition monitoring", Chapman and Hall, London 1977.
3. Bernard J.Hamrock, "Fundamentals of fluid film lubricant", McGraw-Hill Co., 1994.
4. Introduction to Tribology of bearings – B.C.Majumdar – S Chand Publishing.

REFERENCES:
1. Neale MJ, (Editor) "Tribology hand Book" NeumannButterworths, 1975.
2. Connor and Boyd JJO (Editors) "Standard hand book of lubrication engineers " ASLE, McGraw Hill Book & Co.,1968
3. Shigley J, E Charles, "Mechanical Engineering Design", McGraw Hill Co., 1989

COURSE OUTCOMES: Students will be able to
CO 1: Learn the concepts of surface topography and types of lubrication.
CO 2: Learn the genesis of friction, the theories/laws of sliding and rolling friction.
CO 3: Apply the principles and design procedures for hydrostatic bearings.
CO 4: Analyze the principles of hydrodynamic and mixed/ boundary lubrication.
CO 5: Gain knowledge about the types of seals and failure of tribological components.

HONORS		L	T	P	C

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STATISTICAL DESIGN IN QUALITY CONTROL

Course Objectives:

1) To Interpret quality engineering in production design, Loss Function and Quality Level in production process
2) To explain tolerance design for N-type. L-type and S-type characteristics and tolerance allocation
3) To interpret ANOVA techniques and need for ANOVA with multiple level factors.
4) To make use of orthogonal arrays for typical test strategies and interpolate experimental results
5) To explain six sigma DMAIC methodology and tools for process improvement in services and small organizations

UNIT – I:
QUALITY VALUE AND ENGINEERING: An overall quality system, quality engineering in production design, quality engineering in design of production processes. Loss Function and Quality Level: Derivation and use of quadratile loss function, economic consequences of tightening tolerances as a means to improve quality, evaluations and types tolerances.(N-type, S-type and L-type)

UNIT – II:
TOLERANCE DESIGN AND TOLERANCING: Functional limits, tolerance design for N-type. L-type and S-type characteristics, tolerance allocation for multiple components. Parameter and Tolerance Design: Introduction to parameter design, signal to noise ratios, Parameter design strategy, some of the case studies on parameter and tolerance designs.

UNIT – III:
ANALYSIS OF VARIANCE (ANOVA): Introduction to ANOVA, Need for ANOVA, NO way ANOVA, One-way ANOVA, Two-way ANOVA, Critique of F-test, ANOVA for four level factors, multiple level factors.

UNIT – IV:
ORTHOGONAL ARRAYS: Typical test strategies, better test strategies, efficient test strategies, steps in designing, conducting and analyzing an experiment. Interpolation of Experimental Results: Interpretation methods, percent contributor, estimating the mean.

UNIT – V:
SIX SIGMA AND THE TECHNICAL SYSTEM: Six sigma DMAIC methodology, tools for process improvement, six sigma in services and small organizations, statistical foundations, statistical methodology.

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TEXT BOOK: DEPARTMENT OF MECHANICAL ENGINEERING
Taguchi Techniques for Quality Engineering / Phillip J. Ross / McGraw Hill/ Intl. II Edition, 1995.

REFERENCES:
1. Quality Engineering in Production systems by G. Taguchi, A. Elsayed et al, McGraw Hill Intl. Pub 1989.
2. Taguchi Methods explained: Practical steps to Robust Design / Papan P. Bagchi / Prentice Hall Pvt. Ltd. New Delhi

Course Outcomes: At the end of the course, student will be able to
CO 1: Interpret quality engineering in production design, Loss Function and Quality Level in production process
CO 2: Illustrate tolerance design for N-type. L-type and S-type characteristics and tolerance allocation.
CO 3: Interpret ANOVA techniques and need for ANOVA with multiple level factors.
CO 4: Make use of orthogonal arrays for typical test strategies and interpolate experimental results.
CO 5: Understand six sigma DMAIC methodology and tools for process improvement in services and small organizations

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HONORS		L	T	P	C
		4	0	0	4
ADVANCED COMPUTATIONAL FLUID DYNAMICS					

Course objectives:
1) To understand the principles of various flows, finite difference and finite volume methods.
2) To apply the concepts of higher order upwind schemes for incompressible flow.
3) To apply the concepts of implicit methods for incompressible flow.
4) To understand and apply the concepts of compressible flow.
5) To model and simulate the turbulence.

UNIT-I
Introduction: 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

UNIT-II
Incompressible Flow-1: 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.

UNIT-III
Incompressible Flow-2: Semi–implicit method (SIMPLE): Comparison with the SMAC and fully – implicit methods, algorithm for semi–implicit method, discussion on SIMPLE/SIMPLER and SIMPLEC. Discretization of governing equations and boundary conditions in FVM framework. 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-IV
Compressible Flow: N-S and energy equations, properties of Euler equation, linearization. Solution of Euler equation: Explicit and implicit treatment such as Lax-Wendroff, McCormack, 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: McCormack, Jameson algorithm in finite volume formulation and transformed coordinate system

UNIT-V

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Turbulence Reynolds decomposition, turbulence scales, 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.

TEXT BOOKS:
1. Computational Fluid Flow and Heat Transfer, Second Edition by K. Muralidhar, T. Sundararajan (Narosa), 2011.
2. Computational Fluid Dynamics by Chung T. J., Cambridge University Press, 2003.
3. Computational Fluid Dynamics by Tapan K. Sengupta, University Press, 2005.
4. Numerical Computation of Internal and External Flows by Hirch C., Elsevier 2007.

REFERENCES:
1. Numerical Heat Transfer and Fluid Flow by S. V. Patankar (Hemisphere Series on Computational Methods in Mechanics and Thermal Science)
2. Essential Computational Fluid Dynamics by Zikanov. O., Wiley 2010.
3. Computer Simulation of Flow and Heat Transfer by P. S. Ghoshdastidar (4th Edition, Tata McGraw-Hill), 1998

Course Outcomes: At the end of the course, student will be able to

CO1: Learn the principles of various flows, finite difference and finite volume methods
CO2: Learn the concepts of higher order upwind schemes for incompressible flow.
CO3: Analyze the implicit methods for incompressible flow.
CO4: Apply the concepts of compressible flow.
CO5: Model and simulate the turbulence.

HONORS		L	T	P	C
		4	0	0	4
MATERIALS CHARACTERIZATION TECHNIQUES					

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Course Objectives:

1) To understand the various structure analysis tools like X-ray diffraction
2) To apply the microscopy techniques for materials characterization.
3) To understand the concepts of thermal analysis techniques.
4) To learn about the magnetic characterization techniques.
5) To illustrate optical and electronic characterization techniques.

UNIT – 1

Introduction to materials and Techniques: Structure analysis tools: X-ray diffraction: phase identification, indexing and lattice parameter determination, Analytical line profile fitting using various models, Neutron diffraction, Reflection High Energy Electron Diffraction, and Low Energy Electron Diffraction.

UNIT – 2

Microscopy techniques: Optical microscopy, analysis transmission electron microscopy (TEM), energy dispersive X-ray microanalysis (EDS), scanning electron microscopy (SEM), atomic force microscopy (AFM) and scanning probe microscopy (SPM), quantitative metallography.

UNIT – 3

Thermal analysis technique: Differential thermal analysis (DTA), Differential Scanning Calorimeter (DSC), Thermo gravimetric analysis (TGA); Electrical characterization techniques: Electrical resistivity, Hall effect, Magneto resistance.

UNIT – 4

Magnetic characterization techniques: Introduction to Magnetism, Measurement Methods, Measuring Magnetization by Force, Measuring Magnetization by Induction method, Types of measurements using magnetometers: M-H loop, temperature dependent magnetization, time dependent magnetization, Measurements using AC susceptibility, Magneto-optical Kerr effect, Nuclear Magnetic Resonance, Electron Spin Resonance

UNIT – 5

Optical and electronic characterization techniques: UV-VIS spectroscopy, Fourier transform infrared spectroscopy, Raman spectroscopy, X-ray photoelectron spectroscopy.

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TEXT BOOKS:
1. Characterization of Materials (Materials Science and Technology: A Comprehensive Treatment, Vol 2A & 2B
2. Semiconductor Material and Device Characterization, 3rdEdition, D. K. Schroder, Wiley-IEEE Press (2006).
3. Materials Characterization Techniques, S Zhang, L. Li and Ashok Kumar, CRC Press (2008).

REFERENCES:
1. Physical methods for Materials Characterization, P. E. J.Flewitt and R K Wild, IOP publishing (2003).
2. Characterization of Nano - phase materials, Ed. Z L Wang, Willet-VCH (2000).

Course Outcomes: At the end of the course, student will be able to
 CO1: Understand the various structure analysis tools
 CO2: Apply microscopic techniques for material characterization.
 CO3: Learn about thermal analysis techniques.
 CO4: Understand magnetic characterization techniques
 CO5: Learn about optical and electronic characterization techniques.

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HONORS		L	T	P	C
		4	0	0	4
	PRODUCT DESIGN				

Course Objectives:
1. To understand the basic concepts of product design process
2. To interpret the operations of product management and impact of manufacturing processes on product decisions
3. To understand concepts of risks and reliability.
4. To interpret the various testing procedure of the product design.
5. To understand the concepts of maintainability.

UNIT – 1
Product Design Process: Design Process Steps, Morphology of Design. Problem Solving and Decision Making: Problem-Solving Process, Creative Problem Solving, Invention, Brainstorming, Morphological Analysis, Behavioral Aspects of Decision Making, Decision Theory, Decision Matrix, Decision Trees. Modelling and Simulation: Triz, Role of Models in Engineering Design, Mathematical Modelling, Similitude and Scale Models, Computer Simulation, Geometric Modelling on Computer, Finite-Element Analysis.

UNIT – 2
Product management: The operation of product management: Customer focus of product management, product planning process, Levels of strategic planning, Wedge analysis, Opportunity search, Product life cycle Life cycle theory and practice.
Product development: Managing new products, Generating ideas, Sources of product innovation, selecting the best ideas, the political dimension of product design, Managing the product launch and customer feedback.
Product managers and manufacturing: The need for effective relationships, The impact of manufacturing processes on product decisions, Prototype planning,, Productivity potentials, Management of product quality, Customer service levels.

UNIT – 3
Risk and Reliability: Risk and Society, Hazard Analysis, Fault Tree Analysis. Failure Analysis and Quality: Causes of Failures, Failure Modes, Failure Mode and Effect Analysis, FMEA Procedure, Classification of Severity, Computation of Criticality Index, Determination of Corrective Action, Sources of Information, Copyright and Copying. Patent Literature.

UNIT – 4
Product Testing; Thermal, vibration, electrical, and combined environments, temperature testing, vibration testing, test effectiveness. Accelerated testing and data analysis, accelerated factors. Weibull probability plotting, testing with censored data

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UNIT – 5   DEPARTMENT OF MECHANICAL ENGINEERING
Design For Maintainability: Maintenance Concepts and Procedures, Component Reliability, Maintainability and Availability, Fault Isolation in design and Self-Diagnostics. Product Design for Safety, Product Safety and User Safety Concepts, Examples of Safe Designs. Design Standardization and Cost Reduction: Standardization Methodology, Benefits of Product Standardization; International, National, Association and Company Level Standards; Parts Modularization

TEXT BOOKS:
1. Engineering Design, George E. Dieter, McGraw-Hill
2. Product Integrity and Reliability in Design, John W. Evans and Jillian Y. Evans, Springer

REFERENCES:
1. The Product Management Handbook, Richard S. Handscombe, McGraw-Hill
2. New Product Design, Ulrich Eppinger,
3. Product Design, Kevin Otto.

Course Outcomes: At the end of the course, student will be able to
CO1: Understand the basic concepts of product design process
CO2: Identify the operations of product management and impact of manufacturing processes on product decisions
CO3: Understand concepts of risks and reliability of the products design
CO4: Interpret the various testing procedure of the product design.
CO5: Illustrate the concepts of maintainability.

HONORS		**L**	**T**	**P**	**C**
		4	**0**	**0**	**4**
ELECTRIC AND HYBRID VEHICLES					

Course objectives: To

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1) Understand electric vehicle & HEV for various applications
2) Have knowledge about the electric vehicle system and its parameters
3) Learn about EV motor drives
4) Understand the concepts of HEV
5) Learn about the energy sources, battery chargers and charging infrastructure.

UNIT – I
Introduction to EV & HEV: Past, Present & Feature of EV, Current Major Issues, Recent Development Trends, EV Concept, Key EV Technology, State-of-the Art EVs & HEVs, Comparison of EV Vs IC Engine.

UNIT – II
EV System: EV Configuration: Fixed & variable gearing, single & multiple motor drives, In-wheel drives
EV Parameters: Weight, size, force, energy & performance parameters.

UNIT – III
EV Motor Drive:
DC Motor: Type of wound-field DC Motor, Torque speed characteristics, DC-DC Converter, Two quadrant DC Chopper, two quadrant zero voltage transition converter-fed dc motor drive, speed control of DC Motor
Induction Motor Drive: Three Phase Inverter Based Induction Motor Drive, Equal Area PWM, Three Phase Auxiliary resonant snubber (ARS) Inverter Type (ZVC & ZCS), Single Phase ARS Inverter Topology, Speed Control of Induction Motor, FOC, Adaptive Control, Model Reference Adaptive Control (MARS), Sliding mode Control

UNIT – IV
HEV: HEV, Energy Sources & Charging HEV: Configuration of HEV (Series, Parallel, Series-parallel &Complex), Power Flow control, Examples. Power flow control in all HEV configurations, Examples of HEV system performance

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UNIT – V
Energy Sources: Different Batteries, Battery characteristics (Discharging & Charging)
Battery Chargers: Conductive (Basic charger circuits, Microprocessor based charger circuit. Arrangement of an off-board conductive charger, Standard power levels of conductive chargers, Inductive (Principle of inductive charging, Soft-switching power converter for inductive charging), Battery indication methods.
Charging Infrastructure: Domestic Charging Infrastructure, Public Charging Infrastructure, Normal Charging Station, Occasional Charging Station, Fast Charging Station, Battery Swapping Station, Move-and-charge zone.

TEXT BOOKS:
1) C.C Chan, K.T Chau: Modern Electric Vehicle Technology, Oxford University Press Inc., New York 2001.
2) Iqbal Hussein, Electric and Hybrid Vehicles: Design Fundamentals, CRC Press, 2003.

REFERENCE BOOKS:
1) Mehrdad Ehsani, Yimi Gao, Sebastian E. Gay, Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press, 2004.
2) James Larminie, John Lowry, Electric Vehicle Technology Explained, Wiley, 2003.

Course Outcomes: After completing the course, the students will be able to:
CO1: Understand electric vehicle & HEV for various applications
CO2: Have knowledge about the electric vehicle system and its parameters
CO3: Learn about EV motor drives
CO4: Understand the concepts of HEV.
CO5: Learn about the energy sources, battery chargers and charging infrastructure.

HONORS		L	T	P	C

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DEPARTMENT OF MECHANICAL ENGINEERING	0	0	4
MECHANICAL VIBRATIONS AND ACCOUSTICS			

Course objectives:
1) To understand the basic concepts and behavior of vibrations in machines
2) To understand the determination of frequencies and other parameters in multi degree vibration systems
3) To understand to behavior of continuous systems
4) To understand the basic concepts of acoustics
5) To understand the principles of noise measuring instruments

UNIT-I:
INTRODUCTION: Relevance of and need for vibration analysis – Basics of SHM - Mathematical modeling of vibrating systems - Discrete and continuous systems - single-degree freedom systems - free and forced vibrations, damped and undamped systems.

UNIT-II:
MULTI DEGREE FREEDOM SYSTEMS: Free and forced vibrations of multi-degree freedom systems in longitudinal, torsional and lateral modes - Matrix methods of solution- normal modes - orthogonality principle-Energy methods, Eigen values and Eigen vectors

UNIT-III:
CONTINUOUS SYSTEMS: Torsional vibrations - Longitudinal vibration of rods - transverse vibrations of beams - Governing equations of motion - Natural frequencies and normal modes - Energy methods, Introduction to non-linear and random vibrations.

UNIT-IV:
BASICS OF ACOUSTICS: Speed of Sound, Wavelength, Frequency, and Wave Number, Acoustic Pressure and Particle Velocity, Acoustic Intensity and Acoustic Energy Density, Spherical Wave propagation, Directivity Factor and Directivity Index, Levels and the Decibel, Addition and subtraction of Sound levels, Octave Bands, Weighted Sound Levels.

UNIT-V:
NOISE MEASUREMENT AND CONTROL: Sound Level Meters, Intensity Level Meters, Octave Band Filters Acoustic analyzers, Dosimeter, Measurement of Sound Power, impact of noise on humans, A-Weighting, Noise control strategy, sound absorption and insulation.

TEXT BOOKS:
1. S.S.Rao, "Mechanical Vibrations ", 5th Edition, Prentice Hall, 2011.
2. L.Meirovitch, "Elements of vibration Analysis", 2nd Edition, McGraw-Hill, New York, 1985.

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REFERENCES:

1. W.T. Thomson, M.D. Dahleh and C Padmanabhan, "Theory of Vibration with Applications", 5th Edition, Pearson Education, 2008.
2. M.L.Munjal, "Noise and Vibration Control", World Scientific, 2013.
3. Beranek and Ver, "Noise and Vibration Control Engineering: Principles and Applications", John Wiley and Sons, 2006.
4. Randall F. Barron, "Industrial Noise Control and Acoustics", Marcel Dekker, Inc., 2003

Course Outcomes: At the end of the course, student will be able to:
CO1: Learn about the basic concepts and behavior of vibrations in machines
CO2: Analyze the machine vibrations in multi degree of freedom systems
CO3: Apply the torsional vibration concepts to the continuous systems
CO4: Learn about the basic concepts of acoustics
CO5: Utilize the noise measuring instruments

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HONORS		L	T	P	C
		4	0	0	4
	ADVANCED THERMODYNAMICS				

Course Objectives:
1) To understand the thermodynamic laws and corollaries.
2) To illustrate the concepts of real gas behavior
3) To apply the general concepts of combustion
4) To analyze power cycles
5) To illustrate the working principles of direct energy conversion techniques.

UNIT – 1
REVIEW OF THERMODYNAMIC LAWS AND COROLLARIES: Transient flow analysis, Second law thermodynamics, Entropy, Availability and unavailability, Thermodynamic potential. Maxwell relations, Specific heat relations, Mayer's relation. Evaluation of thermodynamic properties of working substance

UNIT – 2
P.V.T SURFACE: Equation of state. Real gas behavior, Vander Waal's equation, Generalization compressibility factor. Energy properties of real gases. Vapour pressure, Clausius-Clapeyron equation. Throttling, Joule Thomson coefficient.

UNIT – 3
COMBUSTION: Combustion Reactions, Enthalpy of formation. Entropy of formation, Reference levels of tables. Energy of formation, Heat reaction, Adiabatic flame temperature generated product, Enthalpies, Equilibrium. Chemical equilibrium of ideal gases, Effect of non-reacting gases equilibrium in multiple reactions, The vent Hoff's equation - Gibbs phase rule.

UNIT – 4
POWER CYCLES: Review binary vapor cycle, co-generation and combined cycles, Second law analysis of cycles. Refrigeration cycles. Thermodynamics off irreversible processes. Introduction, Phenomenological laws, Onsager Reciprocity relation, Applicability of the Phenomenological relations, Heat flux and entropy production, Thermodynamic phenomena, Thermo electric circuits.

UNIT – 5
DIRECT ENERGY CONVERSION INTRODUCTION: Fuel cells, Thermo electric energy, Thermo ionic power generation, Thermodynamic devices magneto hydrodynamic generations, Photovoltaic cells

TEXT BOOKS:

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DEPARTMENT OF MECHANICAL ENGINEERING
1. Basic and Applied Thermodynamics/ P.K. Nag.
2. Thermodynamics/Holman/ Mc Graw Hill.

REFERENCES
1. Engineering Thermodynamics/PL. Dhār / Elsevier
2. Thermodynamics/Sonntag & Van Wylen / John Wiley & Sons
3. Thermodynamics for Engineers/Doolittle-Messe / John Wiley & Sons
4. Irreversible thermodynamics/HR De Groff.
5. Thermal Engineering / Soman / PHI
6. Thermal Engineering / Rathore / TMH
7. Engineering Thermodynamics/Chatopadyaya/

Course Outcomes: At the end of the course, student will be able to:

CO1: Understand the thermodynamic laws and corollaries.

CO2: Illustrate the concepts of real gas behavior

CO3: Apply the general concepts of combustion reactions and chemical equilibrium of ideal gases.

CO4: Analyze power cycles.

CO5: Apply the working principles of direct energy conversion techniques.

HONORS		**L**	**T**	**P**	**C**
		4	**0**	**0**	**4**

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DEPARTMENT OF MECHANICAL ENGINEERING

Course Objectives: The students will acquire the knowledge:
1) To understand the basic concepts of design for manual assembly
2) To interpret basic design procedure of machining processes
3) To understand design considerations metal casting, extrusion and sheet metal work
4) To interpret the design considerations of various metal joining process.
5) To interpret the basic design concepts involved in the assembly automation

UNIT – 1
Introduction to DFM, DFMA: How Does DFMA Work? Reasons for Not Implementing DFMA, What Are the Advantages of Applying DFMA During Product Design? Typical DFMA Case Studies, Overall Impact of DFMA on Industry.
Design for Manual Assembly: General Design Guidelines for Manual Assembly, Development of the Systematic DFA Methodology, Assembly Efficiency, Effect of Part Symmetry, Thickness, weight on Handling Time, Effects of Combinations of Factors and application of the DFA Methodology.

UNIT – 2
Machining processes: Overview of various machining processes-general design rules for machining dimensional tolerance and surface roughness-Design for machining – ease –redesigning of components for machining ease with suitable examples. General design recommendations for machined parts.

UNIT – 3
Metal casting: Appraisal of various casting processes, selection of casting process,-general design considerations for casting-casting tolerance-use of solidification, simulation in casting design-product design rules for sand casting.
Extrusion & Sheet metal work: Design guide lines extruded sections-design principles for punching, blanking, bending, and deep drawing-Keeler Goodman forging line diagram – component design for blanking

UNIT – 4
Metal joining: Appraisal of various welding processes, factors in design of weldments – general design guidelines-pre and post treatment of welds-effects of thermal stresses in weld joints-design of brazed joints. Forging: Design factors for forging – closed die forging design – parting lines of dies –drop forging die design – general design recommendations.

UNIT – 5
Design for Assembly Automation: Fundamentals of automated assembly systems, System configurations, parts delivery system at workstations, various escapement and placement devices

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used in automatic assembly, Type of manual assembly systems, Multi station assembly systems, and single station assembly lines.
Design for Additive Manufacturing: Design considerations, allowances

TEXT BOOKS:
1. Design for manufacture, John cobert, Adisson Wesley. 1995
2. Design for Manufacture by Boothroyd,
3. Design for manufacture, James Bralla

REFERENCE:
1. ASM Hand book Vol.20

Course Outcomes: At the end of the course, student will be able to
CO1: Understand the basic concepts of design for manual assembly
CO2: Identify basic design procedure of various machining processes.
CO3: Illustrate the design considerations metal casting, extrusion and sheet metal work
CO4: Interpret the design considerations of various metal joining process.
CO5: Understand the basic design concepts involved in the assembly automation

HONORS		**L**	**T**	**P**	**C**
		4	**0**	**0**	**4**
	ROBOTICS AND CONTROL				

Course Objectives:

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1) To demonstrate the concepts of basic control, robot actuation and feedback components
2) To interpret the sensing and Digitizing-imaging devices, image processing and analysis on image data reduction, feature extraction and Object recognition
3) To classify generations of robot programming languages, Robot language structures, their elements and function
4) To make use of AML language basic commands
5) To explain Robot cell design and control and practical study of virtual robot

UNIT – 1
INTRODUCTION: **CONTROL SYSTEM AND COMPONENTS:** Basic concepts and motion controllers, control system analysis, robot actuation and feedback components, control systems and dynamic performance, precision of movement.
SENSORS: Desirable features, tactile, proximity and range sensors, uses of sensors in robotics. Positions sensors, velocity sensors

UNIT – 2
MACHINE VISION: Functions, Sensing and Digitizing-imaging devices, Lighting techniques, Analog to digital single conversion, image storage: Image processing and Analysis-image data reduction, Segmentation, feature extraction, Object recognition. Training the vision system, Robotic application.

UNIT – 3
ROBOT PROGRAMMING: Textual robot Languages, Generations of robot programming languages, Robot language structures, Elements and function. VAL language commands motion control, hand control, program control, pick and place applications, palletizing applications using VAL, Robot welding application using VAL program

UNIT – 4
AML LANGUAGE-General description, elements and functions, Statements, constants and variables-Program control statements-Operating systems, Motion, Sensor commands-Data processing

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UNIT – 5
ROBOT CELL DESGIN AND CONTROL: Robot cell layouts-Robot centered cell, In-line robot cell, Considerations in work design, Work and control, Inter locks, Error detection, Work cell controller.
PRACTICAL STUDY OF VIRTUAL ROBOT: Robot cycle time analysis-Multiple robot and machine Interference-Process chart-Simple problems-Virtual robotics, Robot studio online software- Introduction, work planning, program modules, input and output signals – Singularities - Collision detection-Repeatability measurement of robot-Robot economics.

TEXT BOOKS:
1. Industrial Robotics / Grover M P /Pearson Edu.
2. Introduction to Robotic Mechanics and Control by JJ Craig, Pearson, 3rd edition.

REFERENCES:
1. Robotics / Fu K S/ McGraw Hill.
2. Robotic Engineering / Richard D. Klafter, Prentice Hall
3. Robot Analysis and Intelligence / Asada and Slotine / Wiley Inter-Science.
4. Robot Dynamics & Control – Mark W. Spong and M. Vidyasagar / John Wiley
5. Introduction to Robotics by SK Saha, the McGraw Hill Company, 6th, 2012
6. Robotics and Control / Mittal R K & Nagrath I J / TMH

Course Outcomes: At the end of the course, student will be able to
CO1: Demonstrate basic concepts of motion controllers, robot actuation and feedback components
CO2: Interpret the sensing and Digitizing-imaging devices, image processing and analysis on image data reduction, feature extraction and Object recognition
CO3: Classify generations of robot programming languages, Robot language structures, their elements and function
CO4: Make use of AML Language
CO5: Explain Robot cell design and control and practical study of virtual robot

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HONORS		L	T	P	C
		4	0	0	4
TURBO MACHINES					

Course Objectives:
1) To learn basic concepts of turbo machines
2) To learn the thermal analysis of steam nozzles and steam turbines
3) To learn the basic concepts of gas dynamics and centrifugal compressor
4) To learn the basic concepts of cascade analysis and axial compressors
5) To learn the concepts of axial flow gas turbines

UNIT – 1
FUNDAMENTALS OF TURBO MACHINES: Classifications, Applications, Thermodynamic analysis, Isentropic flow. Energy transfer. Efficiencies, Static and Stagnation conditions, Continuity equations, Euler's flow through variable cross sectional areas, Unsteady flow in turbo machines

UNIT – 2
STEAM NOZZLES: Convergent and Convergent-Divergent nozzles, Energy Balance, Effect of back pressure of analysis. Designs of nozzles.
Steam Turbines: Impulse turbines, Compounding, Work done and Velocity triangle, Efficiencies, Constant reactions, Blading, Design of blade passages, Angle and height, Secondary flow. Leakage losses, Thermodynamic analysis of steam turbines.

UNIT – 3
GAS DYNAMICS: Fundamental thermodynamic concepts, isentropic conditions, mach numbers and area, Velocity relations, Dynamic Pressure, Normal shock relation for perfect gas. Supersonic flow, oblique shock waves. Normal shock recoveries, Detached shocks, Aerofoil theory.
Centrifugal compressor: Types, Velocity triangles and efficiencies, Blade passage design, Diffuser and pressure recovery. Slip factor, Stanitz and Stodolas formula's, Effect of inlet mach numbers, Pre whirl, Performance

UNIT – 4
AXIAL FLOW COMPRESSORS: Flow Analysis, Work and velocity triangles, Efficiencies, Thermodynamic analysis. Stage pressure rise, Degree of reaction, Stage Loading, General design, Effect of velocity, Incidence, Performance
Cascade Analysis: Geometrical and terminology. Blade force, Efficiencies, Losses, Free end force, Vortex Blades.

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UNIT – 5

AXIAL FLOW GAS TURBINES: Work done. Velocity triangle and efficiencies, Thermodynamic flow analysis, Degree of reaction, Zweifels relation, Design cascade analysis, Soderberg, Hawthrone, Ainley, Correlations, Secondary flow, Free vortex blade, Blade angles for variable degree of reaction. Actuator disc, Theory, Stress in blades, Blade assembling, Material and cooling of blades, Performances, Matching of compressors and turbines, Off design performance.

TEXT BOOK:
1. Principles of Turbo Machines/DG Shepherd / Macmillan

REFERENCES:
1. Fundamentals of Turbo machinery/William W Perg/John Wiley & Sons
2. Element of Gas Dynamics/Yahya/TMH
3. 3. Principles of Jet Propulsion and Gas Turbine/NJ Zucrow/John Wiley & Sons/New York
4. Turbines, Pumps, Compressors/Yahya/TMH
5. Theory and practice of Steam Turbines/ WJ Kearton/ELBS Pitman/London
6. Element of Gas Dynamics/Liepeman and Roshkow/ Dover Publications

Course Outcomes: At the end of the course, student will be able to

CO1: Illustrate the concepts of turbo machines.

CO2: Analyze the thermal analysis of steam nozzles and steam turbines

CO3: Build the concepts of gas dynamics and centrifugal compressor

CO4: Build the concepts of cascade analysis and axial compressors

CO5: Understand the concepts axial flow gas turbines

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DEPARTMENT OF MECHANICAL ENGINEERING HONORS	T	P	C
	4	0	0	4

MATERIALS TECHNOLOGY

Course objectives:
1) To understand the concepts of different strengthening mechanisms and plastic behaviour of engineering materials.
2) To understand the principles of deformation and fracture mechanism.
3) To understand and analyze the concepts of fatigue and fracture of non-metallic materials.
4) To do appropriate selection of modern metallic materials for various engineering applications.
5) To gain knowledge about the non-metallic materials and applications.

UNIT - I
ELASTICITY IN METALS: Mechanism of plastic deformation, slip and twinning, role of dislocations, yield stress, shear strength of perfect and real crystals, strengthening mechanism, work hardening, solid solution, grain boundary strengthening. Poly phase mixture, precipitation, particle, fiber and dispersion strengthening, effect of temperature, strain and strain rate on plastic behaviour, super plasticity, Yield criteria: Von-mises and Tresca criteria.

UNIT - II
FRACTURE: Griffth's Theory, stress intensity factor and fracture Toughness, Toughening Mechanisms, Ductile and Brittle transition in steel, High Temperature Fracture,
CREEP: Larson – Miller parameter, Deformation and Fracture mechanism maps.

UNIT - III
Fatigue, fatigue limit, features of fatigue fracture, Low and High cycle fatigue test, Crack Initiation and Propagation mechanism and Paris Law, Effect of surface and metallurgical parameters on Fatigue, Fracture of non-metallic materials, fatigue analysis, Sources of failure, procedure of failure analysis. Motivation for selection, cost basis and service requirements, Selection for Mechanical Properties, Strength, Toughness, Fatigue.

UNIT - IV
MODERN METALLIC MATERIALS: Dual Steels, Micro alloyed, High Strength Low alloy (HSLA) Steel, Transformation induced plasticity (TRIP) Steel, Maraging Steel, Inter metallic, Ni and Ti Aluminides. Processing and applications of Smart Materials, Shape Memory alloys, Metallic Glass Quasi Crystal and Nano Crystalline Materials.

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UNIT - V
NON-METALLIC MATERIALS: Polymeric materials and their molecular structures, Production Techniques for Fibers, Foams, Adhesives and Coatings, structure, Properties and Applications of Engineering Polymers, Advanced Structural Ceramics WC, TiC, TaC, Al_2O_3, SiC, Si_3N_4, CBN and Diamond – properties, Processing and applications.

TEXT BOOKS:
1. Mechanical Behavior of Materials/Thomas H. Courtney/ McGraw Hill/ 2nd Edition/2000
2. Mechanical Metallurgy/George E. Dieter/McGraw Hill, 1998..

REFERENCES:
1 Selection and use of Engineering Materials 3e/Charles J.A/Butterworth Heiremann.
2 Engineering Materials Technology/James A Jacob Thomas F Kilduff/Pearson
3 Material Science and Engineering/William D Callister/John Wiley and Sons
4 Plasticity and plastic deformation by Aritzur.
5 Introduction to Ceramics, 2nd Edition by W. David Kingery, H. K. Bowen, Donald R. Uhlmann

Course Outcomes: At the end of the course, student will be able to
CO1: Learn the concepts of different strengthening mechanisms and plastic behaviour of engineering materials.
CO2: Learn the principles of deformation and fracture mechanism.
CO3: Analyze the concepts of fatigue and fracture of non-metallic materials.
CO4: Select the modern metallic materials for various engineering applications.
CO5: Gain knowledge about the non-metallic materials and applications.