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
KAKINADA - 533 003, Andhra Pradesh, India

II YEAR I SEMESTER

S. No.	Course Code	Course Title	L	T	P	Credits
1	BSC-5	Vector Calculus, Fourier Transforms and PDE(M-III)	3	0	0	3
2	PCC-1	Mechanics of Solids	3	0	0	3
3	PCC-2	Fluid Mechanics & Hydraulic Machines	3	0	0	3
4	PCC-3	Production Technology	3	0	0	3
5	PCC-4	Kinematics of Machinery	3	0	0	3
6	PCC-L1	Computer Aided Engineering Drawing Practice	0	0	3	1.5
7	PCC-L2	Fluid Mechanics & Hydraulic Machines Lab	0	0	3	1.5
8	PCC-L3	Production Technology Lab	0	0	3	1.5
9	SOC-1	Drafting and Modeling Lab	0	0	4	2
10	MC-3	Essence of Indian Traditional Knowledge	2	0	0	0
		Total Credits				**21.5**

II YEAR II SEMESTER

S. No	Course Code	Course Title	L	T	P	Credits
1	ESC-6	Material Science & Metallurgy	3	0	0	3
2	BSC-6	Complex Variables and Statistical Methods	3	0	0	3
3	PCC-5	Dynamics of Machinery	3	0	0	3
4	PCC-6	Thermal Engineering-I	3	0	0	3
5	HSC-2	Industrial Engineering and Management	3	0	0	3
6	ESC-L4	Mechanics of Solids and Metallurgy Lab	0	0	3	1.5
7	PCC-L6	Machine Drawing Practice	0	0	3	1.5
8	PCC-L7	Theory of Machines Lab	0	0	3	1.5
9	SOC-2	Python Programming Lab	1	0	2	2
		Total Credits				**21.5**
Honors/Minor courses			**4**	**0**	**0**	**4**

* At the end of II Year II Semester, students must complete summer internship spanning between 1 to 2 months (Minimum of 6 weeks), @ Industries/ Higher Learning Institutions/ APSSDC.

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

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

II Year - II Semester		L	T	P	C
		3	0	0	3

MATERIALS SCIENCE & METALLURGY

Course Objective: To understand the basic fundamentals of Material science and Physical metallurgy. The basic concepts to be taught will help for the improvement, proper selection and effective utilization of materials which is essential to satisfy the ever increasing demands of the society.

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
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 $Fe-Fe_3C$.

UNIT –II

Ferrous metals and alloys: Structure and properties of White Cast iron, Malleable Cast iron, grey cast iron, Spheriodal 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.
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 – III

Heat treatment of Alloys: Effect of alloying elements on $Fe-Fe_3C$ system, Annealing, normalizing, hardening, TTT diagrams, tempering, hardenability, surface - hardening methods, Age hardening treatment, Cryogenic treatment of alloys.

UNIT – IV

Powder Metallurgy: Basic processes- Methods of producing metal powders- milling atomization- Granulation-Reduction-Electrolytic Deposition. Compacting methods – Sintering - Methods of manufacturing sintered parts. Sintering Secondary operations-Sizing, coining, machining -Factors determining the use of powder metallurgy-Application of this process.

UNIT – V

Ceramic and composite materials: Crystalline ceramics, glasses, cermets, abrasive materials, Classification of composites, various methods of component manufacture of composites, particle – reinforced materials, fiber reinforced materials, metal ceramic mixtures, metal – matrix composites and C – C composites. Nano-materials – definition, properties and application

TEXT BOOKS:

1. Introduction to Physical Metallurgy - Sidney H. Avener -McGrawHill
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:

CO1: Understand the crystalline structure of different metals and study the stability of phases in different alloy systems.

CO2: Study the behavior of ferrous and non ferrous metals and alloys and their application in different domains

CO3: Able to understand the effect of heat treatment, addition of alloying elements on properties of ferrous metals.

CO4: Grasp the methods of making of metal powders and applications of powder metallurgy

CO5: Comprehend the properties and applications of ceramic, composites and other advanced methods.

II Year - II Semester		L	T	P	C
		3	0	0	3

COMPLEX VARIABLES AND STATISTICAL METHODS

Course Objectives:

- To familiarize the complex variables.
- To familiarize the students with the foundations of probability and statistical methods.
- To equip the students to solve application problems in their disciplines.

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

- apply Cauchy-Riemann equations to complex functions in order to determine whether a given continuous function is analytic (L3)
- find the differentiation and integration of complex functions used in engineering problems (L5)
- make use of the Cauchy residue theorem to evaluate certain integrals (L3)
- apply discrete and continuous probability distributions (L3)
- design the components of a classical hypothesis test (L6)
- infer the statistical inferential methods based on small and large sampling tests (L4)

UNIT – I: Functions of a complex variable and Complex integration: (10 hrs)

Introduction – Continuity – Differentiability – Analyticity –Cauchy-Riemann equations in Cartesian and polar coordinates –Harmonicand conjugate harmonic functions – Milne – Thompson method.

Complex integration: Line integral – Cauchy’s integral theorem – Cauchy’s integral formula – Generalized integral formula (all without proofs) and problems on above theorems.

UNIT – II: Series expansions and Residue Theorem: (10 hrs)

Radius of convergence – Expansion in Taylor’s series, Maclaurin’s series and Laurent series. Types of Singularities: Isolated – Essential –Pole of order m– Residues – Residue theorem (without proof) – Evaluation of real integral of the types $\int_{-\infty}^{\infty} f(x)dx$ and $\int_{c}^{c+2\pi} f(\cos\theta, \sin\theta)d\theta$.

UNIT – III: Probability and Distributions: (10 hrs)

Review of probability and Baye’s theorem – Random variables – Discrete and Continuous random variables – Distribution functions – Probability mass function, Probability density function and Cumulative distribution functions – Mathematical Expectation and Variance – Binomial, Poisson, Uniform and Normal distributions.

UNIT – IV: Sampling Theory: (8 hrs)

Introduction – Population and Samples – Sampling distribution of Means and Variance (definition only) – Central limit theorem (without proof) – Representation of the normal theory distributions – Introduction to t, χ^2 and F-distributions – Point and Interval estimations – Maximum error of estimate.

UNIT – V: Tests of Hypothesis: (10 hrs)

Introduction – Hypothesis – Null and Alternative Hypothesis – Type I and Type II errors – Level of significance – One tail and two-tail tests – Tests concerning one mean and two means (Large and Small samples) – Tests on proportions.

Text Books:

1. **B. S. Grewal,** Higher Engineering Mathematics, 44th Edition, Khanna Publishers.
2. **Miller and Freund's,** Probability and Statistics for Engineers,7/e, Pearson, 2008.

Reference Books:

1. **J. W. Brown and R. V. Churchill**, Complex Variables and Applications, 9th edition, Mc-Graw Hill, 2013.
2. **S.C. Gupta and V.K. Kapoor**, Fundamentals of Mathematical Statistics, 11/e, Sultan Chand & Sons Publications, 2012.
3. **Jay l. Devore,** Probability and Statistics for Engineering and the Sciences, 8thEdition,Cengage.
4. **ShronL.Myers, Keying Ye, Ronald E Walpole,** Probability and Statistics Engineers and the Scientists, 8th Edition, Pearson 2007.
5. **Sheldon, M. Ross**, Introduction to probability and statistics Engineers and the Scientists, 4thEdition, Academic Foundation, 2011

II Year - II Semester		L	T	P	C
		3	0	0	3
DYNAMICS OF MACHINERY					

Course Objectives:

1. To analyze the forces in clutches, brakes and dynamometers involving friction.
2. Understand the effect gyroscopic couple in motor cycles, aeroplanes and ships.
3. To understand the static and dynamic force analysis of four bar and slider crank mechanisms.
4. To study the turning moment diagrams of reciprocating engines and to learn design procedure of a flywheel
5. To learn analytical and graphical methods for calculating balancing of rotary and reciprocating masses
6. Understanding of vibrations and its significance on engineering design.

UNIT – I

FRICTION: Inclined plane, friction of screw and nuts, pivot and collar, uniform pressure, uniform wear, friction circle and friction axis: lubricated surfaces, boundary friction, film lubrication.

CLUTCHES: Friction clutches- single disc or plate clutch, multiple disc clutch, cone clutch, centrifugal clutch.

BRAKES AND DYNAMOMETERS: Simple block brakes, internal expanding brake, band brake of vehicle. General description and operation of dynamometers: Prony, Rope brake, Epicyclic, Bevis Gibson and belt transmission,

UNIT – II

STATIC AND DYNAMIC FORCE ANALYSIS: Dynamic force analysis of four bar mechanism and slider crank mechanism**,** inertia torque, angular velocity and acceleration of connecting rod, crank effort **TURNING MOMENT DIAGRAMS:** Turning moment diagrams

– fluctuation of energy – fly wheels and their design.

UNIT-III

PRECESSION: Gyroscopes, effect of precession motion on the stability of moving vehicles such as motor car, motor cycle, aero planes and ships.

GOVERNERS: Watt, porter and proell governors, spring loaded governors – Hartnell and Hartung with auxiliary springs. sensitiveness, isochronism and hunting.

UNIT – IV

BALANCING: Balancing of rotating masses single and multiple – single and different planes, use analytical and graphical methods. Primary, secondary, and higher balancing of reciprocating masses. analytical and graphical methods, unbalanced forces and couples – examination of “V” multi cylinder in line and radial engines for primary and secondary balancing, locomotive balancing, hammer blow, swaying couple, variation of tractive effort.

UNIT – V

VIBRATIONS: Free Vibration of spring mass system –Natural frequency-types of damping – damped free vibration, Simple problems on forced damped vibration, vibration isolation and transmissibility transverse loads, vibrations of beams with concentrated and distributed loads. Dunkerly’s methods, Raleigh’s method, whirling of shafts, critical speeds, torsional vibrations, two and three rotor systems.

Text Books:

1. Theory of Machines -S.S Rattan - Mc. GrawHill
2. Theory of Mechanisms and Machines -Dr.JagadishLal - Metropolitan Pvt.Ltd.

References:

1. Mechanism and machine theory - JS Rao & RV Dukkipati - New AgePublishers.
2. Theory of Machines - Shigley – McGrawHillPublishers
3. Theory of Machines - Thomas Bevan - PearsonPublishers

Course outcomes:

1. To compute the frictional losses and transmission in clutches, brakes anddynamometers
2. To determine the effect of gyroscopic couple in motor vehicles, ships andaeroplanes
3. To analyze the forces in four bar and slider crank mechanisms and design aflywheel
4. To determine the rotary unbalanced mass in reciprocatingequipment
5. To determine the unbalanced forces and couples in reciprocating and radialengines
6. To determine the natural frequencies of discrete systems undergoing longitudinal, torsional and transverse vibrations.

II Year - II Semester		L	T	P	C
		3	0	0	3
THERMAL ENGINEERING - I					

Course Objectives:

1. To make the student learn and understand the reasons and affects of various losses that occur in the actual engine operation.
2. To familiarize the student with the various engine systems along with their function and necessity.
3. To learn about normal combustion phenomenon and knocking in S.I. and C.I. Engines and to find the several engine operating parameters that affect the smooth engine operation.
4. To make the student learn to perform testing on S.I and C.I Engines for the calculations of performance and emission parameters.

UNIT – I

Air standard Cycles: otto, diesel and dual cycles, its comparison, Brayton cycle

Actual Cycles and their Analysis: Introduction, Comparison of Air Standard and Actual Cycles, Time Loss Factor, Heat Loss Factor, Exhaust Blowdown-Loss due to Gas exchange process, Volumetric Efficiency. Loss due to Rubbing Friction, Actual and Fuel-Air Cycles of CI Engines.

UNIT – II

I. C. ENGINES : Classification - Working principles, Valve and Port Timing Diagrams, - Engine systems – Fuel, Carburettor, Fuel Injection System, Ignition, Cooling and Lubrication, principle of wankle engine, principles of supercharging and turbocharging.

UNIT – III

Combustion in S.I. Engines : Normal Combustion and abnormal combustion – Importance of flame speed and effect of engine variables – Types of Abnormal combustion, pre-ignition and knocking (explanation of) – Fuel requirements and fuel rating, anti knock additives – combustion chamber – requirements, types.

Combustion in C.I. Engines : Four stages of combustion – Delay period and its importance – Effect of engine variables – Diesel Knock– Need for air movement, suction, compression and combustion induced turbulence – open and divided combustion chambers and nozzles used – fuel requirements and fuel rating.

UNIT – IV

Measurement, Testing and Performance: Parameters of performance - measurement of cylinder pressure, fuel consumption, air intake, exhaust gas composition, Brake power – Determination of frictional losses and indicated power – Performance test – Heat balance sheet and chart.

UNIT –V

GAS TURBINES: Simple gas turbine plant – ideal cycle, essential components – parameters of performance – actual cycle – regeneration, inter cooling and reheating –closed cycle type gas turbines.

JET PROPULSION: Principle of operation –classification of jet propulsive engines – working principles with schematic diagrams and representation on t-s diagram - thrust, thrust power and propulsion efficiency – turbo jet engines – needs and demands met by turbo jet – schematic diagram, thermodynamic cycle, performance evaluation (Definitions and Simple Problems).

ROCKETS: Application – working principle – classification – propellant type – thrust, propulsive efficiency – specific impulse – solid and liquid propellant rocket engines
(only Theoretical concepts).

Text Books:

1. I.C. Engines - V. Ganesan- Tata McGraw Hill Publishers
2. Gas Turbines – V.Ganesan – Tata McGraw HillPublishers

References:

1. Thermal Engineering - Mahesh Rathore- McGraw Hillpublishers
2. I.C.Engines–AppliedThermosciences–C.R.Ferguson&A.T.Kirkpatrick-2nd Edition-WileyPubl
3. I.C. Engines - J.B.Heywood/McGrawHIll.
4. Heat engines, Vasandani& Kumar – Thermalpublications
5. Gas Turbine Theory – HIH Saravanamuttoo, Cohen, Rogers –PearsonPublishers

Course Outcomes: Student must able to,

CO1: Derive the actual cycle from fuel-air cycle and air- standard cycle for all practical applications. CO2: Explain working principle and various components of IC engine
CO3: Explain combustion phenomenon of CI and SI engines and their impact on engine variables. CO4: Analyze the performance of an IC engine based on the performance parameters.
CO5: Explain the cycles and systems of a gas turbine and determine the efficiency of gas turbine. CO6: Explain the applications and working principle of rockets and jet propulsion.

II Year – II Semester		L	T	P	C
		3	0	0	3

INDUSTRIAL ENGINEERING AND MANAGEMENT

UNIT – I
INTRODUCTION: Definition of industrial engineering (I.E), development, applications, role of an industrial engineer, differences between production management and industrial engineering, 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
PLANT LAYOUT: Factors governing plant location, types of production layouts, advantages and disadvantages of process layout and product layout, applications, quantitative techniques for optimal design of layouts, plant maintenance, preventive and breakdownmaintenance.

UNIT – III
WORK STUDY: Importance, types of production, applications, workstudy, 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 – IV
STATISTICAL QUALITY CONTROL: Quality control, Queing assurance and its importance, SQC, attribute sampling inspection with single and double sampling, Control charts – $\overline{X}$ and R – charts $\overline{X}$ and S charts and their applications, numerical examples.
TOTAL QUALITY MANAGEMENT: zero defect concept, quality circles, implementation,

applications, ISO quality systems. six sigma – definition, basic concepts

UNIT – V
RESOURCE MANAGEMENT: Concept of human resource management, personnel management and industrial relations, functions of personnel management, Job-evaluation, its importance and types, merit rating, quantitative methods, wage incentive plans, types.
VALUE ANALYSIS: Value engineering, implementation procedure, enterprise resource planning and supply chainmanagement.

TEXT BOOKS:

1. Industrial Engineering and management / O.P Khanna/KhannaPublishers.
2. Industrial Engineering and Production Management/MartandTelsang/S.Chand& CompanyLtd. New Delhi

Reference Books:

1. Industrial Management / Bhattacharya DK/Vikaspublishers
2. Operations Management / J.G Monks/McGrawHillPublishers.
3. Industrial Engineering and Management Science/T.R. Banga, S.C.Sharma, N. K. Agarwal / Khanna Publishers
4. Principles of Management /Koontz O' Donnel/McGraw Hill Publishers.
5. Statistical Quality Control /Gupta/KhannaPublishers
6. Industrial Engineering and Management /NVS Raju/Cengage Publishers

Course outcomes:

Upon successful completion of this course you should be able to:

1. Design and conduct experiments, analyse, interpret data and synthesize validconclusions
2. Design a system, component, or process, and synthesize solutions to achieve desiredneeds
3. Use the techniques, skills, and modern engineering tools necessary for engineering practice with appropriate considerations for public health and safety, cultural, societal, and environmental constraints
4. Function effectively within multi-disciplinary teams and understand the fundamental precepts of effective project management

DEPARTMENT OF MECHANICAL ENGINEERING

II Year - II Semester		L	T	P	C
		0	0	3	1.5

MECHANICS OF SOLIDS & METALLURGY LAB

Course Objective: To impart practical exposure on the microstructures of various materials and their hardness evaluation. Also to impart practical knowledge on the evaluation of material properties through various destructive testing procedures.

NOTE: Any 6 experiments from each section A and B.

(A) MECHANICS OF SOLIDSLAB:

1. Direct tensiontest
2. Bending teston
    a) Simple supported
    b) Cantileverbeam
3. Torsiontest
4. Hardnesstest
    a) Brinells hardnesstest
    b) Rockwell hardnesstest
5. Test onsprings
6. Compression test oncube
7. Impacttest
8. Punch shear test

(B) METALLURGYLAB:

1. Preparation and study of the Microstructure of pure metals like Iron, Cu and Al.
2. Preparation and study of the Microstructure of Mild steel, Medium carbon steels, High carbon steels.
3. Study of the Micro Structures of Cast Irons.
4. Study of the Micro Structures of Non-Ferrousalloys.
5. Study of the Micro structures of Heat treated steels.
6. Hardeneability of steels by Jominy End QuenchTest.
7. To find out the hardness of various treated and untreated steels.

II Year - II Semester		L	T	P	C
		0	0	3	1.5

MACHINE DRAWING PRACTICE

Course Objective: *The student will acquire knowledge in national and International standards while drawing machine components students will also familiarize in drawing assembly, orthographic and sectional views of various machine components.*

Machine Drawing Conventions:

Need for drawing conventions – introduction to IS conventions-Standardization-Interchangeability-Selective assembly-Tolerance

a) Conventional representation of materials, common machine elements and parts such as screws, nuts, bolts, keys, gears, webs, ribs.

b) Types of sections – selection of section planes and drawing of sections and auxiliary sectional views. Parts not usually sectioned.

c) Methodsofdimensioning,generalrulesforsizesandplacementofdimensionsforholes, centers, curved tapered features and surface finish indication

d) Title boxes, their size, location and details - common abbreviations & their liberal usage

e) Types of Drawings – working drawings for machine parts.

PART-A

I. Drawing of Machine Elements and simple parts

Objective: To provide basic understanding and drawing practice of various joint, simplemechanical parts

Selection of Views, additional views for the following machine elements and parts with every drawing proportions.

a) Popular forms of Screw threads, bolts, nuts, stud bolts, tap bolts, setscrews.

b) Keys, cotter joints, knuckle joint, Hook'sjoint

c) Riveted joints for plates

d) Shaft couplings.

e) Journal, pivot and collar and foot step bearings.

PART-B

II. Assembly Drawings:

Objective: The student will be able to draw the assembly from the individualpart drawing. Drawings of assembled views for the part drawings of the following using conventions and easy drawingproportions.

a) Engine parts –Gear pump, Fuel pump, petrol Engine connecting rod, piston, stuffingboxand eccentric assembly.

b) Other machine parts - Screws jack, Machine swivel vice, Plummer block, Tailstock and Tool post.

III. Manufacturing Drawing

Introduction of Limits and fits, fundamental deviations for Hole based and Shaft based systems, alpha numeric designation of limits & fits. Types of Fits. Form and positional tolerances.

Conventional practices of indicating limits and fits, geometrical form and position tolerances, surface finish and surface treatments requirements. Study of Examples involving selection of fits and calculation of limits. Suggestion of suitable fits for mating parts.

Representation of limits fits and tolerances for mating parts. Use any four parts of above assembly drawings and prepare manufacturing drawing with dimensional and geometric tolerances.

TEXT BOOKS:

1. Machine Drawing – N.Siddeswar, K.Kannaiah&V.V.S.Sastry -TMH
2. Machine Drawing –K.L.Narayana, P.Kannaiah&K. Venkata Reddy / New Age/Publishers
3. Production Drawing- K.L.Narayana, P.Kannaiah&K. Venkata Reddy / New Age/Publishers

REFERENCES:

1. Machine Drawing –P.S.Gill,
2. Machine Drawing –Luzzader
3. Machine Drawing –Rajput
4. Machine Drawing – N.D. Junnarkar,Pearson
5. Machine Drawing – Ajeeth Singh, McGrawHill
6. Machine Drawing – KC John,PHI
7. Machine Drawing – B Battacharya,Oxford
8. Machine Drawing – Gowtham and Gowtham,Pearson
9. Machine Drawing- Dhawan R K-S.chand&Company

Course Outcome:

CO1. Draw and represent standard dimensions of different mechanical fasteners and joints and Couplings.
CO2. Draw different types of bearings showing different components.
CO3. Assemble components of a machine part and draw the sectional assembly drawing showing the dimensions of all the components of the assembly as per bill of materials
CO4. Select and represent fits and geometrical form of different mating parts in assembly drawings.
CO5: To prepare manufacturing drawings indicating fits, tolerances, surface finish and surface treatment requirements.

II Year - II Semester		L	T	P	C
		0	0	3	1.5

THEORY OF MACHINES LAB

1. To determine whirling speed of shaft theoretically andexperimentally.
2. To determine the position of sleeve against controlling force and speed of a Hartnellgovernorand to plot the characteristic curve of radius ofrotation.
3. To analyse the motion of a motorized gyroscope when the couple is applied along its spin axis
4. To determine the frequency of undamped free vibration of an equivalent spring mass system.
5. To determine the frequency of damped force vibration of a spring mass system
6. To study the static and dynamic balancing using rigid blocks.
7. To find the moment of inertia of aflywheel
8. To plot follower displacement vs cam rotation for various Cam Follower systems.
9. To plot slider displacement, velocity and acceleration against crank rotation for single slider crank mechanism/Four bar mechanism
10. To find coefficient of friction between belt and pulley.
11. To study simple and compound screw jack and determine the mechanical advantage , velocity ratio and efficiency
12. To study various types of gears- Spur, Helical, Worm and BevelGears

II Year - II Semester		L	T	P	C
		1	0	2	2

PYTHON PROGRAMMING LAB

Course Objective: To understand the PYTHON environment and make numerical computations and analysis.

Course Outcomes:

At the end of the course, student will be able to

CO1 Solve the different methods for linear, non-linear and differential equations

CO2 Learn the PYTHON Programming language

CO3 Familiar with the strings and matrices in PYTHON

CO4 Write the Program scripts and functions in PYTHON to solve the methods

CONTENTS

Write Programs in PYTHON Programming for the following:

1. To find the roots of non-linear equation using Bisection method
2. To find the roots of non-linear equation using Newton Raphson’s method.
3. Curve fitting by least – square approximations
4. To solve the system of linear equations using Gauss - elimination method
5. To solve the system of linear equations using Gauss - Siedal method
6. To solve the system of linear equations using Gauss - Jordan method
7. To integrate numerically using Trapezoidal rule
8. To integrate numerically using Simpsons rule
9. To find the largest eigen value of a matrix by Power – method
10. To find numerical solution of ordinary differential equations by Euler’s method
11. To find numerical solution of ordinary differential equations by Runge-Kutta method
12. To find numerical solution of ordinary differential equations by Milne’s method
13. To find the numerical solution of Laplace equation
14. To find the numerical solution of Wave equation
15. To find the solution of a tri-diagonal matrix using Thomas algorithm
16. To fit a straight using least square technique

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.

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.

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.

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.

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_3C.

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_3C system, Annealing, normalizing, hardening, TTT diagrams, tempering, hardenability, surface - hardening methods, Age hardening treatment, Cryogenic treatment of alloys.

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.

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.

UNIT-V

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.

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

Course Objectives:

1) To understand the classification of optimization problems and classical 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.

CO5: Learn the principles of dynamic programming and its applications.

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.

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 &amp; 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

MINOR		L	T	P	C
		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.

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 &amp; Vol. 2 / Kirpal Singh/standard publishers
2. Automobile Engineering / William Crouse/TMH Distributors
3. Automobile Engineering/P.S Gill/S.K. Kataria&amp; 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&amp; 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

MINOR		L	T	P	C

	4	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.

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

		4	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

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

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

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) 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

		4	**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.

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 &amp; 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 &amp; analysis / B.C.Nakra &amp; 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.

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.

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.

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

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.

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.

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.

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

CO 1: Understand concepts of 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.

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.

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.

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.

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.

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.

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.

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

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.

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.

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.

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.

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.

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.

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**

4	0	0	4

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.

TEXT BOOK:

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 *I* 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

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

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

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					

Course Objective:

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.

TEXT BOOKS:

1. Characterization of Materials (Materials Science and Technology: A Comprehensive Treatment, Vol 2A & 2B
2. Semiconductor Material and Device Characterization, 3rd Edition, 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.

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

UNIT – 5

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

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

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

	4	**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.

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

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:

1. Basic and Applied Thermodynamics/P.K.Nag/TMH
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

DESIGN FOR MANUFACTURING AND ASSEMBLY

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 used in automated assembly systems, Quantitative analysis of 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:

1) To demonstrate basic concepts of motion controllers, 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

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

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.

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

HONORS		L	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.

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, $A1_2O_3$, 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.