DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MET101	**Introduction to Mechanical Systems**	**2**	**2**	**0**	**0**	**0**

PREREQUISITE : None.

COURSE OUTCOMES

CO1	To understand the construction and working of a mobility system.
CO2	To ascertain the manufacturing processes appropriate for hardware development.
CO3	To select favorable engineering material(s) for the given application.
CO4	To analyze the efficiency of different thermal systems.
CO5	To select appropriate power transmission drive(s) for the given application.

COURSE CONTENTS

Mobility Systems: various modes of transportation – rail, road, air and water; main components of an automobile; conventional and alternative fuels; electric vehicles

Manufacturing Processes: Machining operations and machine tools: lathe, drilling, shaper, milling; Joining methods: shielded metal arc welding, oxy-acetylene gas welding, basic welded joints, soldering, brazing; foundry tools and sand casting; additive manufacturing processes and their mechanisms.

Engineering Materials: Introduction, classification and mechanical properties of engineering materials, criteria for engineering material selection

Power Generation Systems: Steam generation, properties of steam, steam power plant – components, working and their thermodynamic cycle, steam tables, Mollier diagram; internal combustion engines, petrol and diesel engine and their thermodynamic cycles, engine cooling systems.

Refrigeration and Air Conditioning: Refrigerator, heat pump, heat engine, coefficient of performance, unit of Refrigeration, thermodynamic cycles; domestic refrigerator, desert cooler, unitary air conditioner, ice plant.

Power Transmission Devices: Introduction, belt drive, rope drive, chain drive, gear drive

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):-

1. Basics of Mechanical Engineering by Pravin Kumar, Pearson publishing co.
2. Elements of Mechanical Engineering by D. S. Kumar, Kataria & Sons, New Delhi.
3. Engineering Thermodynamics by P. K. Nag, McGraw-Hill Publishing Co., New Delhi.
4. Workshop Technology by S. K. Garg, Laxmi Publications, New Delhi.

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MEP102	**Product Realization through Manufacturing**	**1**	**0**	**0**	**2**	**0**

PREREQUISITE : Nil

COURSE OUTCOMES:

CO1	To select suitable tools and equipment to prepare jobs related to welding, fitting, machining, foundry processes and 3D printing techniques.
CO2	To prepare the equipment/machine tool for the production of the job.
CO3	To produce job using materials of specific shape and size by a suitable set of operations.
CO4	To measure the accuracy of job using different measuring instruments.

COURSE CONTENTS

S. No	Shop / Lab	Topics
1	**All Shops**	Introduction to Product Realization through 3D Printing, Welding, Foundry, Machining, and Assembly.
2	**Machine Shop**	Introduction/Classification of Machine tools (Lathe, Shaper, Drilling, Grinder, Milling machines), Single and Multi-point Cutting tools, Safety/Precautions during machine shop. Demo and hands on practice on preparation of Job on Lathe Machine Tool —Simple Turning, Step turning, facing, Knurling, etc.
3	**Welding Shop**	Introduction/Classification/Advantages and Disadvantages of welding processes (i.e. Arc, Gas and Resistance Welding), Safety/Precautions during welding shop. Demo and hands on practice on preparation of Butt/Lap/Corner/T-Joint on Arc welding machine.
4	**Foundry Shop**	Introduction to Oil/Electric Furnace/Foundry tools/ Moulding Sand, Types of patterns, Types of Allowances, Safety/Precautions during foundry shop. Demo and hands on practice on preparation of Mould cavity and Casting Job(s).
5	**Fitting Shop**	Introduction to various Fitting tools/Measuring tools/ Marking tools, Safety/Precautions during foundry shop. Demo and hands on practice on preparation of fitting job using following operations (Filing, Drilling, Tapping, Assembly etc.)
6	**Product Design & Development Lab**	Introduction to FDM based 3D Printing Steps. Demo and hands on practice on FDM based 3D Printing including Pre and Post Processing.

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year)

1.The Elements of Workshop Technology - Vol I & II, S.K. Hajra Choudhury, A.K. Hajra Choudhury, Nirjhar Roy, latest edition, Media Promoters and Publishers, Mumbai.
2.Lab Manuals

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MET103	**Applied Probability and Statistics**	**3**	**2**	**1**	**0**	**0**

PREREQUISITE : Basic fundamentals of mathematics

COURSE OUTCOMES

CO1	Acquiring a basic knowledge about application of probability theory, useful for modeling uncertain phenomena in engineering
CO2	Learning the general methods of estimating statistical parameters using data and thereby establishing their values with hypothesis testing
CO3	Learning standard statistical methods useful for everyday routine elementary applications
CO4	Implementing Applied Probability and Statistics theory knowledge in real world decision making.

COURSE CONTENTS

Introduction to the role of probability and statistics in engineering: Why study statistics, role of science and engineer in quality improvement, a case study: Visually inspecting data to improve product quality, concept of population and sample.
Descriptive statistics and treatment of data: Measures of central tendency, Pareto diagram, frequency distribution, box plots, pair plots, scatter plots.
Probability concepts: Conditional probability, Bayes' theorem, random variables, types of probability distribution, binomial distribution, mean and variance of probability distribution, Chebyshev's theorem, Poisson distribution, normal distribution, uniform distribution, sampling distribution of mean and variance.
Inferential statistics: Point estimation, interval estimation, inferences concerning means, variance and proportions with hypothesis testing.
Curve fitting: Correlation, Method of least squares, linear regression, residual analysis, auto-correlation.

TEXT BOOKS/ REFERENCE BOOKS:-

1) Probability and Statistics for Engineers, Richard A. J., Miller, I. and Freund J., 8th ed., Pearson, 2015.
2) Data Analysis and Decision Making, Albright, S.C., Winston, W.L. and Zappe, C.J Cengage, 2015.

ONLINE/E RESOURCES

1) https://www.youtube.com/c/joshstarmer
2) https://statquest.org

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MET104	**Casting, Welding and Forming**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE : None

COURSE OUTCOMES:

CO1	To provide detailed information about the moulding processes
CO2	Illustrate casting problem (melting, refining & pouring and production of a mould) and explain process capabilities and application of casting processes. Design a "mould ready to pour" solution for a given casting.
CO3	Illustrate capabilities of welding processes and select an appropriate welding process for a given application
CO4	Illustrate capabilities of forming process and hence application of bulk metal forming processes and sheet metal work.

COURSE CONTENTS

Casting Processes: Casting, molding methods and processes-materials, equipment, molding sand ingredients, essential requirements, sand preparation and control, testing, cores and core making. Design considerations in casting, gating and risering, directional solidification in castings. Heat transfer & fuid mechanics aspects in casting, Sand castings-pressure die casting-permanent mould casting-centrifugal casting precision investment casting, shell moulding, CO2 moudling, continuous casting-squeeze casting-electro slag casting, Thixo Molding, Moulding for Magnesium alloys. Gas injection moulding. Fettling, finishing, defects in Castings. Foundry melting furnaces: selection of furnace-crucibles oil fired furnaces, electric furnaces-cupola, hot blast etc

Welding Processes: Classification of welding processes, gas welding-arc welding-shielded metal arc welding, TAW, GMAW, SAW, ESW-Resistance welding (spot, seam, projection, percussion, flash types)-atomic hydrogen arc, therimit welding soldering, brazing and braze welding. Electron beam and Laser beam welding-plasma arc welding-stud welding-friction welding-explosive welding ultrasonic welding-underwater welding-roll bonding-diffusion bonding-cold welding-welding of plastics, dissimilar metal. Gas welding equipment's-welding power sources and characteristics-safety aspects in welding-automation of welding, seam tracking, vision and arc sensing-welding robots. Defects in welding-causes and remedies-destructive testing methods - NDT of weldments - testing of pipe, plate, boiler, drum, tank-case studies-weld thermal cycle-residual stresses-distortion-relieving of stresses, weld ability of cast iron, steel, stainless steel, aluminium alloys effect of gases in welding, fatigue failure in weldments.

Metal Forming Processes- Principle, solid mechanics aspects of forming, classification and equipment for forging, rolling and extrusion processes, Defects and analysis: Rod/wire drawing-tool, equipment and principle of processes defects, Tube drawing and sinking processes. Mannessmann processes of seamless pipe manufacturing. Classification conventional and HERF processes, Presses-types and selection of presses, formability of sheet metals, Principle, process parameters, equipment and application of the following processes. Deep drawing, spinning, stretch forming, plate bending, press brake forming, Explosive forming, electro hydraulic forming, magnetic pulse forming. Super plastic forming, electro forming-fine blanking, P/M forging-Isothermal forging-high speed, hot forging high velocity extrusion.

TEXT BOOKS/ REFERENCE BOOKS:-

1. Taylor H F, Flemings M C and Wulff J, Foundry Engineering, Wiley Eastern Limited, 1993.
2. Lindberg R.A, Processes and Materials of Manufacture, Prentice Hall of India (P) Limited, 1996.
3. Lancaster J.F., Metallurgy of welding, George Allen and Unwin, 1991.
4. S. K. Hazra Choudhury, A. K. Hajra Choudhury, Nirjhar Roy. Elements of workshop technology Vol I- Manufacturing Processes, MPP.
5. Kalpakjian Serope, Manufacturing engineering and Technology, Wesley Publishing Co., 1995.
6. William F. Hosford & Caddel Robert M., Metal forming (Mechanics & Metallurgy), Prentice Hall Publishing Co., 1990.
7. P. N. Rao, Manufacturing Technology, Volume 1, Tata McGraw-Hill Education, 2013
8. Amitabh Ghosh and Ashok Kumar Mallik, Manufacturing science, East west press private limited 1985.

ONLINE/E RESOURCES

1. SWAYM / NPTEL Portal

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MEP105	**Casting, Welding and Forming Lab**	**2**	**0**	**0**	**2**	**0**

PREREQUISITE : None

COURSE OUTCOMES:

CO1	To provide detailed information about the moulding processes
CO2	Illustrate casting problem (melting, refining & pouring and production of a mould) and explain process capabilities and application of casting processes. Design a "mould ready to pour" solution for a given casting.
CO3	Illustrate capabilities of welding processes and select an appropriate welding process for a given application
CO4	Illustrate capabilities of forming process and hence application of bulk metal forming processes and sheet metal work.

COURSE CONTENTS

- To perform various testing of green sand properties. i.e. (a) Clay content (b) Moisture content test (c) Grain fineness number test
- To perform various testing of green sand properties. i.e. (d) Permeability Test (e) Strength test (f) Hardness test
- Design of greensand mould with complete gating system for a product and testing it through a software
- Study of various castings defects and testing by NDT. i.e. UT
- Performing a parametric study of casting of MMC on stir casting machine
- Performing a butt joint and lap joint using TIG/MIG
- Mechanical testing of butt/lap joint welded by arc welding process
- To study the effect of process parameters in gas welding / arc welding / resistance welding (any one)
- Study of various weld defects and testing by NDT. i.e. UT/DP
- Design of die and punch and performing a forming operation
- To study the different types of dies and producing the washer

TEXT BOOKS/ REFERENCE BOOKS

1. Lab Manuals

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MET106	**Engineering Thermodynamics**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE Nil

COURSE OUTCOMES:

CO1	To understand the basic concepts of thermodynamic such as temperature, pressure, system, properties, process, state, cycles and equilibrium.
CO2	To solve common engineering problems in the thermal sciences field, including problems involving application of the first and second laws of thermodynamics.
CO3	To relate science of thermodynamics to the commonly available thermal systems.
CO4	To apply learned knowledge and skills of this course in order to understand, analyze, and design different thermal components, processes and systems.

COURSE CONTENTS

Introduction and Basic Concepts: Thermodynamics and Energy, Application Areas of Thermodynamics, Systems and Control Volumes, Properties of a System, Density and Specific Gravity, State and Equilibrium, Processes and Cycles, The Steady-Flow Process, Temperature and the Zeroth Law of Thermodynamics.

Energy Conversion and General Energy Analysis: Introduction, Forms of Energy, Some Physical Insight to Internal Energy, Mechanical Energy, Energy Transfer by Heat, Energy Transfer by Work, Electrical Work, Mechanical Forms of Work, Shaft Work, The First Law of Thermodynamics, Energy Balance, Energy Change of a System, Corollaries of 1st law, Application of first law to closed systems and open systems under steady and unsteady flow condition.

Properties of Pure Substances: Pure Substance, Phases of a Pure Substance, Phase-Change Processes of Pure Substances, Compressed Liquid and Saturated Liquid, Saturated Vapor and Superheated Vapor, Saturation Temperature and Saturation Pressure, Property Diagrams for Phase-Change, Processes, The T-v Diagram, The P-v Diagram, Extending the Diagrams to Include the Solid Phase, The P-T Diagram, The P-v-T Surface, Property Tables, Enthalpy, Superheated Vapor, The Ideal-Gas Equation of State

Energy Analysis of Closed Systems: Moving Boundary Work, Polytrophic Process, Energy Balance for Closed Systems, Specific Heats, Internal Energy, Enthalpy, and Specific Heats of Ideal Gases, Specific Heat Relations of Ideal Gases, Internal Energy, Enthalpy, and Specific Heat of Solids and Liquids, Internal Energy Changes, Enthalpy Changes.

The Second Law of Thermodynamics: Introduction to the Second Law, Thermal Energy Reservoirs, Heat Engines, Thermal Efficiency, Kelvin–Planck Statement, Refrigerators and Heat Pumps, Coefficient of Performance, Heat Pumps, Statement, Equivalence of the Two Statements, Perpetual-Motion Machines, Reversible and Irreversible Processes, Irreversibility, Internally and Externally Reversible Processes, The Carnot Cycle, The Reversed Carnot Cycle, The Carnot Principles.

Entropy: Entropy, Statistical definition of entropy, Reversible and irreversible processes in terms of Entropy, Application Second Law of Thermodynamics to closed systems and open systems under steady and unsteady flow condition.

Miscellaneous: Exergy, Second law efficiency, Maxwell Equations, Zeroth Law of Thermodynamics, Third Law of Thermodynamics, Clapeyron equation, Joule-Thomson effect, P-v-T surfaces for ideal and real gases.

TEXT BOOKS/ REFERENCE BOOKS: -

1. Y. A. Cengel & M. A. Boles; Thermodynamics-An Engineering Approach; McGraw-Hill Inc.
2. P. K. Nag; Engineering Thermodynamics; Tata McGraw-Hill, New Delhi.
3. G. Van Wylen, R. Sounting & C Borgnakke; Fundamentals of Classical Thermodynamics; John Wiley & Sons/New Age International, Delhi
4. J. P. Holman; Thermodynamics; McGraw-Hill Book Co. New Delhi.

ONLINE/E RESOURCES

1. https://nptel.ac.in/courses/101104063

Details of the Course

Course Code	Course Title	Credits	L	T	P	Studio
22MET107	**Engineering Mechanics**	**3**	**2**	**1**	**0**	**0**

Prerequisite: None

Course Outcomes:

CO1	Understand the basic principles of engineering mechanics with emphasis on their analysis and application to practical engineering problems
CO2	Analyze planar and spatial systems to determine the forces in members of trusses, frames
CO3	Understand the concept of moment of inertia and apply them to engineering problems
CO4	Apply fundamental ideas of kinematics and dynamics to the analysis of simple practical problems

Course Contents:

Introduction to Mechanics and Laws of Mechanics. Statics of Particles: Forces in a Plane- Force on a Particle, Resultant of Two Forces, Resultant of Several Concurrent Forces, Resolution of a Force into Components Rectangular Components of a Force. Equilibrium of a Particle, Free-Body Diagrams. Forces in Space – Rectangular Components of a Force in Space, Force Defined by Its Magnitude and Two Points on Its Line of Action. Addition of Concurrent Forces in Space, Equilibrium of a Particle in Space.2

Rigid Bodies: Equivalent Systems of Forces: Principle of Transmissibility. Equivalent Forces, Moment of a Force about a Point, Varignon's Theorem, Moment of a Force about a Given Axis, Moment of a Couple, Equivalent Couples, Resolution of a Given Force into a Force and a Couple, Reduction of a System of Forces to One Force and one Couple Equivalent Systems of Forces, Reduction of a System of Forces to a Wrench.

Equilibrium of Rigid Bodies: Introduction, Free-Body Diagram, Equilibrium in Two Dimensions, Reactions at Supports and Connections for a Two-Dimensional Structure, Equilibrium of a Rigid Body in Two Dimensions, Statically Indeterminate Reactions. Partial, Constraints, Equilibrium of a Two-Force Body, Equilibrium of a Three-Force Body, Equilibrium in Three Dimensions, Equilibrium of a Rigid Body in Three Dimensions, Reactions at Supports and Connections for a Three-Dimensional Structure.

Force Analysis of Rigid bodies Structures: Plane Trusses, Methods of Joints, Method of Section, Space Trusses, Frames and Machines, Internal Forces Developed in various Structural Members (such as rod, beam, shaft), Shear and Moment Equations and Diagrams (SFD and BMD), Relations between Distributed Load, Shear, and Moment.

Distributed Forces: Centroids and Center of Gravity: Moments of Inertia of Areas, Second Moment, or Moment of Inertia, of an Area, Determination of the Moment of Inertia of an Area by Integration, Polar Moment of Inertia, Radius of Gyration of an Area, Parallel-Axis Theorem, Moments of Inertia of Composite Areas, Product of Inertia, Principal Axes and Principal Moments of Inertia, Mohr's Circle for Moments and Products of Inertia, Moments of Inertia of a Mass Moment of Inertia of a Mass, Parallel-Axis Theorem, Moments of Inertia of Thin Plates, Determination of the Moment of Inertia of a Three-Dimensional Body by Integration, Moments of Inertia of Composite Bodies, Moment of Inertia of a Body with Respect to an Arbitrary Axis through O, Mass Products of Inertia.

Methods of Virtual Work and Total Potential Energy: Work- Work of a Force and Couple, Virtual Work- Principle of Virtual Work for a Particle and Rigid Bodies, Potential Energy and Stability- Elastic Kinematics and Dynamics of Rigid Bodies: General plane motion.

Text Books/ Reference Books

1. Vector Mechanics for Engineers, Beer, F.P and Johnson Jr. E.R. Vol. 1 Statics and Vol. 2 Dynamics, McGraw-Hill International Edition, 2019.
2. Engineering Mechanics, Hibbeller, R.C., "Engineering Mechanics", Vol. 1 Statics, Vol. 2 Dynamics, Pearson Education Asia Pvt. Ltd., 2017.
3. Engineering Mechanics – Statics and Dynamics, Irving H. Shames, IV Edition – Pearson Education Asia Pvt. Ltd., 2005.
4. Engineering Mechanics, Merian J.L. and Kraige L.G., Vol. 1 Statics and Vol. 2 Dynamics, Wiley-India, 5 Edition, 2017.

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MET201	**Fluid Mechanics**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE : Calculus, Physics, Engineering Mechanics, Engineering Thermodynamics

COURSE OUTCOMES

After attending the course, the student will be able to demonstrate following skills which would be evaluated though various assessments

CO1	Understand the basic principles and identify the governing equations applicable to the engineering problems involving fluids
CO2	Understand and solve problems involving fluid kinematics
CO3	Solve engineering problems involving fluid at rest or relative equilibrium
CO4	Solve engineering problems involving fluid flow over submerged bodies
CO5	Solve engineering problems involving internal fluid flow
CO6	Solve engineering problems involving model studies

COURSE CONTENTS

- Properties of fluid; classification of fluids; fluid pressure and its measurement; pressure variation in fluids; manometers; hydrostatic force on surfaces; buoyancy and floatation; fluids in relative equilibrium.

- Principles of fluid flow; Eulerian and Lagrangian description of fluid flow; velocity and acceleration of a fluid particle; types of fluid flow; flow visualization; Reynolds transport theorem; vorticity and circulation; inviscid and potential flows.

- Basic techniques for fluid flow analysis; equations in integral form for a control volume, Bernoulli equation and its applications; equations in differential form, Continuity equation and its applications; linear and angular momentum, and their application.

- Theory of boundary layer; boundary layer equations and thickness of boundary layer; separation of boundary layer, controlling methods; flow over submerged bodies, flat surface, sphere, cylinder, airfoil.

- Viscous internal flows; flow through orifices; laminar and turbulent pipe flow; energy losses in pipe flows, series and parallel pipe flows, water hammer, pipe networks; laminar flow in circular pipes, annulus, channels, porous media; pipe flows, developing and developed internal flows; turbulent flows in smooth and rough pipes.

- Dimensional analysis; common dimensionless groups; modelling and similitude, types of similarity and similarity laws; model studies.

References-

Text Books/ Reference books-

1. Fluid Mechanics, F. M. White, McGraw Hill, 2017.
2. Introduction to Fluid Mechanics, Fox and McDonald, Wiley, 2011.
3. Engineering Fluid Mechanics, K.L. Kumar, S. Chand 2016.
4. Fluid Mechanics, Streeter and Wiley, McGraw Hill, 2010.
5. Fluid Mechanics, A. K. Jain, Khanna Publishers, 2004.

Online/E resources

1. NPTEL, Introduction to Fluid Mechanics, IIT Kharagpur, Dr. Suman Chakraborty (https://nptel.ac.in/courses/112105269)
2. NPTEL, Fluid Mechanics, IIT Guwahati, Dr. Subhashisa Dutta (https://nptel.ac.in/courses/105103192)

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MET202	**Kinematics of Machines**	**3**	**2**	**1**	**0**	**0**

PREREQUISITE : Engineering Mechanics

COURSE OUTCOMES

CO1	Understand the fundamentals of the theory of kinematics and dynamics of machines
CO2	Kinematic design graphically
CO3	Analyze the motion characteristics of the machine analytically, graphically or computationally
CO4	Analyze CAM motion programs and design of Cam
CO5	Understand gear terminology and kinematics and analyze motion

COURSE CONTENTS

Kinematics Fundamentals: Types of Motions, Degree of Freedom, Links, Joints, and Kinematic Chains, Kinematic diagrams, Determination of degree in freedom of planar and spatial mechanisms, Linkage, mechanisms and Structures, Number synthesis, Paradoxes, Isomers, Inversions-Four bar chains, Single slider crank chain, Double slider crank chain and applications, Linkages of more than four bars-Fivebar, sixbar.

Graphical linkage synthesis: Synthesis-Function, Path, and motion generation, Limiting conditions, Dimensional Synthesis- two and three positions, Quick return mechanisms- fourbar and sixbar, Cognates, Straight line mechanisms, dwell mechanisms, Coupler Curves, design with coupler cuves.

Kinematic Analysis: Position: Graphical and analytical analysis, Vector loo equations for four bar linkages, Circuits and Branches. Velocity and Acceleration: General velocity and acceleration equations, components of acceleration, Graphical velocity and acceleration analysis, Velocity analysis using instant centres, Centrodes, Kennedy theorem.

CAM: Terminology, SVAJ diagrams, Motion programs-Uniform velocity, parabolic, simple harmonic, cycloidal, polynomial functions, Sizing the cam.

Gears and Gear Trains: Fundamental law of gearing, Involutes, Gear tooth Nomenclature, Interference and Undercutting, Contact ratio, Gear Types-Spur, Helical Bevel and Worm, Gear Trains- Simple, Compound, Planetary, Analysis using Equations and Tabular method, Applications.

Text Books/ Reference Books

1. Kinematics and Dynamics of Machinery, First Edition in SI, R.L. Norton, Tata McGraw Hill Publishing Company Ltd, New Delhi, 2016
2. Theory of Machines, 4 Edition, S. S. Rattan, Tata McGraw-Hill, 2014.
3. Theory of Mechanisms & Machines by Amitabha Ghosh, Asok Kumar Mallik, Affiliated East-West Press Pvt Ltd, 2000
4. Theory of Machines and Mechanisms (India Edition) by John J. Uicker Jr., Gordon R. Pennock and Joseph E. Shigley, Oxford University Press, 2014
5. Kinematics, Dynamics and Design of Machinery by by Kenneth J. Waldron , Gary L. Kinzel, Wiley India Pvt Ltd, 2016

Online/E Resources

1. NPTEL: Theory of Mechanisms by Prof. Sujatha Srinivasan, IIT Madras
2. NPTEL: Kinematics of Mechanisms and Machines by, Prof. A. Dasgupta, IIT Kharagpur

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MET203	**Materials Science and Engineering**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: None

COURSE OUTCOMES:

On successful completion of the course, the student should be able to:

CO1	Understand engineering materials classification and their structural geometries. He/she may apply the crystallography of metallic solids and evaluate their structural-related behavior.
CO2	Understand the basic mechanism of deformations in metal and analyze their deformation behavior. He/she would be able to understand strengthening mechanisms.
CO3	Analyze the mechanical behavior of the metals and their evaluation/quantification through various test methods.
CO4	Understand the basic mechanism that drives phase transformation (specifically freezing of metals) as applied to various binary alloy systems, case hardening methods, and heat treatment processes.

COURSE CONTENTS

Historical perspective and development of materials; Engineering structures, relationship between processing – structure – properties – performance, Challenges in material selection, factors aiding material selection, classification of engineering materials.

Crystallography of solids, crystal structures and Bravais lattices in 3D packing, Bravais lattices in 2D packing; Miller indices of directions/planes with family of symmetry related directions/planes, Miller- Bravais indices in cubic, tetragonal system, hexagonal systems, etc., Inter-planner spacing, Weiss Zone Law, linear and planner densities, X-ray diffraction

Packing in metallic solids or crystalline solids with parameters like packing efficiency, theoretical density, effective number of atoms/cells, coordination number, inter-atomic distance, edge length, etc.; Triangular, tetrahedral, octahedral, and cubic voids in FCC/BCC/HCP packing and their positions; Single crystals solids, polycrystalline solid, microstructure, amorphous solids.

Defects in solids: Classification and description of defects (based on dimensionality) like point defect (vacancies, interstitial, substitutional, Frenkel, Schottky, etc.), line or dislocation defect (edge, screw and mixed dislocations); surface defects (homophase like stacking fault, twin boundary, grain boundary, etc., and hetrophase boundary [like free surfaces, solid/liquid interface, phase boundary etc.); volume defect (like voids, foreign particles, inclusions, etc.); Dislocation density, Frank-Read source, Slip systems in FCC, BCC, HCP, etc.

Strengthening mechanisms: Work or Strain hardening, Solid solution hardening, Grain size hardening, Precipitation hardening, Annealing of cod worked of metal: recovery, recrystallization, grain growth

Mechanical behavior of solids: Tensile behavior, Creep behavior, Fatigue behavior, Fracture behavior, Impact behavior, Non-destructive testing of materials.

Structure of alloy: Solid solutions and inter-metallic compounds; Interstitial and substitutional solid solutions; Hume Rothery Rule of solid solubility limit; Substitutional solid solutions: Ordered and Random; Primary and intermediate

Phase diagram: Concept nad its classification, Gibbs phase rule, Binary alloy system like Isomorphous systems (Cu-Ni alloy system), and Eutectic systems (Pb-Sn system, Fe-C system), Microstructure evolution and phase diagram parameters; Overview of various grades of ferrous alloys like grades of hypo/hyper eutectoid steel, Cast Iron.

Phase transformation, TTT diagram and heat treatment processes: Concept of various phase transformations, concept of nucleation & growth, development of TTT diagram, TTT diagram of Eutectoid steel or various heat treatment processes like Annealing, Normalizing, Austempering, Tempering, Quenching. Details of Microstructure evolution, TTT diagram of hypo/hyper Eutectoid steels, TTT diagram of alloy steels; Concept of hardenability and its difference with hardness, effect of alloying on hardenability

Diffusion: Concept of diffusion, Adolf Ficks law; Steady and unsteady diffusion; Interstitial and substitutional diffusion; Mechanism of atomic diffusion; Diffusion paths (lattice diffusion, surface diffusion, grain boundary diffusion, dislocation diffusions); Application of diffusion in case hardening methods.

TEXTBOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):-

1. Materials Science, V Raghavan, PHI Learning Private Ltd.
2. Materials Science and Engineering, WD Callister and adapted by R Balasubramaniam, Wiley India (P) Ltd.
3. Mechanical Behaviour of Materials, Thomas H Courtney, Mc Graw Hill Eduction (India) Private Ltd.
4. Donald R. Askeland, Pradeep P. Phule, Wendelin J. Wright,"The Science and Engineering of Materials", 6th Edition, Cengage Learning, 2006.

ONLINE/E RESOURCES: https://nptel.ac.in

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MET204	**Mechanical Measurements & Metrology**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Product Realization through Manufacturing

COURSE OUTCOMES:

CO1	Understand the principles of metrology and the importance of measurements in industry.
CO2	Apply measurement error analysis and uncertainty calculations to ensure measurement accuracy and reliability.
CO3	Use various measuring instruments for dimensional, surface, and form measurements, including micrometers, calipers, gauges, and profilometers etc.
CO4	Apply calibration methods and traceability requirements to ensure measurement accuracy and reliability.
CO5	Develop an ability of problem solving and decision making by identifying and analyzing the cause for variation and recommend suitable corrective actions for quality improvement

COURSE CONTENTS

Unit I : Basic Concepts of Measurements – Introduction to Measurement and Measuring Instruments, Methods of Measurement, Modes of Measurement, Generalized Measuring System and Functional Elements, Instruments and its Classifications, Sensors & Transducer and its Classification, Data Acquisition (DAQ) and data loggers, Static and Dynamic Performance Characteristics of Measurement Devices, Sources of Error in Measurement, Classification and Elimination of Errors, Uncertainty in Measurements. Need for Measurement - Precision and Accuracy - Reliability - Errors in Measurements - Causes – Types; Measurement of Engineering Components – Limits, Fits and Tolerances.

Unit II : Linear Measurement – Surface Plate, V-blocks, Scaled Instruments, Vernier, Micrometer, Slip Gauges. Angular Measurement – Protractor, Sine Bar, Angle Gauges, Clinometer, Autocollimator. Comparators – Types of Comparators, Mechanical Comparators, Mechanical–Optical Comparator, Electricals Comparator, Pneumatic Comparators.

Unit III : Optical Measurement and Interferometry – Optical Measurement Techniques, Interferometers, Metrology of Gears and Screw Threads. Metrology of Surface Finish – Methods of Measuring Surface Finish, Stylus Probe Instruments, Pneumatic Methods, Light Interference Microscopes. Miscellaneous Metrology – Precision Instrumentation Based on Laser Principles, Coordinate Measuring Machines, Machine Tool Metrology.

Unit IV: Mechanical Measurements – Introduction, Functional Elements of Measurement Systems, Transducers, Classification of Transducers. Measurement of Force – Direct Methods, Load Cells, Cantilever Beams, Proving Rings, Linear Variable Differential Transformers. Measurement of Torque – Torsion-bar Dynamometer, Servo-controlled Dynamometer, Absorption Dynamometer.

Measurement of Strain – Mechanical Strain Gauges, Electrical Strain Gauges, Methods of Strain Measurement.

Unit V : Temperature Measurement – Methods of Temperature Measurement, Expansion thermometers: Bi-metallic, Liquid in glass; Filled System Thermometers; Electrical Temperature Measuring Instrument: Thermocouples, RTD, Thermistors; Pyrometers; Calibration of Temperature Measuring Instruments. Pressure Measurement – Pressure Measurement Scales, Methods of Pressure Measurement, Classification of Pressure Measuring Devices, Gravitation-type manometers, Mechanical displacement-type manometers, Elastic pressure transducers, Electrical pressure transducers, Low-pressure measurement gauges. Flow Measurement – Rotameter, Electromagnetic Flow Meter, Ultrasonic Flow Meter, Turbine Flow Meter, Hot Wire Anemometer, Laser Doppler Anemometer.

Text Books/ Reference books-

1. Metrology for Engineers by Gaylor, Shotbolt, Sharp
2. Mechanical Measurements by Thomas G. Beckwith , 6E Book
3. J. P. Holman, “Experimental Methods for Engineers”, 8th Edition, McGraw-Hill Series in Mechanical Engineering).
4. S. P. Venkateshan, “Mechanical Measurements”, 2nd Edition, John Wiley & Sons Ltd.
5. N.V. Raghavendra and L. Krishnamurthy, “Engineering Metrology and Measurements”, Oxford University Press.

DETAILS OF THE COURSE

Course Code	Course Title	Credits	L	T	P	Studio
22MET205	**Solid Mechanics**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE: Engineering Mechanics

COURSE OUTCOMES:

CO1	Understand the concepts of internal forces (including SFD and BMD), force equilibrium, deformation, stress, strain, differential equilibrium equations, strain-displacement and constitutive (i.e., stress-strain) relationships for deformable bodies.
CO2	Construct Mohr circle for plane stress and plane strain conditions, and analyse for principal stresses and strains, and their directions
CO3	Apply the concepts of mechanics of deformable bodies to analyze basic structural elements such as bar, beam, shaft, and column.
CO4	Understand and apply the concepts of yielding criteria for the analysis of ductile material.

COURSE CONTENTS:

Introduction to mechanics of deformable bodies: Analysis of deformable bodies, uniaxial loading & deformation, statically determinate & indeterminate situations, Castigliano's theorem.

Stress & Strain: Introduction, stress, plane stress, equilibrium of an element in plane stress, Mohr circle representation of a plane stress, general state of stress, Analysis of deformations, strain components, relation between strain & displacement, strain component associated with arbitrary set of axes, Mohr circle representation of plane strain, general state of strain.

Stress-Strain-Temperature relations: Introduction, tensile test, idealization of stress strain curve, elastic stress strain relation, Thermal strain, complete equations of elasticity, strain energy in an elastic body, Thin pressure vessels, factor of safety and yielding criteria.

Torsion: Introduction, geometry of deformation of a twisted circular shaft, stress strain relations, equilibrium requirements, stresses & deformations in twisted elastic circular shaft, torsion of elastic hollow circular shaft, combined stresses, strain energy due to torsion, yielding in torsion**.**

Stresses due to bending: Introduction, deformation in pure bending, stress-strain relations, equilibrium requirements, stresses & deformations in pure bending Stresses due to shear force and bending moment, combined stresses, strain energy due to bending, yielding in bending

Deflections due to bending: Introduction, moment-curvature-relations, integration of moment-curvature relations, superposition, Load-deflection differential equation, Energy Methods

Stability of equilibrium: Buckling: Introduction, elastic stability, examples of instability, elastic stability of flexible columns

TEXT BOOKS/ REFERENCE BOOKS

1. An Introduction to Mechanics of Solids by S. H. Crandall et al., McGraw-Hill International editions, 2017.
2. Engineering Mechanics of Solids by E P Popov and T A Balan, Pearson Education, 2012.
3. Introduction to Solid Mechanics by I. H. Shames, 2nd Edition, 2009, Prentice Hall of India Private Ltd. New Delhi.
4. Mechanics of Materials; F. P. Beer, E. R. Johnston and J. T. DeWolf, 2019, McGraw-Hill International Edition.

Details of the Course

Course Code	Course Title	Credits	L	T	P	Studio
22MEP206	**Computer-Aided Machine Drawing**	**2**	**0**	**0**	**4**	**0**

Prerequisite: Engineering Drawing and Sketching

Course Outcomes:

CO1	Understand the production drawing of a given object.
CO2	Identify and describe different standards, symbols, fits, and tolerances used in the drawing.
CO3	Create 2D drawings and 3D models of the machine components using the software.
CO4	Create assembly drawings of machine components using the software.

Course Contents:

Introduction to Machine Drawing: Principle of projection, methods of projection, first angle projection, third angle projection, Code of practice for Engineering Drawing, BIS code of practice, specifications, type of machine drawing, production drawing, assembly drawing, list of parts or bill of materials.

Introduction to computer-aided drawing: Elements of Computer Aided Drawing, CAD software.

Fits and Tolerances: Geometrical tolerances, terminology for geometrical tolerances, selection of tolerances, representation of geometrical tolerances. Fits: Nomenclature, Classification of fits, Systems of fits and tolerances, Designation, Selection of fits. Representation of fits, surface-roughness, surface-roughness representation on drawing.

2D Drawing: Draw commands: line, spline, polygon, rectangle, arc, circle, ellipse, undo, hatch, point, tangent etc. Modify commands: move, rotate, copy, mirror, array, erase, fillet, chamfer, offset, trim, etc.
Conversion of pictorial projections into orthographic projections, dimensioning, sectional views: Rules and conventions of sectioning, full sectional, half sectional, partial sectional and revolved sectional views of simple machine parts such as Bearings, Bush bearing, Plummer block, Valves, Safety and non-return valves. Nomenclature of threads, conventional representation of threads, hexagonal and square headed bolts and nuts, locking arrangements of nuts, various types of machine screws and set screws, Foundation bolts.

3D Geometric Modeling: Sketcher, Datum planes, Holes, Part modeling, Extrude, Revolve, Sweep, Loft, Blend, Fillet, Pattern, Chamfer, Round, Mirror etc. practice for simple 3D drawings.
3D modeling of machine components: nut and bolt, screw, keys, step shaft, pulley, spur gear, helical gear etc.

Assembly Drawings: Types assembly drawings - Accepted norms for assembly drawings, sequence of assembly drawing preparation.
Assembly of Engine parts: Piston: Connecting rod, crank shaft, cam shaft, piston ring etc.
Assembly of lathe machine parts: Tail stock, Head stock assembly, Tool post and carriage. Valves: Stop valves, Safety valves, feed-check valves, Pressure relief valves, and flow and direction control valves. Joints: pin joint or knuckle joint, cotter joints, Couplings: muff coupling, split muff coupling, flanged coupling, protected type flanged coupling, universal coupling or Hook's joint, Oldham's coupling. Miscellaneous assemblies: ball bearings, Vices, Screw jack, Stuffing box and crosshead.

Text Books/ Reference Books

1. Machine Drawing, Bhatt N.D., Charotar Publishing House, 2022
2. Machine Drawing, Narayana K.L., Kannaiah P., and Reddy K.V., New Age International Pvt Ltd., 2016
3. Machine Drawing, Sidheswar N., Kannaiah P, and Sastry V. V. S., Tata McGraw Hill, 2014
4. Machine Drawing, John K.C., and Varghese P.I., PHI Publication, 2009

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MEP207	**Fluid Mechanics Laboratory**	**1**	**0**	**0**	**2**	**0**

PREREQUISITE : Measurements and Instrumentation, Fluid Mechanics, and laboratory course of Physics.

COURSE OUTCOMES: Students who successfully complete this course will have an ability to:

CO1	Identify, name, and characterize flow patterns and regimes
CO2	Measure fluid pressure and relate it to flow velocity.
CO3	Demonstrate practical understanding of friction losses in internal flows.
CO4	Demonstrate the ability to write clear lab reports
CO5	Compare the results of analytical models introduced in lecture to the actual behaviour of real fluid flows and draw correct and sustainable conclusions.

COURSE CONTENTS

- To measure losses due to friction in pipes
- To measure discharge through Venturi meter, orifice meter and Rotameter.
- To verify Bernoulli's Equation Experimentally.
- To determine Reynold's number and hence the type of flow either laminar or turbulent.
- To determine the loss of head due to pipe fittings at different flow rates
- To determine loss coefficient for the pipe fittings.
- To measure the solid liquid contact angle of surface.
- To determine the hydrostatic force and center of pressure.

Text Books/ Reference Books

1. Lab Manuals

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MEP208	**Materials Science and Engineering Lab**	**1**	**0**	**0**	**2**	**0**

PREREQUISITE: Basic knowledge of material science and engineering theory.

COURSE OUTCOMES:
On successful completion of the course, the student should be able to:

CO1	To determine and evaluate the wear and co-efficient of friction of a standard specimen.
CO2	To examine the microstructural behavior of materials under microscope by understanding examination procedure.
CO3	To evaluate mechanical properties like tensile/compressive strength, shear stress, toughness, and bending stress of a specimen necessary for material selection design and development.
CO4	Ability to analyze various heat treatment methods for a given specimen to observe mechanical properties and grain size.

COURSE CONTENTS

- To study the behavior of the given material under tensile load and to determine the following: Percentage elongation in length, b. Percentage reduction in area, c. Working stress or permissible stress or safe stress Young"s modulus, e. Yield stress, f. Ultimate stress or Maximum tensile stress g. Breaking stress or Failure stress
- Compare the Tensile strength before and after heat treatment of the selected metals when subjected to uniaxial tensile loading
- To determine the shear strength of the given standard specimen under single and double shear.
- To study the behavior of the given material under Compressive load and to determine the following: a. Modulus of elasticity, b. Maximum Compressive strength or ultimate stress, c. Percentage Decrease in length and Percentage Increase in area
- Compare the compressive strength before and after heat treatment
- To Conduct bending test for the given specimen and to determine the following: a. Modulus of elasticity b. Modulus of Rupture or flexure modulus (maximum bending stress at failure using bending equation).
- To study procedure of specimen preparation for microscopic examination and to carry out a micro structural examination of different materials
- To determine the Impact strength (Specific impact factor) through Izod test
- To determine the Impact strength (Specific impact factor) through Charpy test
- To determine the Rockwell hardness number of the given Specimen using "Rockwell Hardness tester"
- To determine the Brinell hardness number of the given Specimen using Brinell hardness tester

Text Books/ Reference Books

1. Lab Manuals

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MEP209	**Mechanical Measurements & Metrology Laboratory**	**1**	**0**	**0**	**2**	**0**

PREREQUISITE : Product Realization through Manufacturing

COURSE OUTCOMES

CO1	Understand the principles of metrology and the importance of measurements in industry.
CO2	Use various measuring instruments for dimensional, surface, and form measurements, including micrometers, calipers, gauges, profilometers, surface roughness tester, coordinate measuring machine.
CO3	Apply measurement error analysis and uncertainty calculations to ensure measurement accuracy and reliability.
CO4	Apply calibration methods and traceability requirements to ensure measurement accuracy and reliability.

COURSE CONTENTS

- To study about the basics of the engineering metrology and measurements.
- To study calibration of micrometer using slip gauge.
- To measure length measurement with various types of vernier
- To measure the height/depth of the object using vernier height gauge/depth gauge.
- To study various measuring instruments like, radius gauge, Screw pitch gauge and Go/No-go gauge like Snap gauge, Plain plug gauge and Thread plug gauge, Wire gauge, feeler gauge.
- To measure the angle of given specimen by Vernier Bevel Protractor.
- To measure gear parameters for the given spur gear by gear tooth Vernier.
- To measure the characteristic of weight using Load Cell.
- To measure the surface roughness of the given specimen using Surface Roughness Tester / Profilometer.
- To measure the thread parameter of given screw thread using profile projector.
- To measure the temperature and vibration using data acquisition system.
- To measure the various parameters of an object using coordinate measuring machine.

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):-

1. Metrology for Engineers by Gaylor, Shotbolt, Sharp
2. Mechanical Measurements by Thomas G. Beckwith , 6E Book
3. J. P. Holman, “Experimental Methods for Engineers”, 8th Edition, McGraw-Hill Series in Mechanical Engineering).
4. S. P. Venkateshan, “Mechanical Measurements”, 2nd Edition, John Wiley & Sons Ltd.

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MET251	**Dynamics of Machines**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE : Engineering Mechanics; Kinematics of Machines

COURSE OUTCOMES:

CO1	Derivations Equations of Motions, computation of static and dynamic forces of mechanisms.
CO2	Dynamic Force analysis for linkages
CO3	Calculate the balancing masses and their locations for parallel and linkage
CO4	Compute the frequency of free vibration, forced vibration and damping coefficient.
CO5	Calculate the speed and lift of the governor and estimate the gyroscopic effect on automobiles, ships and airplanes.

COURSE CONTENTS

Dynamics Fundamentals: Three-dimensional Dynamics of rigid bodies: translations, Fixed-axis rotation, parallel-plane motion, rotation about a fixed axis, General motion, Angular momentum, Moments and products of Inertia, Equations of Motion.

Dynamic Force Analysis: Force analysis of fourbar linkages, Shaking force and shaking moment, Controlling input torque-flywheel

Balancing: Static and dynamic balancing, balancing conditions, balancing for parallel plane motions, balancing of linkages. Engine dynamics: Equivalent dynamic models, Shaking force and shaking moments, Balancing of single-cylinder engine, multi-cylinder engines

Control Mechanisms: Governors, types, centrifugal governors, gravity controlled and spring controlled centrifugal governors characteristics – stability- sensitiveness-hunting, isochronisms-effect of friction-controlling force; Gyroscopes, gyroscopic forces and torques, gyroscopic stabilization, gyroscopic effects in automobiles, ships and airplanes

Vibrations: Free and forced vibration of single degree of freedom systems, effect of damping; vibration isolation; resonance; critical speeds of shafts.

TEXT BOOKS/ REFERENCE BOOKS

1. Kinematics and Dynamics of Machinery, First Edition in SI, R.L. Norton, Tata McGraw Hill Publishing Company Ltd, New Delhi, 2016
2. Theory of Machines, 4 Edition, S. S. Rattan, Tata McGraw-Hill, 2014.
3. Theory of Mechanisms & Machines by Amitabha Ghosh, Asok Kumar Mallik, Affiliated East-West Press Pvt Ltd, 2000
4. Theory of Machines and Mechanisms (India Edition) by John J. Uicker Jr., Gordon R. Pennock and Joseph E. Shigley, Oxford University Press, 2014
5. Kinematics, Dynamics and Design of Machinery by by Kenneth J. Waldron , Gary L. Kinzel, Wiley India Pvt Ltd, 2016
6. Engineering Mechanics – Dynamics, vol. 2, J.L. Meriam, L.G. Kraige, Wiley India Pvt. Ltd, New Delhi
7. Dynamics and Balancing of Multibody Systems, Himanshu Chaudhary, S.K. Saha, Springer

ONLINE/E RESOURCES

1. NPTEL: Theory of Mechanisms by Prof. Sujatha Srinivasan, IIT Madras
2. NPTEL: Kinematics of Mechanisms and Machines by, Prof. A. Dasgupta, IIT Kharagpur

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MET252	**Heat Transfer**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE: Calculus, Physics, Engineering Thermodynamics, Fluid Mechanics, Material Science

COURSE OUTCOMES

After attending the course, the student will be able to demonstrate following skills which would be evaluated though various assessments

CO1	Understand different modes of heat transfer and the governing laws
CO2	Model the governing equations and boundary conditions applicable to one dimensional steady state conduction with and without heat generation
CO3	Solve engineering problems involving forced convection
CO4	Solve engineering problems involving free convection
CO5	Solve elementary problems involving rating and sizing of heat exchanger(s)
CO6	Solve engineering problems involving radiation heat exchange

COURSE CONTENTS

- Basic modes of heat transfer; mechanisms of heat transfer; governing laws; thermal conductivity of matter in different states.
- General conduction equations; boundary and initial conditions; variable thermal conductivity; one dimensional steady state conduction with and without heat generation; conduction in composite medium; critical thickness of insulation; extended surfaces, efficiency, effectiveness; unsteady conduction.
- Convective boundary layers; local and average heat transfer coefficients; governing equations for forced convection, dimensionless groups, laminar and turbulent flow convection; external and internal flow convection; empirical correlations for forced convection.
- Free convection boundary layers, governing equations, dimensionless groups; laminar and turbulent free convection, integral solution; empirical correlations; mixed convection; phase-change convection.
- Types of heat exchangers; arithmetic and log mean temperature difference for parallel and counter flow arrangement; overall heat transfer coefficient, effect of fouling; analysis of multi-pass heat exchangers; effectiveness of heat exchangers; considerations for heat exchanger selection.
- Thermal radiation and governing laws; radiation properties; emissive power and intensity of radiation; diffused radiation; Gray body radiation; solar radiation; radiation exchange between surfaces, shape factor; radiation shields.

References-

Text Books/ Reference books

1. Introduction to Heat Transfer, Bergman TL, Lavine AS, Incropera FP, Dewitt DP, Wiley, 2011.
2. Heat Transfer, Holman JP, McGraw Hill, 2004.
3. Heat and Mass Transfer, Cengel YA, Ghajar AJ, McGraw Hill, 2017.
4. Heat & Mass Transfer, Arora and Domkundwar, Dhanpat Rai and Company, 2006.

Online/E resources

1. NPTEL, Heat and Mass Transfer, IISc Bangalore, Prof. Pradip Dutta (https://nptel.ac.in/courses/112108149

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MET253	**IC engines**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE : Engineering Thermodynamics and fundamental knowledge of Fluid Mechanics.

COURSE OUTCOMES:

CO1	Perform calculations for efficiency and M.E.P. for ideal air standard cycles and actual cycles of operation. Explain the combustion process in SI and CI engines. Understand factors influencing combustion chamber design
CO2	Illustrate the working principal of basic engine components such as fuel supply systems and ignition system
CO3	Lubricating systems and cooling systems. Get familiarized with the terms supercharging, turbocharging and scavenging.
CO4	Understand I.C. engine emission and emission reduction techniques,
CO5	Recognize special engines; gain some knowledge of various sensors, ECU etc. Understand basic I.C. engine simulation models

COURSE CONTENTS

Components, classification and application of IC engine, working of four/ two stroke engine, valve timing diagram, scavenging, fuel, qualities of fuel, rating of fuel, stoichiometric air fuel ratio, Ideal and actual cycles of operation, air standard cycles, combustion and abnormal combustion in SI and CI engines, factors affecting knocking, control of knocking, combustion chambers

Mixture requirement for different loads and speeds, carburetor and its working, types of injection systems in SI and CI engine, ignition system for SI engine

Lubrication: Need, function and classification of lubrication system-wet sump and dry sump, crankcase ventilation. Cooling: Types of cooling systems-liquid and air cooled, comparison of liquid and air-cooled systems, working of supercharger, working of turbocharger, control of turbocharger

Air pollution due to IC engines, emission norms, formation and control of PM, HC, CO and NOx emission for SI and CI engine

Measurement and testing of IC engines, introduction to special engines, sensors used to IC engine, electronic control unit, computer simulation of two stroke & four stroke engines

TEXT BOOKS/ REFERENCE BOOKS (Title, Authors, Publisher & Year):-

1. Stone, R., Introduction to Internal Combustion Engines, The Macmillan Press Limited, London,
2. Heywood, J.B., Internal Combustion Engine Fundamentals, McGraw Hill Book Co., NY
3. Obert, E.F., Internal Combustion Engines and Air Pollution, Harper & Row, NY
4. Ganesan, V., Internal Combustion Engines, Tata McGraw-Hill, New Delhi
5. Mathur, M.L. and Sharma, R.P., A Course in Internal Combustion Engines, DhanpatRai & Sons, New Delhi
6. Taylor, C.F., The Internal Combustion in Theory and Practice Vol. I & II, The M.I.T. Press.

ONLINE/E RESOURCES

1. https://nptel.ac.in/courses/112103262
2. https://nptel.ac.in/courses/112104033

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MET254	**Operations Planning and Control**	**3**	**2**	**1**	**0**	**0**

PREREQUSITE- None

COURSE OUTCOMES:

CO1	To understand the importance and basic concepts of the operation planning and control
CO2	Analyze and evaluate various facility locations alternatives and their decisions
CO3	Apply qualitative and quantitative models for forecasting of product demand
CO4	Develop aggregate production and capacity plans for operations
CO5	Apply inventory models to decide appropriate inventory policy
CO6	Develop sequence of jobs in production environment

COURSE CONTENTS

Introduction to production and operations management, Service v/s production operations, Characteristics of MTS, MTO, ETO, and ATO. Plant location and layout, factors affecting plant location, Types of layouts, Line Balancing

Forecasting: Qualitative and quantitative forecasting, Simple and moving averages, Exponential smoothing, Time series decomposition: trend and seasonality, Quantitative evaluation of forecasting models

Aggregate production plans, Master Production Schedule, Capacity planning.

Inventory Control: Basic EOQ model and its extension to finite production rate and quantity discounts, Single period probabilistic models, Inventory policies, MRP, MRP-II.

Operations scheduling, Sequencing and scheduling, Job shop and flow shop, Sequencing using FCFS, SPT, EDD, Johnson's rule.

JIT and Lean manufacturing

References-

Text Books/ Reference books:

1. Everett E. Adam, Ronald J. Ebert, Production and Operations Management. 5th Edition, PHI.
2. Steven Nahmias, Production and Operations Analysis. 5th Edition, Mc Graw Hill.
3. Joseph S. Martinich, Production and Operations Management. 5th Edition, Wiley India.
4. Seetharama L. Narasimhan, Dennis W. McLeavey, Peter J. Billington. Production planning and Inventory Control. 2th Edition, PHI.

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical
22MET255	**Science of Machining**	**4**	**3**	**1**	**0**

Pre-requisite course: Product Realization through Manufacturing

Course Outcomes

CO1	To understand the cutting tool geometry, mechanism of chip formation and mechanics of orthogonal cutting.
CO2	To identify different forces acting during machining with the help of merchant circle force diagram and Cutting force measuring techniques.
CO3	To understand the thermal Aspects In Machining and how to control that temperature with the help of Cutting fluid.
CO4	To understand the fundamental knowledge on the relation of tool with machinability and tool life.
CO5	To understand the fundamental knowledge of jig and fixtures during machining.

COURSE CONTENTS

MATERIALS AND GEOMETRY OF CUTTING TOOLS: Introduction, Desirable Properties of Tool Materials, Characteristics of Cutting Tool Materials, Cutting tool geometry, Chip flow direction, Tool angles specification systems, Cutting parameters and Tool geometry, Index able inserts, chip breakers, Tools of unusual geometry.

MECHANICS OF METAL CUTTING: Merchant's circle diagram- determination of cutting and thrust forces; Coefficient of friction; shear plane angle, Velocity and force relationship, shear stress and strain and strain rate in orthogonal cutting, stress distribution along rake face, theories of Lee and Shaffer's, Oxley's, etc. Cutting force measuring techniques i.e dynamometer.

THERMAL ASPECTS IN MACHINING AND CUTTING FLUID: Regions of heat generation; Heat In the Primary Shear Zone, Heat at the Tool/work Interface, Heat Flow at the Tool Clearance Face, Average shear plane temperature; Average chip-tool interface temperature; method of tool temperature measurement, temperature distribution in tool, Cutting Fluid: Types and composition of cutting fluids, selection of cutting fluid.

TOOL WEAR, TOOL LIFE AND MACHINABILITY: Tool wear mechanisms, Types of tool damage during cutting, Wear and chipping characteristics of different tool materials, Tool wear equations, tool failure criteria, Tool life equations, Effect of process parameters on Tool life, Tool life testing, Machinability, Surface finish and surface integrity.

INTRODUCTION TO JIGS & FIXTURES: Introduction, Important Considerations while Designing Jigs and Fixtures, Meaning of Location, Principles of Locations, Different Methods Used for Locations, Different Types of Jigs and fixtures, Advantages of Jigs and Fixtures.

Text Books / Reference Books:

1. Manufacturing Engineering and Technology Kalpakjain
2. Metal cutting theory and practice by Bhattacharya
3. Manufacturing Engineering and Technology Groover
4. Metal Cutting Principles Milton C Saw, Oxford
5. Machining Sciences Amitabh Ghosh
6. Jigs and fixtures, 3rd edition Prakash Hiralal Joshi

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MEP256	**Heat Transfer Lab.**	**1**	**0**	**0**	**2**	**0**

PREREQUISITE: Calculus, Physics, Engineering Thermodynamics, Fluid Mechanics, Material Science

COURSE OUTCOMES

After attending the course, the student will be able to demonstrate following skills which would be evaluated though various assessments

CO1	Ability to apply theory to analyze different modes of Heat Transfer.
CO2	Ability to distinguish between heat transfer at steady and Unsteady states.
CO3	Ability to rate the thermal performance of extended surfaces.
CO4	Ability to rate the thermal performance of a heat exchanger.

COURSE CONTENTS

- Measurement of thermal conductivity of fluids.
- Measurement of thermal conductivity of solids.
- Study of Heat conduction through a solid composite medium.
- Study of unsteady Heat Transfer.
- Study of free convection over an extended surface.
- Study of forced convection over an extended surface.
- Study of convection in internal flows.
- Study of natural convection in external flows.
- Study of parallel flow heat exchanger.
- Study of counter flow Heat Exchanger.
- Measurement of radiative emissivity of a test surface.
- Measurement of Stefan-Boltzmann Constant.

REFERENCES-

TEXT BOOKS/ REFERENCE BOOKS

1. Introduction to Heat Transfer, Bergman TL, Lavine AS, Incropera FP, Dewitt DP, Wiley, 2011.
2. Heat Transfer, Holman JP, McGraw Hill, 2004.
3. Heat and Mass Transfer, Cengel YA, Ghajar AJ, McGraw Hill, 2017.
4. Heat & Mass Transfer, Arora and Domkundwar, Dhanpat Rai and Company, 2006.

ONLINE/E RESOURCES

1. NPTEL, Heat and Mass Transfer, IISc Bangalore, Prof. Pradip Dutta (https://nptel.ac.in/courses/112108149)

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MEP257	**IC engines Laboratory**	**2**	**0**	**0**	**2**	**0**

PREREQUISITE : Engineering Thermodynamics and fundamental knowledge of Fluid Mechanics.

COURSE OUTCOMES:

CO1	Understand the practical operation of 2 stroke and 4 stroke I.C engines using valve timing diagram and experimentally draw valve timing diagram for a four stroke single cylinder Ruston diesel engine
CO2	Analyze the performance of single and multi-cylinder engines with the variation of Various performances like load and speed.
CO3	Discuss the importance of engine testing and demonstrate and experiment with dynamometer
CO4	Explain the effect of various exhaust gases on the environment and demonstrate how to minimize them by using different techniques
CO5	To understand types of dynamometers and Dartturbo-prop engine.

COURSE CONTENTS

- To draw the valve timing diagram for a four-stroke single cylinder Ruston diesel engine.
- Study of construction, working and various types of dynamometers.
- To draw the volumetric efficiency and performance characteristics for four stroke four stroke single cylinder water cooled diesel engine (Kirloskar).
- To calculate and draw heat balance sheet of four stroke four stroke single cylinder water cooled diesel engine (Kirloskar).
- To draw the volumetric efficiency and performance characteristics for four stroke single cylinder air cooled diesel engine (Kirloskar).
- To draw the volumetric efficiency and performance characteristics for four stroke single cylinder air cooled engine (Kirloskar) fueled with diesel blends.
- To draw the volumetric efficiency and performance characteristics for four stroke single cylinder four stroke gasoline Honda Genset engine.
- To draw the volumetric efficiency and performance characteristics of Mahindra multi-cylinder diesel engine at fixed load and varying engine rpm.
- To draw the volumetric efficiency and performance characteristics of Mahindra multi-cylinder diesel engine at fixed rpm and varying engine load.
- To draw performance and emission characteristics of four stroke single cylinder water cooled four stroke VCR C.I engine coupled with eddy current dynamometer.
- Study of Dartturbo-prop engine.
- Study of IC engine generated emissions, effects measurement and control.

REFERENCES-

1. Lab Manuals

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MEP258	**Kinematics and Dynamics of Machines lab**	**1**	**0**	**0**	**2**	**0**

PREREQUISITE : Engineering Mechanics, Kinematics of Machines

COURSE OUTCOMES

CO1	Explain gear parameters, kinematics of mechanisms, gyroscopic effect and working of lab equipments.
CO2	Determine mass moment of inertia of mechanical element, governor effort and range sensitivity, natural frequency and damping coefficient, torsional frequency, critical speeds of shafts, balancing mass of rotating and reciprocating masses, and transmissibility ratio.
CO3	Understanding of balancing mass of rotating and reciprocating masses, and transmissibility ratio.
CO4	Understanding of Coriolis forces and centrifugal forces through experiments
CO5	Modeling of linkages through software

COURSE CONTENTS

- Four Bar linkage mechanism including Accessories
- Cam analysis mechanism
- Slider Crank/ Quick return mechanism
- Scotch Yoke Mechanism
- Geneva mechanism
- Universal Joint
- Mechanical Power Transmission training system including accessories
- Balance of Reciprocating Masses Simulator
- Vibration Fundamental Training System
- Portable Stand-alone Vibration Analyzer
- Coriolis and centrifugal forces
- Modeling and analysis of linkages on motion solve of Hyper works
- Modeling and analysis of linkages on motion solve of Hyper works

REFERENCES-

1. Lab Manuals

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MEP259	**Science of Machining Lab**	**1**	**0**	**0**	**2**	**0**

PREREQUISITE: Product Realization through Manufacturing

COURSE OUTCOMES:

CO1	Students will able to understand the cutting tool geometry and cutting tool materials of single point.
CO2	Students will able to understand the different forces acting during machining through merchant circle diagram. Force analysis through dynamometer.
CO3	Students will able to understand thermal aspects in machining and different cutting fluid to control the temperature and method of applying cutting fluid.
CO4	Students will able to understand tool wear mechanism and tool life equation.
CO5	Students will able to understand about jig and fixtures.

COURSE CONTENT:

- Measurements of Tool angles of the given single point cutting tool in orthogonal rake system (ORS) and Machine Tool Reference system (MTR).
- Make a job as per drawing using lathe machine.
- To study the Constructional features of a Milling Machine and Indexing on Horizontal Milling Machine and **m**ake a job using Gear Cutting Machine (Horizontal Milling machine
- To Study the constructional features of a Capstan and Turret lathe machine and make a rivet job using the same out of an Aluminum rod on Capstan and Turret Lathe machine.
- To study the constructional features of a Copying Lathe Machine and make a job for a standard component using Copying Lathe machine
- To study the Constructional features of a shaper machine and make a job as per drawing using shaper machine.
- Experiments for jig and fixtures
- Experimentations on Dies for Press Tools.
- Experiments for tool wear mechanism and tool life equation.
- Study of universal dynamometer and determine cutting and feed force.

REFERENCES-

1. Lab Manuals

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical
22MET301	**CAD & CAM**	**3**	**3**	**0**	**0**

COURSE OUTCOMES:

After completion of this course the students are expected to be able to demonstrate following knowledge, skills and attitudes. The student will be able:

CO 1	To explain 2D and 3D geometric and modelling transformations
CO 2	To understand solid modelling of curves
CO 3	To understand different CAD standard systems
CO 4	To apply concepts of NC and CNC programming to develop part programmes
CO 5	To understand different types of techniques used in Cellular Manufacturing and FMS

COURSE CONTENT

INTRODUCTION : Brief introduction to CAD and CAM – Introduction to CAD/CAM concepts; Types of production; Manufacturing Planning, Manufacturing control; Product cycle – Design process - sequential and concurrent engineering; Computer aided design – CAD system architecture; Computer graphics – 2D and 3D Geometric and modelling transformations - Coordinate systems, homogeneous coordinates - Line drawing – Clipping - viewing transformation.

GEOMETRIC MODELING : Solid modelling and applications – Introduction to curves - Hermite curve - Bezier curve - B-spline curves-rational curves; Techniques for surface modelling – surface patch - Coons and bicubic patches- Bezier and B - spline surfaces.

CAD STANDARDS: Standards for computer graphics - Graphical Kernel System (GKS) - standards for exchange images - Open Graphics Library (OpenGL) - Data exchange standards - IGES, STEP, CALS etc.

FUNDAMENTAL OF CNC AND PART PROGRAMING : Introduction to NC systems and CNC; Machine axis and coordinate system; NC motion control systems; CNC machine tools - Principle of operation CNC; Drives and CNC controllers - 2D and 3D machining on CNC; CNC Part Programming, types - Detailed part programming using G codes and M codes; Machining of free form geometries.

FLEXIBLE MANUFACTURING SYSTEM (FMS) AND CAD/CAM APPLICATIONS : Group Technology; Part Families – Parts Classification and coding; Cellular Manufacturing; FMS – FMS Components - FMS Application & Benefits - FMS Planning and Control -Quantitative analysis in FMS; CAD/CAM applications – Computer Aided Assembly Planning - Computer Aided Inspection.

Reference Book(s)/ Text Book(s)

1. Zeid, I., “Mastering CAD/CAM”, Tata McGraw Hill, 2007.
2. Onwubiko, C., “Foundation of Computer Aided Design”, West Publishing Company, 1989.
3. Mortenson, M. E., “Geometric Modeling”, 3rd Ed., Industrial Press. 2006.
4. Groover, M. P., “Automation, Production systems and Computer Integrated Manufacturing”, 3rd Ed., Prentice-Hall, 2007.
5. Chang, T.-C., Wysk, R. A. and Wang, H.-P. “Computer Aided Manufacturing”, 3rd Ed., Prentice Hall, 2005.
6. Lynch, M., “Computer Numerical Control for Machining”, McGraw-Hill, 1992.

Rao, P. N., Tiwari, N. K. and Kundra, T. K., “Computer Aided Manufacturing”, Tata McGraw Hill, 199

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MET302	**Design of Machine Elements**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE : Engineering Mechanics, Mechanics of Solids, Kinematics and Dynamics of Machines

COURSE OUTCOMES

CO1	Understand and apply the fundamental design practices with regard to material selection, material properties, manufacturing considerations, and standards and codes.
CO2	Understand and apply stress analysis theory, appropriate static and fatigue failure theories/criteria to the design of various machine elements, the concept of Hydrodynamic lubrication
CO3	Analysis of basic machine elements, such as solid and hollow shafts, keys and couplings under various load conditions (i.e., static and dynamic); Temporary and Permanent Joints- riveted, bolted, welded Joints;
CO4	Design of basic machine elements, such as solid and hollow shafts, keys and couplings under various load conditions (i.e., static and dynamic); hydrodynamic bearings; Rolling contact bearings; Temporary and Permanent Joints, Compression Spring

COURSE CONTENTS

Overview of Design Process: Selection of Materials and Processes: Standard numbering system including BIS designations of materials, Load and Stress Determination, Stress concentration, Allowable stresses: factor safety.

Static and Fatigue Failure Theories in Design: Static failure theories, Variable load, load factor, Endurance strength; Endurance limit and modifying factors; Notch sensitivity and stress concentration. Goodman & Soderberg lines.

Design of machine members subjected to steady and/or alternating stresses: Shafts and Couplings; Temporary and Permanent Joints- riveted, bolted, welded Joints; Design of Compression Spring; Design of sliding & journal bearing; Selection of antifriction (rolling) bearings for different loads and load cycles.

Text Books/ Reference Books :

1. Machine Design: An Integrated Approach, Norton Robert L., Pearson Education Asia, 2020.
2. Mechanical Engineering Design, Shigley J. E. and Mischke C. R., Budynas R. G. and Nisbett K. J., Tata–McGraw Hill, 2020.
3. Design of Machine Elements, M. F. Spotts, Prentice Hall of India, 2019.

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MET303	**Fluid and Turbo Machines**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE: Engineering Thermodynamics**,** Fluid Mechanics

COURSE OUTCOMES:

CO1	Understand the concepts of energy flow, losses, and efficiencies in fluid machines
CO2	Apply the principles of model studies in the design of fluid machines
CO3	Understand the concept of velocity triangles as a tool for analysis of power consuming and power producing fluid machines
CO4	Analyze the performance of fluid machines with the effects of various parameters on performance

COURSE CONTENTS

Basics of Turbomachines, Classification of fluid machines, Turbomachines and Positive Displacement Machines, application of first and second laws of thermodynamics to turbo machines, Model Studies, Dimensional Analysis, Unit and Specific Quantities, Non-Dimensional Parameters and Their Significance, effect of Reynolds Number, Specific Speed

Thermodynamics of Fluid Flow: Static and Stagnation States, Thermodynamics of Turbomachine Processes, Isentropic and Isothermal Compression Process, Isentropic Expansion Process, Overall Isentropic Efficiency versus Stage Efficiency, Pre-heat Effect in Multi-stage Compressor, Re-heat Effect in Multi-stage Turbines, Infinitesimal-Stage or Small-Stage Efficiency or Polytropic Efficiency, Reheat Factor for Expansion Processes, Overall Isentropic Efficiency versus Finite-Stage Efficiency.

Energy Exchange in Turbomachines: Velocity Triangles, Basic Equations: Linear Momentum Equation, Impulse Momentum Equation, Moment of Momentum Equation, and Euler Turbine Equation, Alternate Form of the Euler Turbine Equation, *Components of Energy Transfer, Energy Equation of Relative Velocities,* Impulse and Reaction, Utilization Factor of Turbines, Speed Ratio.

General Analysis of Turbomachines: General Analysis of Radial Flow Machines, Radial Flow Machines (Pumps, Blowers, and Compressors): Velocity Triangles, Axial Flow Machines (Turbines and Compressors).

Steam Turbines: Classification of Steam Turbines, Compounding of Steam Turbines, Analysis: Rateau Stages, Parsons Stages, Curtis Stage. Governing of Steam Turbines.

Hydraulic Turbines: Classification of Hydraulic Turbines, Pelton Turbine, Francis turbine, Kaplan Turbine and Propeller Turbine. *Analysis, Efficiencies, Design Parameters;* Draft Tube, Cavitation, Governing of Hydraulic Turbines: Parts, working; Characteristics of the Hydraulic Turbine

Centrifugal Pumps: *Advantages of Centrifugal Pumps over Reciprocating Pumps,* Classification, different heads, efficiency, Analysis and Minimum Starting Speed of a Centrifugal Pump, Maximum Suction Lift and Net Positive Suction Head, Cavitation, Priming.

References-

Text Books/ Reference books- (Title, Authors, Publisher & Year)

1. S.L. Dixon and C.A. Hall. Fluid Mechanics and Thermodynamics of Turbomachinery, Sixth Edition. Butterworth-Heinemann, 2010
2. S. M. Yahya. Turbines Compressors and Fans. McGraw Hill, 2017
3. D. G. Shepherd. "Principles of Turbo Machinery. The Macmillan Company

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MET304	**Industrial Engineering**	**2**	**2**	**0**	**0**	**0**

PREREQUISITE: None

COURSE OUTCOMES: The course objectives define the student learning outcome for the course. After completing the above course, student is expected to:

CO1	Understand the evolution of different management theories.
CO2	Learn the basic concepts of productivity, work study along with the applications of ergonomics.
CO3	Determine the capacity and capability of workers engaged in a specific job.
CO4	Analyze and design wage and incentive plans for the workers.
CO5	Learn and apply the concepts of time value of money.
CO6	Apply the concept of depreciation and break-even analysis.

COURSE CONTENTS:

Industrial Engineering and Productivity: Evolution of Industrial Engineering, Contribution of Taylor, Gilbirth, Mayo etc.; Productivity, Factors influencing productivity, Productivity measurement techniques.

Work Study and Ergonomics: Work study, Method Study, Time Study, Recording techniques, Performance rating, Allowances, **Work Sampling, Predetermined Motion Time Systems (PMTS). Ergonomics:** Introduction and definitions of Ergonomics, Aspects of Ergonomics, Human-Machine System, Anthropometric measurement in product design.

Job Analysis and Job Evaluation: Job Description, Job Analysis and Job Evaluation, Job Evaluation techniques; Merit rating, Wage and Wage incentives, Bonus Schemes.

Engineering Economics and Cost Analysis: Concept and Scope of Engineering Economics, Element of costs, Break-even analysis; Value engineering and analysis; Time value of money; Replacement and Maintenance analysis – Types of maintenance, types of replacement problem; Depreciation.

References:

1. "Introduction to Work Study", International Labour Organisation.
2. "Motion and Time Study; Design and Measurement of Work", Ralph M. Barnes, John Wiley.
3. "Contemporary Engineering Economics", Chan S. Park, Prentice Hall of India, 2002.

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MET305	**Operations Research**	**3**	**2**	**1**	**0**	**0**

PREREQUISITE: None

COURSE OUTCOMES:

CO1	To develop mathematical operations research models from the verbal descriptions of real systems.
CO2	To understand the characteristics of different types of decision-making environments and the appropriate decision-making approaches and tools to be used in each type.
CO3	To understand and apply the mathematical tools that are needed to solve real life optimization problems related to assignments, transportation, replacement, waiting line, inventory etc.
CO4	To implement operational research knowledge in real world decision making

COURSE CONTENTS

- The Art and Science of Operation Research, Linear Programming: Formulation and Solution, Duality and Sensitivity Analysis.
- Transportation and Assignment Models, Integer Programming.
- Decision under Risk, Decision under Uncertainty, Game Theory.
- Basic elements of queuing model, Role of Poisons and Exponential distributions, Queuing with Combined arrival and departures, Simulation

References-

Text Books/ Reference books-

1. Operations Research, Taha, Hanmdy A., Prentice Hall, 2019
2. Principles of Operations Research, Wagner, Harvey M., McGraw hill,
3. Operations Research, Rao. K.C., Alpha Science Intl. Ltd., 2005.

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical
22MEP306	**CAD & CAM Lab**	**1**	**0**	**0**	**2**

COURSE OUTCOMES:

After completion of this course the students are expected to be able to demonstrate following knowledge, skills and attitudes.
The student will be able:

CO 1	To understand the Science behind the CAD Software's
CO 2	To use the software packages for drafting and modelling
CO 3	To create 2D and 3D models of Engineering Components
CO 4	To create parts by using CNC programming

COURSE CONTENT

- Introduction and different features of the CAD/CAM Software
- To experiment for mathematical elements of Curves for geometric modeling, 2-D and 3D drafting and Assembly for a standard component using geometric modelling software.
- To move from CAD to CAM tabs in CAD/CAM software for CNC part programming
- To study the working principle and dimension systems in CNC machines.
- To study the common codes used in programming of CNC machines tools.
- To study various safety features of CNC Machine and Work offset Procedure on CNC milling machine.
- Manual and CAD based part programming using G and M codes for Linear and circular interpolation, Pocket milling, slotting, peck drilling and other fixed canned cycles on vertical milling machine tool.
- Manual and CAD based part programming using G and M codes for turning, step turning, taper turning on cylindrical components using CNC Lathe machine tool.
- Experimentation on design, slice and printing a standard component involving CAD/CAM tool for 3D printing purpose.

REFERENCE BOOK(S)/ TEXT BOOK(S)

1. Zeid, I., "Mastering CAD/CAM", Tata McGraw Hill, 2007.
2. Mortenson, M. E., "Geometric Modeling", 3rd Ed., Industrial Press. 2006.
3. Groover, M. P., "Automation, Production systems and Computer Integrated Manufacturing", 3rd Ed., Prentice-Hall, 2007.
4. Chang, T.-C., Wysk, R. A. and Wang, H.-P. "Computer Aided Manufacturing", 3rd Ed., Prentice Hall, 2005.
5. Lynch, M., "Computer Numerical Control for Machining", McGraw-Hill, Latest edition

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MEP307	**Industrial Engineering Lab**	**1**	**0**	**0**	**2**	**0**

PREREQUISITE: None

COURSE OUTCOMES: On successful completion of the course, the student will be able to:

CO1	Identify and apply various method improvement techniques.
CO2	Perform time study and estimate the standard time for doing a particular job.
CO3	Measure the anthropometric data and analyze it to interpret the relevant outcomes.
CO4	To be able to apply the concept of VE/VA.

COURSE CONTENTS

- Method to Improve the Assembly and Dis-assembly of Nut-Bolt and Washers
- Activity Charts
- Pegboard Study Experiment
- Determination of Standard Time by using Stop Watch Time Study Technique
- Rating Practice using Pack of Cards
- Measurement of Anthropometric- Data
- Ergo cycle Experiment
- Performing value analysis of given product.

References:

1. "Introduction to Work Study", International Labour Organisation.
2. "Motion and Time Study; Design and Measurement of Work", Ralph M. Barnes, John Wiley.
3. "Contemporary Engineering Economics", Chan S. Park, Prentice Hall of India, 2002.

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MET351	**Advanced Machining & Additive Manufacturing**	**3**	**3**	**0**	**0**	**0**

PREREQUISITE: Casting, Welding, Forming, Machining and CAM

COURSE OUTCOMES:

CO1	Classification and grouping of manufacturing processes based on various criteria and need.
CO2	Understanding of the Electro-Thermal-based Machining Processes.
CO3	Understanding of the Abrasive-based Advanced Machining/Finishing Processes.
CO4	Understanding of the Chemical and Electro-Chemical based Machining Processes.
CO5	Understanding of the Additive Manufacturing Processes including metal powder-based Manufacturing Processes

COURSE CONTENTS

Classification of Manufacturing Processes: Classification of manufacturing processes, Limitations of conventional machining processes, Classification of Advanced Machining Processes, ISO/ASTM-based Classification of Additive Manufacturing Processes,

Electro-Thermal Energy Based Machining Processes: EDM, LBM, PAM, EBM – Process Science & Working Principles, Equipment, Process parameters, Modelling MRR and Applications**.**

Abrasive Machining Processes: AJM, AWJM, USM, AFM, MRF- Process Science & Working Principles, Equipment, Process parameters, Modelling MRR and Applications**.**

Chemical/ Electro-Chemical Energy Based Machining Processes: CHM, ECM, CMP: Process Science & Working Principles, Equipment, Process parameters, Modelling MRR and Applications**.**

Polymer Additive Manufacturing Processes: Material extrusion, Vat-Photopolymerization, Material Jetting: Working Principles, Equipment, Process Parameters, Modelling Part Build Time and Applications**.**

Metal Additive Manufacturing Processes: Metal Powders, Metal-based AMPs like Binder jetting, Sheet Lamination, Powder Bed Fusion, Direct Energy Deposition: Working Principles, Equipment, Process parameters, Modelling Part Build Time and Applications**.**

TEXT BOOKS/ REFERENCE BOOKS: -

1. "Nontraditional Manufacturing Processes", G.F. Benedict, Marcel Dekker, Inc. New York, Latest Edition
2. “Advanced Machining Processes” Vijay.K. Jain, Allied Publishers Pvt. Ltd., New Delhi, Latest Edition
3. “Manufacturing Engineering & Technology”, Kalpakjian. S., Pearson Education Asia, Latest Edition
4. Additive Manufacturing Technologies, by Ian Gibson, Springer, Latest Edition

ONLINE/E RESOURCES

1. Downloads - Harlal Singh Mali

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MET352	**Design of Mechanical Systems**	**4**	**3**	**1**	**0**	**0**

PREREQUISITE : Engineering Mechanics, Mechanics of Solids, Kinematics and Dynamics of Machines

COURSE OUTCOMES

CO1	Understand the advance design practices with regard to material selection, material properties, manufacturing considerations, and standards and codes.
CO2	Apply the concepts of advance design practices with regard to material selection, material properties, manufacturing considerations, and standards and codes
CO3	Design and Analysis of transmission mechanical systems, such as gears and gear boxes, flexible machine elements
CO4	Design and Analysis of mechanical systems involving multiple machine components.

COURSE CONTENTS

Design of gears: Force analysis and design of spur, helical, and bevel gears;

Design of Flexible Elements: Design of Flat belts and pulleys - Selection of V belts and pulleys – Selection of hoisting wire ropes and pulleys – Design of Transmission chains and Sprockets.

Gear Boxes: Geometric progression - Standard step ratio - Ray diagram, kinematics layout -Design of sliding mesh gear box - Design of multi speed gear box for machine tool applications - Constant mesh gear box - Speed reducer unit. – Variable speed gear box, Fluid Couplings, Torque Converters for automotive applications.

Design Case Studies involving multiple machine components (any two): Design of Floor Crane, Design of Overhead Crane; Design of Belt conveyor System, Design of IC Engine Components, etc.

TEXT BOOKS/ REFERENCE BOOKS :

1. Machine Design: An Integrated Approach, Norton Robert L., Pearson Education Asia, 2020.
2. Mechanical Engineering Design, Shigley J. E. and Mischke C. R., Budynas R. G. and Nisbett K. J., Tata–McGraw Hill, 2020.
3. Design of Machine Elements, M. F. Spotts, Prentice Hall of India, 2019.

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MET353	**Refrigeration and Air-Conditioning**	**3**	**2**	**1**	**0**	**0**

PREQUISITE –

Engineering Thermodynamics, Fluid Mechanics and Machines, Heat Transfer

COURSE OUTCOMES:

CO1	Awareness about different types refrigeration systems and illustrate basics, ideal and actual refrigeration cycles and heat pump cycle and their analysis
CO2	Explain the working of vapour compression and vapour absorption cycles system and identify methods for performance improvement. Also identify suitable refrigerant for various refrigerating systems.
CO3	Estimate the performance of air-conditioning systems using the principles of psychometry. Also compute and interpret cooling and heating loads in an air-conditioning system.
CO4	Explain working, analysis and applications of air conditioning systems, human comfort and air distribution system
CO5	Recognize components in load estimation, role of solar radiations and other heat transfers.

COURSE CONTENTS;

Introduction, Applications of air-conditioning and refrigeration, Reverse Carnot cycle, Different methods of refrigeration, heat pump.

Air refrigeration cycles- Bell Coleman air cycle, actual cycle and its application in air-crafts air conditioning, performance and comparison.

Vapour compression refrigeration- Ideal, theoretical and actual cycle, cycle analysis, factors affecting its performance, Multi stage compression, use of flash gas removal and flash inter cooling, cascade systems. Different refrigerants, including eco-friendly refrigerants, and their applications

Vapour absorption refrigeration and its components, solar powered refrigerator, Electrolux refrigerator.

Psychometry- Properties, charts and its uses, processes, air washer, evaporative cooling and air cleaners.

Air conditioning- winter and Summer Air conditioning system and their analysis, human comfort and comfort charts, air distribution system.

Load estimation- heating/cooling load components, solar load, ventilation and infiltration, air changes, load calculation.

TEXT BOOKS/ REFERENCE BOOKS:-

1. Elementary Refrigeration and Air conditioning. Stoecker, W.F., and Jones, J.W., McGraw-Hill, 1982
2. Principles of Refrigeration. Dosset, R.J., Pearson Education ,2001
3. Refrigeration and Air conditioning. Arora, C.P., Tata-McGraw-Hill, 2017
4. Refrigeration and Air Conditioning. Prasad, M., New Age International, 2015
5. ASHRAE Handbook (Fundamentals) ,2005

ONLINE/E RESOURCES

1. NPTEL

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MEP354	**Advanced Machining & Additive Manufacturing Lab**	**1**	**0**	**0**	**2**	**0**

PREREQUISITE : Casting, Welding, Forming, Machining and CAM Labs

COURSE OUTCOMES:

CO1	The understanding and skilling in additive manufacturing technologies like FDM, SLA, etc. process for faster product realization.
CO2	The understanding and skilling in Manual and CAM-based EDM, Micro-EDM, and AFM processes.
CO3	The understanding and skilling in hybrid machining processes
CO4	The understanding and skilling in the manufacturing flow for need-based product manufacturing

COURSE CONTENTS

- Experiments based on: Design, Part program, Simulate and additively manufacture (AM) using Fused Deposition Modelling or any other AM to machine a convergent divergent die-kind component for rapid prototype/tooling.
- To make a die-kind of the component while doing CAM-based experimentations on :
    - Vertical Machining Center and (b) Turning Centre
- To make a die-kind of insert out of hard material on a Die Sink - Electro Discharge Machine (EDM)
- Finish internally a die kind component on Abrasive Flow Machine.
- Experimentation on EDM assisted grinding and Centre less grinding setup
- Understand the need and working of Hybrid-Micro-Machine for miniaturization.
- Experimentation on laser-based manufacturing system.
- Experimentation on electro chemical-based manufacturing system.

TEXT BOOKS/ REFERENCE BOOKS:-

1. "Nontraditional Manufacturing Processes", G.F. Benedict, Marcel Dekker, Inc. New York.
2. “Advanced Machining Processes” Vijay.K. Jain, Allied Publishers Pvt. Ltd., New Delhi.
3. “Manufacturing Engineering & Technology”, Kalpakjian. S., Pearson Education Asia.

ONLINE/E RESOURCES

1. Downloads - Harlal Singh Mali
2. Software and Services for Education | Autodesk Education Community

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MEP355	**Computer Aided Engineering Lab**	**1**	**0**	**0**	**2**	**0**

PREREQUISITE : Engineering Drawing, Machine Drawing and Machine Design, and Basics of Finite Element Method

COURSE OUTCOMES

After completing this lab course, the students will be able to

CO1	Understand and explain the basic steps solid modelling
CO2	Construct 3-D solid models, 2-D drawing, assembly and sub-assembly structure.
CO3	Generate 2-D and 3-D models for finite element analysis.
CO4	Design and analyse basic structural/mechanical elements using FEA.

COURSE CONTENTS

Analysis of Mechanical Components – Using Software like Hyperworks/ABAQUS/ANSYS.
The exercises would include the followings:

- Introduction to FEA.
- Introduction to CAE tool environment (Hyperworks/ABAQUS/ANSYS)
- Analysis of machine elements under Static loads
- Thermal Analysis of mechanical systems
- Modal Analysis of Machine elements
- Analysis of Machine elements under Dynamic loads
- Analysis of Machine elements under Fatigue Loads
- Non-linear Analysis of Machine elements.

TEXT BOOKS/ REFERENCE BOOKS:-

1. The Finite Element Method: A Practical Course by G. R. Liu & S. S. Quek, Butterworth-Heinemann Ltd, 2013.
2. Introduction to Finite Element Analysis Using MATLAB and Abaqus by Amar Khennane, CRC Press Inc; 2013.
3. CAE Lab Manual and Lecture Slides/Lab tutorials to be provided in the class.

DETAILS OF THE COURSE:

Course Code	Course Title	Credits	Lecture	Tutorial	Practical	Studio
22MEP356	**Refrigeration and Air-Conditioning Lab**	**1**	**0**	**0**	**2**	**0**

PREREQUISITE: Engineering Thermodynamics, Fluid Mechanics and Machines, Heat Transfer

COURSE OUTCOMES:

CO1	To perform experimentations on refrigeration tutor
CO2	To perform experimentations for refrigeration system(s)
CO3	To perform experimentations for air conditioning system(s)
CO4	To learn advances in R & AC technologies

COURSE CONTENTS

- To perform test on the **refrigeration tutor** to determine different COPs and other performance parameters.
- To study the **air conditioning test rig** and calculate different parameters of actual and theoretical COP.
- To perform test on **cooling tower** and calculate various performance parameters such as efficiency, evaporation loss, range and approach.
- To study the performance characteristics of **Hilton Mechanical Heat Pump**.
- To study **experimental ice plant** and determine its Coefficient of Performance.
- To study and evaluate the performance of a **two-stage reciprocating air compressor.**
- To find out the performance parameters of a **LPG refrigerator (Eco-fridge)**
- To study the **solar air heater** and calculate its performance parameters.

TEXT BOOKS/ REFERENCE BOOKS:-

1. Elementary Refrigeration and Air conditioning. Stoecker, W.F., and Jones, J.W., McGraw-Hill, 1982
2. Principles of Refrigeration. Dosset, R.J., Pearson Education ,2001
3. Refrigeration and Air conditioning. Arora, C.P., Tata-McGraw-Hill, 2017
4. Refrigeration and Air Conditioning. Prasad, M., New Age International, 2015
5. ASHRAE Handbook (Fundamentals) ,2005

ONLINE/E RESOURCES

1. NPTEL

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical
22MEO401	**Training Seminar**	**2**	**0**	**0**	**4**

PRE- REQUISITE

Nil

COURSE OUTCOMES

CO1	To develop understanding related to the working of any mechanical engineering domain industry.
CO2	To be able to select any industrial problem and work on the problem.
CO3	To be able to relate the courses studied with the industrial setup.
CO4	To be able to compile the observations/ learning during training in the form of a report and present.

COURSE CONTENTS

Format of the Training Seminar Report

- Title
- Certification
- Introduction
- Literature Review
  - Research Gaps
  - Objectives
- Solving Objective-1
- Solving Objective-2

- Conclusions and Future Scope
- References

Format of the Presentation

- Title
- Certification
- Introduction
- Literature Review
  - Research Gaps
  - Objectives
- Solving Objective-1
- Solving Objective-2

- Conclusions and Future Scope
- References

RECOMMENDED READINGS

1. https://www.djkasiagroup.com/business/ai.html?gclid=EAIaIQobChMImp7E0uSy_gIVAT8rCh1d1QgMEAAYAiAAEgJcovD_BwE
2. https://www.simplilearn.com/growing-role-of-ai-in-manufacturing-industry-article

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical
22MEW402	**Minor Project**	**3**	**0**	**0**	**6**

PRE- REQUISITE

Knowledge of computational or experimental courses required to computable the objectives of project

COURSE OUTCOMES

CO-1	To be able to identify industrial and societal problems
CO-2	To learn the method of conducting literature review
CO-3	To acquire skills for identification of problem solving tools and methods
CO-4	To learn the concept documentation and develop critical thinking on the chosen problem

Few Examples of Mini Project Topics based on past Projects: -

- Developing solutions for CTEV (Clubfoot) affected patients.
- Bottlenecks problems for implementation of industry 4.0
- Design Enhancement and Automation of Sanitary Waste Incinerator
- Design Improvement of Linkage of Tractor Seat
- Design of Hydraulic operated wheel chair for standing assistance
- Design and Fabricate green house dryer assisted with tube type absorber

RECOMMENDED READINGS

1. https://www.djkasiagroup.com/business/ai.html?gclid=EAIaIQobChMImp7E0uSy_gIVAT8rCh1d1QgMEAAYAiAAEgJcovD_BwE
2. https://www.simplilearn.com/growing-role-of-ai-in-manufacturing-industry-article

DETAILS OF THE COURSE

Course Code	Course Title	Credits	Lecture	Tutorial	Practical
22MEW980	**Major Project**	**9**	**0**	**0**	**18**

PRE- REQUISITE

Preferably Mini Project may be continued.

COURSE OUTCOMES:

CO-1	To be able to design and develop solutions of problems following inventive and novel steps and industrial application.
CO-2	To be able to analyse the designed solution
CO-3	To be able to implement the mini-project design solutions towards enhancing TRL (technological readiness levels).
CO-4	To understand manufacturing technologies, developing functional minimum viable prototype and testing the developed product / process.

Few Examples of Mini Project Topics based on past Projects: -

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