Mechanisms and Machines

Module1: Introduction- General concepts, Introduction of Simple mechanism, Different types of Kinematics pair, Grublers rule for degree of freedom, Grashof"s Criterion for mobility determination. Inversions of 3R-P, 2R-2P chains.

Module 2: Kinematic Analysis- Concepts of vectorial analysis. Velocity and Acceleration Analysis of planar mechanisms.

Module 3: Cams- Classification, Cams with uniform acceleration and retardation, SHM, Cylcloidal motion, oscillating followers.

Module 4: Vibrations- Vibration analysis of SDOF systems, Natural, damped forced vibrations, Based-excited vibrations, transmissibility ratio.

Module 5: Gears- Geometry of tooth profiles, Law of gearing, Involute profile, interference, helical, spiral and worm gears, simple, compound gear trains. Epicyclic gear trains – Analysis by tabular and relative velocity method, fixing torque.

Module 6: Dynamic Analysis- Slider-crank mechanisms, turning moment computations.

Module 7: Balancing- Static and Dynamic balancing Balancing of revolving & reciprocating masses in single and multi-cylinder engines.

Module 8: Gyroscopes- Basic concepts Gyroscopic law, effect of gyroscopic couple on automobiles, ships, aircrafts.

CAD and Computer Graphics

Module 1: Introduction- Need and Scope of Computer Aided Design, Fundamental of CAD and computer graphics- Application areas, Hardware and software- overview of graphics systems, video-display devices, and raster-scan systems, random scan systems, graphics monitors and 84 workstations and input devices. Interactive hardware/software techniques, Drawing standards, dimensioning and text writing, concept of layers, advanced concepts of CAD software- blocks, UCS, 3D-line, 3D object, DXF & DXB file formats. Output primitives- Points and lines, line drawing algorithms, mid-point circle and ellipse algorithms.Filled area primitives Scan line polygon fill algorithm, boundary fill and flood-fill algorithms.

Module 2: 2-D geometrical transforms- Translation, scaling, rotation, reflection and shear transformations. Matrix representations and homogeneous coordinates, composite transforms, transformations between coordinate systems. 2-D viewing- The viewing pipeline, viewing coordinate reference frame.Window to view port coordinate transformation, viewing functions. Cohen-Sutherland and Cyrus-beck line clipping algorithms, Sutherland –Hodgeman polygon clipping algorithm.

Module3: 3-D Object Representation- Polygon surfaces, quadric surfaces, spline representation. Hermite curve, Bezier curve and B-Spline curves, Bezier and B-Spline surfaces. Basic illumination models, polygon-rendering methods. 3-D viewing- Viewing pipeline, viewing coordinates, view volume and general projection transforms and clipping.

Module 4: 3-D Geometric transformations- Translation, rotation, scaling, reflection and shear transformations, composite transformations. Visible surface detection methods- Classification, back-face detection, depth buffer, scan-line, depth sorting, BSP-tree methods, area sub-division and octree methods.

Module 5: Finite Element Method- Numerical Methods-Introduction, Errors in numbers, Root finding-Bisection method, Newton Raphson method, Curve fitting-Least square method, Numerical differentiation-Newton"s interpolation, Numerical Integration-Trapezoidal and Simpson method. Introduction to the principles of Finite elements modeling, Stiffness matrix/displacement matrix, Stiffness matrix for spring system, bar & beam elements, bar elements in 2D space (truss element), solution of finite element equation-higher order and iso-parametric elements, equilibrium problems in structural mechanics, Eigen value problems.

Module 6: Introduction to CAD CAM- Overview, orientation and application commands of CAD and CAE modeling software platforms for feature based Parametric and Variation modelling and analysis. Boolean, and sweep operations on primitives with applications to CAD of machine

elements.

Engineering Workshop

Module 1: Turning- Taper turning using tailstock offset method and taper turning attachment Eccentric external turning using a four jaw chuck.
Module 2: Boring- Using a boring tool – both concentric and eccentric. Boring using a boring bar in a centre lathe. Square and hexagonal hole drilling using die-sinking EDM.
Module 3: Grinding- Cylindrical grinding using grinding attachment in a centre lathe
Module 4: Thread Cutting- Internal and external thread cutting using a single point cutting tool.
Module 5: Gears- Cutting teeth of spur gears using form milling cutter in a universal milling machine, Gear hobbing, Gear shaping.
Module 6: Welding- Introduction. Edge/Joint preparation in welding and joining using shielded metal arc welding. Hands-on practice on metal inert gas welding (MIG) or gas metal arc *welding.* Hands-on practice on tungsten inert gas welding (TIG) or gas tungsten arc welding. Hands-on practice on spot welding. Hands-on practice on submerged arc welding

Design of Machine Elements
Module 1: Introduction to Mechanical Engineering Design- Review of models of Solid mechanics, uncertainties in design equations and factor of safety. Role of off the shelf available machine elements and standards. Standard numbering system including BIS designations of materials. Application of theories of failure to design
Module 2: Design procedure and applications of Statically Loaded Machine Elements- Design of elements subjected to simple loading: Riveted joints, Screws including power screws Bolted joints including eccentrically loaded joints, Axles, and coupling, Clutches and brakes.
Module 3: Fatigue- Introduction to design for fatigue strength. Endurance and modifying factors. Surface strength. Review of design procedure of fatigue failure with application to the design of bolts and springs subjected to fatigue loading.
Module 4: Design procedure and applications of Dynamically Loaded Machine Elements. Shafts, Spur, helical, bevel and worm gears, Journal and rolling contact bearings, Belts and chains. Assemblies of various machine elements like those of a screw jack and a gear box

Primary Manufacturing *4:0:2 [5]*
Module 1: General Introduction- Manufacturing; definition and broad classification with typical examples of applications.
Module 2: Casting -Introduction; History of the technology; Definition and major classification; Casting materials, Sand mould casting:- Basic principles with simple examples of a solid casting and a hollow casting. Patterns; types, material and design including pattern allowances; Moulding sands; composition, preparation, properties and testing; Core; Purpose, definition, materials, preparation and applications; Design of gating system; pouring basin, sprue, runner and risers; Advantages, limitations and applications of top gate, bottom gate, parting gate and step gate; Estimation of pouring time for top gate and bottom gate type moulds. Foundry equipment and furnaces. Melting, pouring and solidification. Principles, method, relative advantages and applications of floor mould casting, shell mould casting, pit mould and loam mould casting CO2 mould casting; centrifugal casting (pure, semi and centrifuging types) investment casting including mercasting ; Permanent mould casting. Die casting; types, methods, relative advantages and applications Slush casting; principle and use, Casting defects; types, causes and remedy
Module 3: Forming Processes - Introduction; General principles; major classification with typical examples ;Hot working and cold working; principle, purpose, relative advantages and applications. Forging:-Definition and classification giving few example of application; work materials different forging operations, tools and equipment ; Smithy, drop forging and press forging (pressing) methods and use; Forging dies ;types, materials and design. Rolling:-Introduction ; basic principles and general applications; Characteristics and applications of hot rolling and cold rolling; various rolling processes and applications and rolled products; Roll pass design for different products Wire drawing and Extrusion:- Basic principles and requirements; Classification, methods and applications; Work materials and products; Press tool works; Basic principles, system, operations and applications.

Shearing; Parting, notching, blanking and piercing. Cupping(drawing) and deep drawing. Design of blanks for any shearing and cupping operation. Estimation of forces and power required for shearing and cupping operations. Coining and embossing ; basic principle and methods. Other forming processes:- Principles, methods, essential requirements and applications of Spinning and flow turning; Bulging; Hydro forming; Magneto forming; Explosive forming.
Module 4: Welding- Introduction: Major classes of joining; Mechanical joining; temporary, semipermanent and permanent Giving examples; Welding; Brazing and soldering; Adhesive bonding; Welding in Liquid state. Fusion welding: - Introduction; basic principle, definition and major classification; characteristics and applications of different fusion welding processes using different heat-sources.Heat source:-chemical; gas welding; thermit welding; Heat source:-electrical; Arc welding; Manual arc welding; Submerged arc welding; TIG and MIG; Induction welding; Plasma arc welding; Resistance welding; Spot welding; Butt welding; Seam welding; Projection welding. Laser beam welding and electron beam welding. Solid state welding: - Principles. Methods, requirements and application of the different types; Solid state welding in hot condition; Forge welding; Friction welding; Diffusion welding; Solid state welding in cold condition; Ultrasonic

Fluid Mechanics
Module 1: Basic Concepts and Properties- Fluid – definition, distinction between solid and fluid - Modules and dimensions - Properties of fluids - density, specific weight, specific volume, specific gravity, temperature, viscosity, compressibility, vapour pressure, capillary and surface tension. Fluid statics concept of fluid static pressure, absolute and gauge pressures – pressure measurements by manometers and pressure gauges. Hydrostatic forces on submerged surfaces, Stability of floating bodies.
Module 2: Fluid Kinematics and Fluid Dynamics- Fluid Kinematics - Flow visualization - lines of flow - types of flow - velocity field and acceleration - continuity equation (one and three dimensional differential forms)- Equation of streamline - stream function - velocity potential function - circulation - flow net. Fluid dynamics - equations of motion - Euler's equation along a streamline - Bernoulli's equation, applications - Venturi meter, Orifice meter, Pitot tube. Dimensional analysis - Buckingham's Pei theorem- applications - similarity laws and models.
Module 3: Incompressible Fluid Flow- Viscous flow - Navier - Stoke's equation (Statement only) - Shear stress, pressure gradient relationship - laminar flow between parallel plates - Laminar flow through circular tubes. (Hagen Poiseulle's equation). Hydraulic and energy gradient - flow through pipes - Darcy -Weisback's equation – pipe roughness -friction factor- Moody's diagram-minor losses - flow through pipes in series and in parallel - power transmission. Boundary layer flows, boundary layer thickness and boundary layer separation. Drag and lift coefficients.
Module 4: Hydraulic Turbines- Fluid machines definition and classification - exchange of energy - Euler's equation for turbo machines - Construction of velocity vector diagram's - head and specific work - components of energy transfer - degree of reaction. Hydro turbines definition and classifications - Pelton turbine - Francis turbine - propeller turbine Kaplan turbine .Working principles - velocity triangles - work done - specific speed – efficiencies -performance curve for turbines.
Module 5: Hydraulic Pumps- Pumps definition and classifications. Centrifugal pump classifications, working principles, velocity triangles, specific speed, efficiency and performance curves. Reciprocating pump classification, working principles, indicator diagram, work saved by air vessels and performance curves ,cavitation in pumps Rotary pumps working principles of gear and vane pumps.

Heat Transfer
Module 1: Introduction-Modes and mechanisms of heat transfer: Basic laws of heat transfer, General discussion about applications of heat transfer. Conduction Heat Transfer: Fourier rate equation, General heat conduction equation in Cartesian, Cylindrical and Spherical coordinates. Simplification and forms of the field equation: steady, unsteady and periodic heat transfer, Initial and boundary conditions.
Module 2: One Dimensional Steady State Conduction- Heat Transfer in homogeneous slabs,

hollow cylinders and spheres overall heat transfer coefficient electrical analogy Critical radius of insulation. Variable thermal conductivity systems with heat sources of heat generation. Extended surface (fins) heat transfer along a fin, fin with insulated tip and short fin. Application to error measurement of Temperature.
Module 3: One Dimensional Transient Conduction Heat Transfer- Systems with negligible internal resistance; Significance of Biot and Fourier Numbers. Chart solutions of transient conduction systems- Concept of Functional Body.
Module 4: Convective Heat Transfer- Classification of systems based on causation of flow, condition of flow, configuration of flow and medium of flow.Dimensional analysis as a tool for experimental investigation .Buckingham Pi Theorem and method, Application for developing semi-empirical non- dimensional correlation for convection heat transfer, Significance of nondimensional numbers. Concepts of Continuity. Momentum and Energy Equations. Forced convection: External Flows: Concepts about hydrodynamic and thermal boundary layer and use of empirical correlations for convective heat transfer.-Flat plates and Cylinders. Internal Flows: Concepts about Hydrodynamic and Thermal Entry Lengths Division of internal flow based on this Use of empirical relations for Horizontal Pipe Flow and annulus flow.
Module 5: Free Convection- Development of Hydrodynamic and thermal boundary layer along a vertical plate – Use of empirical relations for vertical plates and pipes.
Module 6: Heat Transfer with Phase Change- Boiling: Pool boiling Regimes Calculations on Nucleate boiling, Critical Heat flux and Film boiling. Condensation: Film wise and drop wise condensation, Nusselt Theory of Condensation on a vertical plate - Film condensation on vertical and horizontal cylinders using empirical correlations. Heat Exchangers- Classification of heat exchangers overall heat transfer -Coefficient and fouling factor. Concepts of LMTD and NTU methods - Problems using LMTD and NTU methods.
Module 7: Radiation Heat Transfer- Emission characteristics and laws of black-body radiation, Irradiation total and monochromatic quantities, laws of Planck, Wien, Kirchhoff, Lambert, Stefan and Boltzmann, heat exchange between two black bodies, concepts of shape factor. Emissivity heat exchange between grey bodies radiation shields electrical analogy for radiation networks.

Control Engineering
Module 1: Introduction to Control-Brief history and developments in Feedback control.
Module 2: Modeling of physical systems- Mechanical, electrical, thermal and hydraulic systems. Concepts of state, state variable, state model. State models for linear continuous time functions, state space model formulation. Block diagram and signal flow graph analysis, transfer function. (*Modern approaches such as Bond graphs may be used for modeling and control.)*
Module 3: System response- Time response of first and second-order systems, Steady-state errors and error constants. Performance specifications in time-domain. Effect of pole locations. Concept of stability, relative stability, Routh"s stability criterion. Root locus method of analysis and design. Lead and lag compensation.
Module 4: Frequency-response analysis- Relationship between time & frequency response, Polar plots, Bode"s plot, stability in frequency domain, Nyquist plots. Nyquist stability criterion. Performance specifications in frequency-domain. Frequency-domain methods of design. Compensation and their realization in time and frequency domains.
Module 5: State variable Analysis- Solution of state equations. Concepts of controllability and observability. Pole placement design. Proportional, Integral and Derivative feedback. Simple case studies.

Integrated Design & Manufacturing
Module 1: Life cycle of Mechanical Equipment Design.
Module 2: Requirements of life cycle personnel like customer, management, marketing, manufacturing, transportation, etc.
Module 3: Role of analysis, creativity/ innovation, decision making and information processing in engineering design and problem solving.
Module 4: Practice in engineering problem solving and designing. DFMA to meet requirements of design and manufacturing.
Module 5: Principles of Material selection. Case studies and practice on Material selection and

Design for manufacture and assembly using first principles, programs/ packages.

Machine Tools and Machining

Part – A: Machine Tools and Machining

Module 1: Introduction- Classifications of manufacturing processes, characteristics of material removal processes, need and purpose of conventional material removal processes. Basic description of conventional machining processes, identification of process parameters, concept of machinability. General Constructional Configuration of Basic Machine Tools- Constructional configuration and specifications of basic machine tools like lathe, drilling machine, shaping machine, milling machine, grinding machine.Concept of generatrix and directrix.

Module 2: Basic Kinematic Structure of Centre Lathe- Kinematic analysis of: Speed Gear Box, Feed Gear Box, Apron Mechanism, Thread Cutting. Tool Geometry- Detailed discussions restricted to ASA, ORS and MRS and for single point cutting tool as well as WRS, Introduction to NRS.Introduction to tool geometry of milling cutters and drills.

Module 3: Mechanism of Chip Formation- Detailing on chip formation mechanism of brittle and ductile work material. Chip reduction coefficient, shear angle. Kronenberg"s relation. Build-up edge (BUE). Cutting strain, cutting strain rate, orthogonal machining, causes and modelling of chip deviation concept of effective rake, concept of oblique machining. Effect of process parameters and tool geometry on mechanism of chip formation. Introduction to characteristics of chip formation in milling.

Module 4: Mechanics of machining- Identification of cutting forces on orthogonal plane. Merchant"s circle diagram, interrelations between cutting forces, angle relationships. Merchant"s 1st solution, 2nd solution and Lee and Shaffer"s solution. Cutting forces in turning, milling, shaping and drilling. Effect of process parameters and tool geometry on mechanics of chip formation, Measurement of cutting forces, effect of tool geometry.Mechanism of chip formation of surface roughness.Effect of cutting forces on product quality.Cutting temperature- Identification of heat sources in machining.Effect of cutting temperature on product quality and cutting tool. Estimation, measurement and control of cutting temperature.Effect of process parameters and tool geometry on cutting temperature.

Module 5: Tool Wear, Tool Life and Tool Material- Different mechanism of tool wear.Types of tool wear (crater, flank etc), Measurement and control of tool wear, Concept of tool life, Taylor"s tool life equation (including modified version). Different tool materials and applications including effect of tool coating. Machining Time- Estimation of machining time in different machining operations, Introduction to economics of machining, Revisit to the concept of machinability.

Module 6: Introduction To Grinding-Need and different methods of grinding, Wheel specifications, Mechanics of grinding, Similarities and differences between grinding and machining.Basic Kinematic systems and operations of Other Machine Tools- Kinematic system and operations of drilling machines.Kinematic system and operations of milling machines.Construction, working principle and applications of shaping, planing and slotting

Part – B: Metrology

Module 1: Precision and Accuracy- Methods of estimating accuracy and precision; Needs for accuracy and precision; Standards and their evolution; Types of errors in measurements.Limits, Fits and Tolerances, & Gauge Design- Basic concepts in limits, fits and tolerances Tolerance grades; ISO system of tolerance, Principles gauge design.Work Shop and Inspection gauges.

Module 2: Screw Thread Measurement- Standard thread profiles, Different Thread Elements, Effective diameter, 2 wire and 3 wire methods as applied to standard and non-standard thread profiles, Best wire size, Virtual Effective Diameter. Surface Roughness-Sources of surface irregularities in manufacturing, Different elements of surface roughness, Definition of center line and related roughness parameters, Measurement Instruments, Profilometers, Analysis of roughness signal in frequency domain

Module 3: Gear Metrology- Different types of gears, Basic elements of a gear, Involute function, Relations between different gear elements of spur and helical gears, Virtual number of teeth, Use

of gear tooth Vernier for chordal and constant chordal measurements,Span measurement using Base Tangent Micrometers. Coordinate Measuring Machines-Introduction to Coordinate Measuring Machines.

Non-Traditional and Computer Aided Manufacturing

Part-A: Non-Traditional Manufacturing

Module 1: Introduction- Classifications of material removal processes. Characteristics of conventional material removal (machining) processes. Need for non-conventional or nontraditional processes.

Module 2: Process Description, Modelling, Application and Product Quality Related Issues-Abrasive Jet Machining, Ultrasonic Machining, Water Jet Machining, Abrasive Water Jet Machining, Electro-Discharge Machining, Chemical & Photo Chemical Machining, Electro-Chemical Machining, Electron Beam Machining,Laser Beam Machining.

Module 3: Advanced Topics- Basic introduction to Chemical, physical vapour deposition processes, Thermal spraying processes, Hybrid processes like electro-jet drilling, electro chemical grinding, electro-chemical discharge machining. Rapid prototyping.

Part – B: Computer Aided Manufacturing

Module 1: Introduction- Relation between production volume and flexibility. Various manufacturing systems – batch, mass, group, cellular and flexible manufacturing systems; Type of automation and benefits of soft or flexible automation.

Module 2: Automation in Material Handling and Assembly.

Module *3*: CNC Machines- Introduction, classification, design and control features including interpolations.

Module 4: NC Part-Programming;

Module 5: Introduction to Robotics-Definitions, motivation, historical development. Basic structure, classification, workspace, drives, controls, sensors, grippers, specifications

IC Engines and Refrigeration

Part A: IC Engines

Module 1: Basic Concepts-Air standard cycles and fuel-air cycles Assumptions, Otto, Diesel & Dual cycles, comparison of cycles, fuel air cycle, Valve Timing diagram, Actual engine cycle.

Module 2: S.I. Engines- Theory of Carburetion, Types of carburettors, Electronic fuel injection system, GDI. Combustion in spark Ignition engines, stages of combustion, flame propagation, rate of pressure rise, abnormal combustion. Phenomenon of Detonation in SI engines, effect of engine variables on Detonation. Combustion chambers. Rating of fuels in SI engines. Additives.

Module 3: C.I. Engines- Fuel supply system, types of fuel pump, injector and distribution system, Combustion in compression ignition engines, stages of combustion, factors affecting combustion, Phenomenon of knocking in CI engine. Effect of knocking. Types of combustion chambers rating of fuels in CI engines. Additives; Comparison of knocking in SI & CI engines, Concepts of Supercharging and Turbo charging.

Module 4: Engine systems and components-Ignition system.(battery, magneto & electronic); Lubrication system; Engine starting system; Engine cooling system; Governing system (quality and quantity hit & miss governing); Intake and exhaust systems (two valves & four valves); Drive train (cam shaft, valves etc.)

Module 5: Performance characteristics & Testing of I.C. Engines-Introduction to Indian. Standards for testing of I.C. Engine, Mean effective pressure, indicated power, brake power, friction power, Methods to determine power and efficiencies Variables affecting performance of engine, characteristic curves, heat balance sheet, Methods of improving engine performance; super & turbocharged engines.

Module 6: Fuels and Emissions- Chemical structure of the Petroleum, Refining process for petroleum, important qualities of the Engine fuels - (SI & CI engines), Diesel, and Gasoline fuels-Indian specifications. Alternate fuels (SI & CI engines)- Liquid fuels, gaseous fuels, hydrogen engines (LPG, HC NG (15%, 20%, 25 % Blends Hydrogen and Biofuels), Air pollution due to IC engine, Engine emissions, Hydrocarbon emissions, (HC) & PPM & Carbon monoxide emissions (CO), oxides of Nitrogen (NOx) Euro norms , Bharat stage norms, Introduction to EDC and IDC , Introduction to carbon credit, Emission control methods for SI and CI engines, Electronic control

module, Catalytic converters, EGR Concept of hybrid vehicles.

Part B: Refrigeration
Module 1: Introduction- Necessity and applications; Module of refrigeration and C.O.P. Mechanical Refrigeration; Types of Ideal cycles of refrigeration. Air Refrigeration: Bell Coleman cycle and Brayton Cycle, Open and Dense air systems ; Actual air refrigeration system problems ; Refrigeration needs of Aircrafts.
Module 2: Vapour Compression Refrigeration- Working principle and essential components of the plant ;Simple Vapour compression refrigeration cycle ;COP ;Representation of cycle on T-S and p94 h charts ;effect of sub cooling and super heating ; cycle analysis; Actual cycle Influence of various parameters on system performance; Use of p-h charts; numerical Problems.
Module3: Refrigeration System Components-Compressors; General classification; comparison; Advantages and Disadvantages. Condensers:– classification ;Working Principles. Evaporators:– classification ; Working Principles. Expansion devices:– Types ; Working Principles. Refrigerants:– Desirable properties ; classification refrigerants used ; Nomenclature; Ozone Depletion; Global Warming.
Module 4: Vapor Absorption Refrigeration- Calculation of max COP; description and working of NH3; water system and Li Br; water (Two shell & Four shell) System. Principle of operation Three Fluid absorption system, salient features.
Module 5: Other Refrigeration Systems- Steam Jet Refrigeration System; Working Principle and Basic Components. Principle and operation of (i) Thermoelectric refrigerator (ii) Vortex tube or Hilsch tube.

Part C: Air Conditioning
Module 1: Introduction- Psychometric Properties & Processes; Characterization of Sensible and latent heat loads; Need for Ventilation, Consideration of Infiltration; Load concepts of RSHF, GSHF- Problems, Concept of ESHF and ADP. Requirements of human comfort and concept of effective temperature; Comfort chart; Comfort Air conditioning; Requirements of Industrial air conditioning ;
Module 2: Air Conditioning System Components -Equipment for cooling, heating humidification and dehumidification, filters, grills and registers, fans and blowers. Heat Pump; Heat sources, different heat pump circuits.

Power Plant Engineering
Module 1: Introduction-Analysis of steam cycles, optimization of reheat pressure and degree of regeneration, coupled cycles and combined plants, process heat and power. Fuels and their properties, stoichiometric and actual air requirements, flue gas analysis.
Module 2: Boilers- Different types of boilers, boiler mountings, feed water treatment, boiler loading and manner of operation. boiler energy balance, draft system. Different types of furnaces
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for burning coal, fuel oil and gas. Circulation theory, down-comers and risers, economizers and super-heaters, air pre-heater, drum and its internals.
Module 3: Steam Turbines- Convergent and convergent-divergent nozzles - theory and design. Impulse and reaction turbines, compounding of turbines, optimum velocity ratio, reheat factor and condition line, parallel exhaust, losses in steam turbines, steam turbine governing.
Module 4: Plant Components- Theory and design of condensers, air ejector and cooling towers. Types and applications.
Module5: Power Plant Economics & Environmental Considerations- Plant energy studies: concepts and resources, procedures and implementation. Energy accounting. Various thermal systems and energy management. Electrical load management. Economic analysis. Waste heat recovery. Multi objective energy management- conservation, pollution control and evaluation of alternative energy sources. Cost of energy management and payback.

Environmental Pollution and Abatement
Module 1: Historical perspectives
Module 2: Effects of Pollutants on Human Health- Human respiratory system
Module 3: Classification and sources of pollutants-CO, CO2, O2, N2 cycles – sources and sinks.

Module 4: Reactions of pollutants in the atmosphere-Smoke, smog, fog, acid rain and ozone layer. Global warming and its effects. Regulatory laws and standards. Atmospheric diffusion of pollutants, transport, transformation and deposition. Atmospheric lapse rate, inversions and heat balance.
Module 5: Air sampling and pollutant measurement methods- Principles and instruments. Ambient air quality and emission standards.
Module 6: Control principles- Removal of gaseous pollutants by absorption, adsorption, chemical reaction and other methods. Selective catalytic reduction of NOX. Particulate emission control; settling chambers, cyclone separation, wet collectors, fabric filters and electrostatic precipitators. Clean coal technology and shifted emphasis on non-carbon sources of energy.

Vibration and Noise Control
Module 1: Vibration of single degree of freedom (SDF) system-Modelling of stiffness and damping (both Viscous and Coulomb). Estimation of damping by decay plots and half power method. Impulse, transient and forced vibration response of SDF system.Theory and practice of vibration isolation. Vibration measuring instruments.
Module 2: Two degree freedom system- Application to undamped and damped absorbers. Multidegree freedom systems. Modal analysis. Rayleigh"s and Dunkerley"s method. Holzer"s and Myklestad-Prohl transfer matrix methods.
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Module 3: Continuous systems-Governing wave equation and Euler Bernoulli equation. Free and forced vibrations including modal analysis.
Module 4: Finite element analysis-Dynamic analysis of simple systems.Introduction to modal testing and system identification problems.
Module 5: Acoustics and Noise Control-Acoustic wave equation, Acoustic energy and sound intensity. Propagation of sound, Concept of Acoustic impedance. Sound power transmission, Transmission Loss. Human Response and ratings,Various Measures of Sound. Weighting filters, Loudness, Indices of Loudness. Acoustic radiation from spherical source and piston source. Acoustic sensors. Measuring Techniques and Instruments, Octave Filtering, Sound Intensity Measurement, Intensity Mapping. Different types of measurement environment and uses. Sound absorption coefficient. Noise control measures in building. Reverberation time and auditorium design. Industrial Noise control, Noise in Machinery, Traffic Noise, Vehicle Noise. Design of silencers and mufflers. Active noise control.

Advanced Computer Graphics and Solid Modeling
Module 1: Introduction to application of computer graphics for visualizing concepts
Module 2: Introduction of hardware including operating systems- Introduction to Workstations, Graphic Terminals, Input/output Devices, File management and hardware limitations , Data Representation ,Languages, Operating Systems.
Module 3: Graphic Packages- Exploration of various packages for illustration, drawing, desk top publishing page composition and animation. Introduction to the concepts of programming in media applications.
Module 4: Fundamentals of CAD-Design Process, Database Constructing The Geometry, Wire Frame and Solid Modelling. Introduction to software packages and its applications for CAD, Use of auto lisp. CAD-CAM Integration.

Advanced Engineering Thermodynamics
Module 1: Review of laws of thermodynamics-Energy concepts for closed and open systems.
Module 2: Entropy considerations- Minimization of entropy generation principle and thermodynamic optimization.
Module 3: Energy- Energy analysis of thermal systems and plants; Thermo economic applications.
Module 4: Phase transition- Equations of state. Multi-component and multi-phase system. Reactive systems.
Module 5: Kinetic theory of gases. Distribution of molecular velocities and energy, transport properties of gases.
Module 6: Principles of irreversible thermodynamics and applications.

Tribology

Module 1: Surfaces and Friction- Topography of Engineering surfaces- Contact between surfaces - Sources of sliding Friction -Adhesion Ploughint- Energy dissipation mechanisms, Friction Characteristics of metals - Friction of non-metals. Friction of lamellar solids - friction of Ceramic materials and polymers - Rolling Friction. Source of Rolling Friction - Stick slip motion - Measurement of Friction.

Module 2: Wear- Types of wear - Simple theory of Sliding Wear Mechanism of sliding wear of metals - Abrasive wear. Materials for Adhesive and Abrasive wear situations - Corrosive wear - Surface Fatigue wear situations - Brittle Fracture wear - Wear of Ceramics and Polymers - Wear Measurements.

Module 3: Lubricants and Lubrication Types- Types and properties of Lubricants - Testing methods - Hydrodynamic Lubrication – Elasto hydrodynamic lubrication- Boundary Lubrication - Solid Lubrication Hydrostatic Lubrication.

Module 4: Film Lubrication Theory- Fluid film in simple shear - Viscous flow between very close parallel plates - Shear stress variation, Reynolds Equation for film Lubrication - High speed unloaded journal bearings - Loaded journal bearings - Reaction torque on the bearings -Virtual Coefficient of friction - The Somerfield diagram.

Module 5: Surface Engineering and Materials for Bearings- Surface modifications - Transformation Hardening, surface fusion - Thermo chemical processes - Surface coatings –

Turbo Machinery

Module 1: Steam Turbines-Types of turbines, constructional details, application of turbines, types of seals, and packing to reduce leakage, losses in turbines. Compounding of turbine, velocity diagrams, output efficiency, losses in turbines, reaction turbine, velocity, diagrams, degree of reaction, constructional features of blades. Governing of turbines

Module 2: Gas Turbine-Theory and fundamentals of gas turbines, principles, classification, Joule"s cycles, assumptions for simple gas turbines, cycle analysis, work ratio, concept of maximum and optimum pressure ratio, actual cycle, effect of operating variable on thermal efficiency. Regeneration, inter cooling, reheating, their effects on performance. Closed cycle and semi closed cycles gas turbine plant/ Applications of gas turbines.

Module 3: Jet Propulsion-Introduction, types of jet engines, application of jet engines. Theory of jet propulsion, energy flow through jet engines, thrust, thrust power, and propulsive efficiency. Turbo jet, turbo prop, turbo fan engines, pulse jet and ram jet engines, performance characteristics thrust segmentation.Concept of rocket propulsion.

Module 4: Rotary Compressor- Concepts of: Rotary compressors, Root blower and vane type compressors, Centrifugal compressors. Velocity diagram construction and expression for work done, introduction to slip factor, power input factor.

Module 5: Hydraulic Turbines- Classification of hydraulic turbines, Heads & various efficiencies. Impulse momentum principle,Fixed and moving flat plate and curve vanes, series of plates & vanes. Velocity triangles and their analysis, work done, efficiency etc. Impulse turbine: Main components and constructional features of pelton wheel, velocity diagrams & work done, condition for max. Hydraulic Efficiency, number of buckets, jets, Non dimensional parameters (speed ratio, jet ratio).Governing mechanisms for pelton wheel. Reaction turbine, main components & constructional features, types of reaction turbine (Francis, Kaplan), draft tube types, efficiency, cavitation, , Francis, Kaplan turbines, Types of characteristic curves, unit quantities, selection of turbine considering various factors, specific speed, Application of similarity as applied to turbines, scale effect

Welding Technology

Module 1: Introduction- Welding as a production process – its advantages and limitations. Gas welding process, Types of fuels, Acetylene, Indane, Butane etc. Gas welding equipment, Gas welding technique. Electric arc welding – Manual metal arc welding – Power supplies, cables and other accessories for arc welding, Welding technique - atomic, hydrogen welding, Thermit welding, soldering, brazing and braze welding.

Module 2: Special Welding Processes- Power sources, equipments and accessories, application ,limitation and other characteristics of: (a) Gas tungsten arc (TIG) welding (b) Gas metal arc (MIG) welding (c) Submerged arc welding (d) Electro slag welding processes. Resistance welding processes- principle-Types (spot, seam, projection, percussion, flash), Equipment required for each application.
Module 3: Modern Welding Processes-Electron beam welding, Laser beam welding, Plasma arc welding, Friction welding, Explosive welding, Ultrasonic welding, Stud welding, Under water welding, Diffusion bonding, Cold welding, Welding of dissimilar metals.
Module 4: Weldment Testing- Defects in welding in various processes-Causes and remedies; Destructive testing of weldments - Strength, hardness, ductility, fatigue, creep properties etc. Nondestructive testing of weldments; Ultrasonic dye penetrant, magnetic particle inspection. X ray testing procedures and identification of defects – case studies. Weld thermal cycle – Residual stressed distortion in welding stress relieving techniques.
Module 5: Weldability, Automation And Design In Welding-Weldability –definition. Temperature distribution in welding –heat affected zone weldability of steel, cast iron. Aluminum, Pre heating and post heating of weldments. Estimation of transition temperature. Automation in welding

Automobile Engineering
Module 1: Vehicle Structure and Engines-Types of Automobiles, Vehicle Construction – Chassis, Frame and Body ,Aerodynamics, Components of Engine – Their forms, Functions and Materials, Review of Cooling and Lubrication systems in Engine, Turbo Chargers, Engine Emission Control by 3–Way Catalytic Controller, Electronic Engine Management System.
Module 2: Engine Auxiliary Systems- Carburettor–working principle, Electronic fuel injection system – Mono-point and Multi - Point Injection Systems, Electrical systems – Battery generator – 105
Starting Motor and Drives – Lighting and Ignition (Battery, Magneto Coil and Electronic Type)- Regulators-cut outs.
Module 3: Transmission Systems-Clutch – Types and Construction, Gear Boxes-Manual and Automatic, Simple Floor Mounted Shift Mechanism, Over Drives, Transfer Box Fluid flywheel-Torque convertors, Propeller shaft – Slip Joint – Universal Joints, Differential and Rear Axle, Hotchkiss Drive and Torque Tube Drive.
Module 4: Steering, Brakes and Suspension- Wheels and Tires – Wheel Alignment Parameters ,Steering Geometry and Types of steering gear box, Power Steering, Types of Front Axle – Suspension systems. Braking Systems – Types and Construction – Diagonal Braking System – Antilock Braking System.
Module 5: Alternative Energy Sources-Use of Natural Gas, LPG, Biodiesel, Gasohol and Hydrogen in Automobiles, Electric and Hybrid Vehicles, Fuel Cells.

Quality Assurance and Reliability
Module 1: Introduction-Definition of Quality, Quality function, Dimensions of Quality, Quality. Engineering terminology, Brief history of quality methodology, Statistical methods for quality improvement, Quality costs – four categories costs and hidden costs. Brief discussion on sporadic and chronic quality problems. Introduction to Quality function deployment.
Module 2: Quality Assurance-Definition and concept of quality assurance, departmental assurance activities. Quality audit concept, audit approach etc. structuring the audit program, planning and performing audit activities, audit reporting, ingredients of a quality program.
Module 3: Statistical Process Control-Introduction to statistical process control – chance and assignable causes variation. Basic principles of control charts, choice of control limits, sample size and sampling frequency, rational subgroups. Analysis of patterns of control charts. Case Studies on application of SPC. Process capability – Basic definition, standardized formula, relation to product tolerance and six sigma concept of process capability, Seven QC tools.
Module 4: Control Charts for Variables- Controls charts for X bar and Range ®, statistical basis of the charts, development and use of X bat and R charts interpretation of charts. Control charts for X bar and standard deviation (S), development and use of X bat and S chart. Brief discussion on – Pre

control X bar and S control charts with variable sample size, control charts for individual measurements, moving-range charts.

Mechanical Handling Systems and Equipment

Module 1: Elements of Material Handling System-Importance, Terminology, Objectives and benefits of better Material Handling; Principles and features of Material Handling System; Interrelationships between material handling and plant layout, physical facilities and other organizational functions; Classification of Material Handling Equipment.

Module 2: Selection of Material Handling Equipment-Factors affecting for selection; Material Handling Equation; Choices of Material Handling Equipment; General analysis Procedures; Basic Analytical techniques; The unit load concept; Selection of suitable types of systems for applications ; Activity cost data and economic analysis for design of components of Material Handling Systems; functions and parameters affecting service; packing and storage of materials.

Module 3: Design of Mechanical Handling Equipment- Design of Hoists, Drives for hoisting, components, and hoisting mechanisms; rail travelling components and mechanisms; hoisting gear operation during transient motion; selecting the motor rating and determining breaking torque for hoisting mechanisms.Design of Cranes, Hand-propelled and electrically driven E.O.T. overheat Travelling cranes; Traveling mechanisms of cantilever and monorail cranes; design considerations for structures of rotary cranes with fixed radius ; fixed post and overhead travelling cranes; Stability of stationary rotary and travelling rotary cranes.

Module 4: Design of load lifting attachments- Load chains and types of ropes used in Material Handling System; Forged, Standard and Ramshorn Hooks; Crane Grabs and Clamps; Grab Buckets; Electromagnet; Design consideration for conveyor belts; Application of attachments.

Simulation of Mechanical Systems

Module 1: Introduction-A review of basic probability and statistics, random variables and their properties, Estimation of means variances and correlation.

Module 2: Physical Modeling-Concept of System and environment, Continuous and discrete systems, Linear and nonlinear systems, Stochastic activities, Static and Dynamic models, Principles of modeling, Basic Simulation modeling, Role of simulation in model evaluation and studies, advantages of simulation

Module 3: System Simulation and Approach-Techniques of simulation, Monte Carlo method, Experimental nature of simulation, Numerical computation techniques, Continuous system models, Analog and Hybrid simulation, Feedback systems, Computers in simulation studies, Simulation software packages. System Dynamics: Growth and Decay models, Logistic curves, System dynamics diagrams. Probability Concepts in Simulation: Stochastic variables, discrete and continuous probability functions, Random numbers, Generation of Random numbers,

Module 4: Variance reduction techniques, Determination of length of simulation runs. Simulation of Mechanical Systems: Building of Simulation models, Simulation of translational and rotational mechanical systems, Simulation of hydraulic systems. Simulation of Manufacturing Systems: Simulation of waiting line systems, Job shop with material handling and Flexible manufacturing systems, Simulation software for manufacturing, Case studies.

Applied Elasticity and Plasticity

Module 1: Theory of Elasticity- Analysis of stress and strain, equilibrium, Compatibility and constitutive equations, Plane stress and plane strain problems, General equation in Polar coordinates, Rotating discs and stresses in circular discs, Stress function in terms of harmonic and complex functions, Equation of equilibrium of a deformed body in curvilinear coordinates, Principle of superposition and principle of virtual work, Torsion of thin tubes, Bending of cantilevers, Uniformly and continuous loaded beams, Bending of circular, elliptical and rectangular cross-section bars, Axi-symmetric formulation and deformation of solids of revolution.

Module 2: Theory of Plasticity-Nature of engineering plasticity, Differential equations of equilibrium, 3D stress analysis, infinitesimal deformation, finite deformation, Von Mises', Tresca's and anisotropic yield criteria, Halgh-Westergard stress space representation of yield criteria, experimental verification of yield criteria, Subsequent yield surfaces. Elastic and plastic stress-strain relations and stress strain rate equations, Prandtle-Reuaa equations, Generalized

plastic stress strain relations, Anisotropy and instability.Plane plastic flow, Slip-line field theory, Application of slip line field theory to plane strain metal forming processes Plane plastic stress and pseudo plane stress analysis and its applications, Extremum principle for rigid perfectly plastic material, surfaces of stress and velocity discontinuity. Upper bound and lower bound theorems and applications.

Technology of Surface Coating

Module 1: Introduction= Influence of different manufacturing processes on various surface and sub-surface properties; need of augmentation of surface properties; need from the view point of friction, wear, thermal barrier, erosion, corrosion etc.

Module 2: Techniques of different surface engineering- Heat treatments, dip-coatings, galvanizing, painting electro-depositions, physical vapour deposition processes, chemical vapour deposition

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processes, thick coating processes (like plasma spraying, high velocity oxy fuel spray, detonation gun spray, cold spray gun etc.)

Module 3: Corrosion- Fundamentals of corrosion, types or corrosions and electrochemical protection, protective coating, corrosion measurement

Module 4: Experimental and Approach- Evaluation of engineered properties – control properties, response properties; surface geometry – characterization techniques (conventional and recent trends); coating thickness measurements – laboratory techniques and special techniques for accurate routine thickness measurements; adhesion measurement – conventional methods and recent developments;

Module 5: Tribology and Nano technology- Measurement of mechanical properties of engineered surface in nano scale; Evaluation of tribological characteristics of engineered surface in macro, micro and nano scale, simulation of actual application environment in tribometer

Mechatronics

Module 1: Introduction- Mechatronics: What and Why?

Module 2: Essential electronics and Boolean algebra. Digital representation: Binary, Decimal, Hexadecimal, Conversion from Binary to Decimal and vice-versa. Binary arithmetic: Addition, Subtraction: 2"s complement, Multiplication and Division, Boolean algebra: AND, OR, NOT, NAND, NOR, XOR logic, Truth table, Realization of logic in physical systems: switches-LEDs, cylinders. Fundamental identities, De Morgan"s theorems and relationship with sets, Simplification, Electronics fundamentals: Review of some semiconductor devices, Concepts of Digital and Analog systems, Digital output (DO) and input (DI), Using switches, transistors, pneumatic devices, etc. to realize DI & DO Operational Amplifier: Principles, Configurations: Inverting; Summing; Integrating and Differentiating configurations, Digital to Analog conversion (DAC), The R-2R and summing Op-Amp circuit, Analog to Digital conversion (ADC), Successive approximation method, Flash method, etc. Programs for DI, DO, DA and AD for PC based plug in cards.

Module 3: Microprocessor, Computers and Embedded systems- Introduction to the 8085 (8-bit microprocessor) and microcontroller: Architecture, programming, I/O, Computer interfacing, Programmable logic controller basics.

Module 4: Sensors and actuators- Strain gauge, resistive potentiometers, Tactile and force sensors, tachometers, LVDT, Piezoelectric accelerometer, Hall effect sensor, Optical Encoder, Resolver

Theory of Combustion and Emission

Module 1: Combustion Principles- Combustion - Combustion equations, heat of combustion - Theoretical flame temperature, Chemical equilibrium and dissociation - Theories of Combustion - Pre-flame reactions, Reaction rates-Laminar and Turbulent, Flame Propagation in Engines.

Module 2: Combustion in SI Engine- Initiation of combustion, stages of .combustion, normal and

abnormal combustion, knocking combustion, pre-ignition, knock and engine variables, features and design consideration of combustion chambers.- Flame structure and speed, Cycle by cycle variations, Lean burn combustion, stratified charge combustion systems. Heat release correlations. After treatment devices for SI engines.
Module 3: Combustion in CI Engine- Stages of combustion, vaporization of fuel droplets and spray formation, air motion, swirl measurement, knock and engine variables, features and design considerations of combustion chambers- delay period correlations, heat release correlations, and influence of the injection system on combustion. Direct and indirect injection systems. After treatment devices for diesel engines.
Module 4: Combustion in Gas Turbines- Flame stability, re-circulation zone and requirements – Combustion chamber configuration, materials.
Module 5: Emissions- Main pollutants in engines, Kinetics of NO formation, NOx formation in SI and CI engines. Unburned-hydrocarbons, sources, formation in SI and CI engines, Soot formation and oxidation, Particulates in diesel engines, Emission control measures for SI and CI engines, Effect of emissions on Environment and human beings.

Robotics: Mechanics and Control
Module 1: Introduction to Robotics- Robot, Robotics, Types of Robot, Robot classification, Types of Robot, Degrees of freedom.
Module 2: Kinematics and Dynamics of Robotic linkages (open ended type manipulators)- Frames, Transformations: Translation and rotation, Denavit-Hartenberg parameters, Forward and Inverse Kinematics, Jacobian, Dynamics: Equations of motion, Newton-Euler formulation.
Module 3: Sensors and actuators- Strain gauge, resistive potentiometers, Tactile and force sensors, tachometers, LVDT, Piezoelectric accelerometer, Hall effect sensors, Optical Encoders, Pneumatic and Hydraulic actuators, servo valves, DC motor, stepper motor, drives.
Module 4: Control of Manipulators- Feedback control of II order linear systems, Joint control, Trajectory control, Controllers, PID control
Module 5: Robot Programming-Language-overview, commands for elementary operations.

Note: The above syllabus is indicative and not exhaustive

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