Himachal Pradesh
Public Service Commission

No.09-18/2022-PSC (R-IV) **Dated: 27.06.2024**

Syllabus for Paper-II i.e. Descriptive Type Subject Aptitude Test (SAT) for the recruitment to the posts of Assistant Environmental Engineer, Class-I (on contract basis) in H.P. State Pollution Control Board under the Department of Environment, Science & Technology, H.P. The SAT shall be of 03 hours duration having 120 Marks. The SAT paper shall have two parts i.e., Part-I and Part-II, and cover the following topics:-

{Bachelor of Engineering (Chemical) level}

PART-I

1. **MATHEMATICS:**

Multivariable Functions: Limit, Continuity, and Partial Derivatives; Euler's Theorem for Homogeneous functions; Differentiability, Linearization, and Differentials; Chain rule; Extreme values and Saddle Points; Lagrange multipliers; Taylor's Formula. **Differential Calculus:** Scalar and vector fields, Gradient of a scalar field, Divergence and Curl of a vector field. **Infinite Series:** Infinite series and convergence, alternating series, power series and convergence, Taylor's and Maclaurin's Series. **Integral Calculus/Theorems:** Statement of Green's, Gauss and Stoke's Theorem and their simple applications, Area between plane curves; Volumes of solids of revolution; Lengths of plane curves; Areas of surfaces of revolution, Double integrals in rectangular and Polar form, Triple integrals in Rectangular, Cylindrical and Spherical coordinates, Substitutions in Multiple Integrals. **Ordinary Differential Equations:** First-order exact differential equations, Integrating factor, Orthogonal trajectories, Second and Higher-order Linear Differential Equations with constant coefficients, Differential Operators, Methods of Variation of Parameters and Undetermined Coefficients, Euler Cauchy Equation. **Partial Differential Equations (Pde)**:Formation and classification of partial differential equations, first-order linear equations, standard forms of non-linear equations, Charpit's method, homogeneous linear equations with constant coefficients, Method of separation of variables. Fourier Series, Euler's Formulae, Dirichelet's Conditions for Expansion, Change of the interval, Odd and Even Functions, Expansion of Odd and Even Functions and Periodic functions, Engineering Applications, Solution of partial differential equations of engineering interest by the method of separation of variables. **Laplace Transform:** Definition, Transforms of Elementary functions, Properties of Transforms, Inverse Transforms, Transforms of Derivatives, Unit Step Function, Dirac's Delta Function & Unit Impulse function. Periodic Functions, Application of Transform to the solution of ordinary Differential equations. **Calculus of Complex Functions**: Functions of complex variables, analytic functions, Cauchy-Riemann equations, Cauchy's theorem, Cauchy's, Integral formula, introduction to Tayler's series and Laurent's series, Residues, Residue theorem, and its simple applications.

2. **MATERIAL & ENERGY BALANCE:**

Review: Units and dimensions, Stoichiometric and composition relationships, Engineering calculations on process variables like flow rate, temperature and pressure, Ideal gas law calculations, Real gas relationships, Gaseous mixtures, vapour pressure and liquids, Saturation, Partial saturation, and humidity. **Material Balances on Non-reactive processes:** Fundamental Material balance calculations, Balances on multiple-unit processes, Material

balance on Recycle, By-pass and Purge streams. **Material Balances on Reactive processes:** Molecular Species Balance, Atomic Species Balance and extent of reaction method, calculations involving recycle and purge streams, and Combustion Calculations. **Energy balance on Non-reactive processes:** Elements of Energy Balance Calculations, Calculations involving a change in pressure, temperature and phase change operations. **Energy balanceon Reactive processes:** Heat of reaction, the heat of formation and heat of combustion calculations, Energy balance calculations on reactive processes, Fuels and combustion,Humidity charts and their use.

3. **FLUID FLOW:**

Fluid Statics: Hydrostatic equilibrium, Manometers, Pressure measurements, Normal forces in fluids, Forces on Submerged bodies, Buoyancy and stability Fluid Flow Phenomena**:** Potential flow, Newtonian and non-Newtonian fluids, Viscosity, Reynolds number, Nature of turbulence, Eddy viscosity, Flow in boundary layers (laminar and turbulent flow), Transition length, Boundary layer separation. **Fluid flow of incompressible fluids:** Bernoulli's equation, Kinetic energy and momentum correction factors, Pump work in Bernoulli's equation, Navier-Stokes equation. **Dimensional analysis:** Rayleigh's and Buckingham's π theorem, applications of dimensional analysis. **Fluid Flow of compressible fluids:** acoustic velocity, Mach number, sonic, subsonic, supersonic flows, Mach angle, stagnation properties, flow through the nozzle, effect of area variation on properties in an isentropic flow, choking in a converging duct, isentropic flow through a converging-diverging duct**,** pressure distribution, working chart for an isentropic flow. **Flow measurement devices and machines:** Pilot tube, Orifice, Venturi and Rota meter, Notches and weirs, wet gas meter. **Fluid Machinery:** Pumps, classification and performance of pumps, selection and specification of pumps, priming, cavitation, net positive suction head, turbines, blowers and Compressors.

4. **MECHANICAL OPERATIONS:**

Size Reduction: Crushers and Grinders- jaw crusher, crushing rolls, Gyratory Crusher Tumbling/revolving mills, hammer Mill and Fluid energy mill. Closed and open circuits grinding. Power requirements, Laws of crushing, **Mechanical Separation:** Screening**:** Stationery screens, Grizzlies, Trommel and Vibrating screens. International Standard Screens & Indian Standard Screens, Screening Analysis-differential and cumulative. **Motion of particle through a fluid:** Stoke's Newton's law, Free and hindered setting. Setting tank and double cone classifiers, Batch and continuous thickeners, Settling chamber, cyclone, filter bag and electrostatic precipitators. **Centrifugation:** Tubular bowl centrifuge, disk centrifuge and batch basket centrifuge. **Filtration:** Plate and frame filter press, continuous rotary vacuum filter, filter aids, theory of filtration for non-compressible cakes. **Fluidization:** Conditions for fluidization**:** Aggregate and particulate fluidization. Ergun's and Carman-Kozeny equations. **Mixing and Agitation:** Basic ideas and characteristics of mixing equipment power consumptions scale-up. **Conveying:** Mechanical and pneumatic conveying systems, storage & handling of materials.

5. **HEAT TRANSFER:**

Conduction: Steady state conduction in the one-dimensional system, general conduction equation, the effect of variable thermal conductivity, steady state conduction involving internal heat generation, lagging on pipes, the critical thickness of insulation on pipes, extended surfaces of uniform thickness and fin effectiveness, fin efficiency. **Convection:** Free and forced convection, the concept of heat transfer coefficient, dimensionless numbers

in free and forced convection, Dimensional analysis, experimental determination of heat transfer coefficient and common working correlations. **Radiation Heat Transfer:** Black Body radiation, and gray body radiation, physical mechanism, radiation properties and shape factor, heat exchange between non-black bodies, radiation shields, pyrometer and effect of radiation on temperature measurement. **Condensation and Boiling:** Condensation heat transfer phenomenon, film condensation on vertical plates and cylinders as well as on horizontal cylinders. Effects of non-condensable gases and vapor velocity on condensation, pool boiling, forced convection boiling, working correlations for pool boiling. **Evaporation:** Types of Evaporators, single and multiple effects, single and multiple-effect calculations, evaporator capacity, economy, effect of liquid head and boiling point elevation, methods of feeding. **Heat Exchangers:** Various types of heat exchangers, overall heat transfer coefficients, heat exchanger mean temperature differences, heat exchanger effectiveness and the number of transfer units.

6. **CHEMICAL ENGINEERING THERMODYNAMICS:**

Brief review of the terms: state functions, types of systems, internal energy, heat and work and reversible and irreversible processes. Use of Steam tables. **First Law of Thermodynamics and its Engineering Applications**: Constant volume processes, constant pressure processes, isothermal and adiabatic processes, pumps, turbines, compressors, nozzles, heat exchangers, pitot tube, venturi meter and orifice meter, Throttling Processes, Joule-Thomson Coefficient, liquefication of gases. **Thermochemistry**: Heat capacities and their measurement, standard heat of reaction, standard heat of formation, standard heat of combustion, flame temperature, H-x diagrams, heat of solution, partial, molar enthalpies, enthalpy for phase change. etc. **Equation of state** for real gases and their mixtures. Principle of corresponding states and generalized compressibility factor. **Second law of thermodynamics**: entropy concept, Entropy and lost work calculations, Microscopic interpretation of entropy. **Third Law of thermodynamics** and its applications. **Free energy functions** and their significance in phase and chemical equilibria, Clapeyron's equation and some important correlations for estimating vapour pressures. Estimation of thermodynamic properties by using graphs and tables. **Phase Equilibria:** Partial molar properties, partial molar Gibbs free energy, Chemical potential and its dependence on temperature and pressure Ideal solutions (Lewis-Randel Rule), Fugacity and its calculations, Dependence of fugacity of temperatures and pressure**,** Solution behaviour of real liquids and solids, Activity and activity coefficients, Variation of activity co-efficient with temperature and composition, Activity coefficients of electrolytes standard states. Properties of mixing, Residual and Excess Properties, Gibbs-Duhem equation and its application to vapour-liquid equilibria. **Chemical Equilibria:** Equilibrium constant in terms of measurable properties variations of the equilibrium constant with temperature and pressure, Adiabatic reactions, Gibbs phase rule, equilibration homogeneous reactions.

7. **CHEMICAL TECHNOLOGY (INORGANIC):**

Chloralkali industry: Electrochemistry of brine electrolysis current efficiency, energy efficiency, diaphragm, mercury and dow cells, caustic soda, chlorine. **Soda Ash:** Manufacture of soda ash by Solvay and Modified Solvay process, handling and safety. **Sulphuric Acid:** Introduction, Manufacture of sulphuric acid by Chamber and Contact process, Material of construction, Storage and handling. **Cement:** Types of cement, Constituents of cement, Manufacture of Portland cement. **Glass**: Introduction, Types of

glass, Raw materials, Manufacture of glass. **Industrial gases:** Manufacture and uses of carbon dioxide, oxygen and nitrogen, acetylene. **Paints:** Introduction, Classification of paints, Manufacture of paints, Requirement of a good paint. **Fertilizers:** Nitrogenous fertilizers, Manufacture of Ammonia, Nitric acid, Urea, CAN, Ammonium Sulphate, Phosphatic fertilizers, super phosphate and triple super phosphate. Potassic fertilizers, Potassium Chloride and Potassium Sulphate, Safety aspects.

8. **CHEMICAL TECHNOLOGY (ORGANIC):**

Oils & Fats: Introduction, Extraction of oils from vegetable oils, refining of oils and fats, hydrogenation of oils. **Soaps and Detergents:** Introduction, Raw materials, Manufacture of soap, Classification of detergents, finishing of detergents. **Water:** Sources and Constraints, Impurities**,** dissolved, suspended, colloidal; Hardness of water; Water softening; Lime soda, Ion exchange. **Desalination:** Classification of processes; Evaporative processes, Multi-effect evaporation, multi-stage flash, vapour compression; Membrane processes, Reverse osmosis, electro dialysis. **Pulp & paper:** Introduction, Raw Materials, types of pulp, Manufacture of paper. **Sugar:** Introduction; Sugar extraction, defacation, sulphitation, carbonation, concentration, crystallization, drying, refining; Uses of molasses and bagasse. **Polymers:** Introduction, Degree of polymerization, Classification of polymers, Polyethylene, Polyesters. **Petroleum Refining:** Introduction, composition of crude oil, typical refinery operations like thermal cracking, catalytic cracking.

PART-II

1. **ENERGY TECHNOLOGY:**

Fuels: Types of conventional fuels, their merits and demerits, Non-conventional/renewable energy sources, their importance for sustainable development and environmental protection. **Solid Fuels:** Origin of coal, proximate and ultimate analysis of coal, coal preparation and washing methods, safe storage of coal. Low and High-temperature carbonization, products of carbonization, coke ovens. Synthetics fuels from coal–Bergius process and Fischer Tropsch process. **Liquid fuels:** Origin of petroleum, refining and distillation of crude oil, uses of petroleum products. **Gaseous fuels:** Natural gas, manufacture of water gas and producer gas, gas cleaning methods. **Principles of combustion:** Combustion calculations, waste heat utilization. **Furnaces:** Classification of furnaces, draught, furnace atmosphere, Portland cement continuous rotary kiln, blast furnace, glass melting furnace. **Alternate sources of energy:** Introduction to solar radiation and evaluation of radiation incidents on a solar collector, Applications of solar thermal energy such as solar water heater, solar concentrators and solar thermal power generation, Solar photovoltaic systems and applications**,** Biomass Energy, Wind Energy, Geothermal Energy, Tidal and Wave Energy.

2. **CHEMICAL REACTION ENGINEERING:**

Introduction and a brief review of the kinetics of homogeneous reactions: Kinetics of homogeneous reactions, single and multiple reactions, order & Molecularity, rate constant, elementary and non-elementary reactions, temperature dependent term of rate equation, Arrhenius equation , Activation energy, Collision Theory of reaction rates. **Interpretation of rate data from constant volume and constant pressure systems:** Constant volume batch reactor, integral method of analysis of data, series and parallel reactions, irreversible &

reversible reactions, Variable volume batch reactor, Differential & integral method of analysis, Temperature and reactions rate. **Introduction to Reactor Design:** Ideal batch reactor, mixed flow reactor, plug flow reactor, holding and space time. **Design for single reactions:** Size comparison of single reactors, Multiple reactor systems, mixed flow reactors of different sizes in series Recycle reactor. **Design for Multiple Reactions:** Parallel and series reactions, quantitative treatment of product distribution and of reactor size for different types of ideal reactors, selectivity and yield factors, potpourri of multiple reactions, reactor choice for multiple reactions, Denbigh reactions. **Thermal characteristics of reactors:** Temperature and pressure effects, general graphical design procedure Optimum temperature progression , adiabatic operations. **Non-ideality in reactors and its effects on chemical conversion:** Non-ideal flow patterns, E, F& C Curve, Mean residence time, One parameter models to represent the behaviour of chemical reactors, N Tanks in series model, dispersion number. **Fluid Solid non-catalytic reactors:** Rate equation and their application to the design of reactors. **Fluid-fluid reactions:** Kinetic Regimes for Mass Transfer and Reaction, Film Conversion parameter, Cluesto the kinetic Regime from solubility data, Clues to the Kinetic Regime from equipment, Applications to design. **Heterogeneous Catalyses:**A brief review of catalyses catalytic specificity, Rates of Adsorption, Surface reaction, Desorption, Rate limiting step, Power Law, Langmuir Hinshelwood rate, Eley- Rideal mechanism, Theories of heterogeneous catalysis, Classification of catalysts, Preparation of catalyst, Promoter and inhibitors, catalyst poisoning and catalyst regeneration. **Fluid Solid Catalytic Reaction:** External transport processes, Reaction and diffusion within porous spherical catalyst pellet. **Different modes of diffusion:** Bulk diffusion, Knudsen diffusion and surface diffusion, Diffusion in Liquids, Diffusion in Porous Catalyst Effective diffusivity, thermal conductivity and effectiveness factor. **Solid Catalyst:** Determination of surface area adsorption isotherms. Nature of adsorbed state, Adsorption of gases on solids, Freundlich isotherm, Langmuir adsorption isotherm and BET isotherms, Void volume and solid density, Pore volume distribution, Physical adsorption, chemisorptions. **Analysis of rate data design outline:** Selection of fixed bed, fluidized bed and slurry reactors for fluid-solid catalytic reactions.

3. **MASS TRANSFER:**

Mass transfer operations: classification of mass transfer operations, choice of separation methods, methods of conducting mass transfer operations, design principles.**Introduction to mass transfer and diffusion**: molecular diffusion in gases and liquids, diffusion coefficients for gases and liquids, diffusion in solids, types of solid diffusion.**Mass transfer coefficients**: types of mass transfer coefficients, mass transfer coefficients in laminar flow, theories of mass transfer, Interphase mass transfer, the concept of overall mass transfer coefficient, **Gas-liquid contacting equipment**:Working principle, construction and industrial applications of sparged vessels, mechanically agitated vessels, tray towers, packed towers, spray chambers, Venturi scrubber. **Drying**: Principle, batch drying, drying curve, constructional details and working of different dryers.**Humidification operations**: psychometric chart, adiabatic saturation temperatures, wet bulb temperature,Adiabatic operations, types of cooling towers.**Absorption:** Equilibria for absorption systems – use of Raoult's law, Henry's law for solubility predictions, Selection of absorbent, limiting liquid gas ratios, absorption factor use in the design of plate absorbers. Kremser equation for ideal plates and translation of ideal plates to real plates using various efficiencies. Concept of

transfer units for the design of packed absorbers.**Distillation:** Limitations and applications, prediction of VLE using thermodynamic & experimental techniques. Dew point & bubble point estimations for binary & multi-component mixtures. Distillation methods – flash distillation, differential distillation for binary systems, steam distillation, optimum reflux ratio. Fractionation of binary mixtures using McCabe –Thiele method and enthalpy concentration method (Ponchon and Savarit method). Packed distillation columns. Azeotropic & extractive distillation preliminaries and molecular distillation.**Liquid-Liquid Extraction:** Ternary Equilibria and its representation on various plots. Selection criteria for solvent, Multistage extraction using partially miscible& immiscible solvents. Stage-wise contact for countercurrent and crosscurrent extraction. Constructional details of equipment like mixer-settler, packed columns, pulsed extractor, sieve-tray extractor and centrifugal extractor.**Leaching:** Preparation of solid, countercurrent and crosscurrent multistage contact Shank's system. Constructional details of equipment like Rotocel extractor, Hildebrandt extractor, Bollman extractor, Kennedy Extractor& Beet- Sugar Diffusion battery extractor.**Adsorption:**Types of adsorption, nature of adsorbents, equilibria for adsorption systems. Brief manufacture and commercial applications and characteristics for common adsorbents, stage-wise and continuous contacting of fluid and solid phase. Description of contact filtration adsorption system, Hypersorber Ion-exchange system.**Crystallization:** Growth and properties of crystals saturation, nucleation, growth of crystals, effect of impurities on crystal formation, effect of temperature on solubility, fractional crystallization, yield of crystals, crystal purity, yield calculation using phase diagram, energy requirements using enthalpy-concentration diagram. Methods of creating super saturation-Meirs super solubility curve, Mechanism and methods for nucleation, Derivation for ideal growth of crystals and discussion of actual growth, Swanson-Walker and various vacuum crystallizers.

4. <u>ENVIRONMENTAL ENGINEERING:</u>

Introduction: Inter-relationship between man, energy and environment pollution, Population models and effect of population on the degradation of the environment, Ambient air quality standards and description of atmospheric layers.**Air Pollution**: Principal Air pollutants (gaseous and particulates) and their sources, Effect of air pollutants on human health, animals, vegetation and materials, Different concentration scales of air pollutants and their calculation, Prevention of environmental pollution through conservation, raw material substitutions, process and equipment modifications, Metrological aspects of air pollution, stability of atmosphere, adiabatic lapse rate, topography and terrain effects, types of temperature inversions and plumes. Atmospheric dispersion of air pollutants, Estimation of pollutants by Gaussian plume model. Calculation of air pollutants concentration at different space coordinates using model equations (solution) for gaseous, particulates and aerosols, Point, line and area sources and effect of the inversion layer, Process and equipment used for the control of particulate pollutants, Analysis and design of the various air pollution control equipment and evaluation of their collection efficiencies and important features, **Water Pollution:** Types of water pollutants, their sources and effects, Calculation of water quality parameters (physical, chemical and biological) e.g. BOD, COD, DO, TDS, TSS, color, odor, turbidity, hardness, alkalinity, microbial activity, DO level in water bodies and its calculation. Calculation of Ultimate BOD, rate constant, critical DO level and BOD_5, Oxygen sag curve and nitrogenous BOD, Application of Thomas model,Wastewater

sampling and its analysis, Water quality standards, Waste water treatment techniques and equipment, flocculation, skimming, floatation, Pre-treatment, Primary Treatment, Microbial growth rate, Monod equation. Secondary Treatment-Aerobic and anaerobic digestion, activated sludge process, Calculation of bio-kinetic para meters and F/Mratio, Material balance of activatedsludge process and recycle options and their analysis. Different aeration schemes and extended aeration and analysis of design parameters used in wastewater treatment. Different bio-film systems e.g. rotating biological contactors (RBCs), trickling filters, Sequential batch reactors and different types of oxidation ponds and facultative ponds. **Sludge treatment and disposal**: Classification of Solid wastes, Collection methods and disposal, sanitary landfill, incineration, pyrolysis gasification and recycling.

5. **PROCESS INSTRUMENTATION:**

General Concept: Need and classification of measurements and instruments, Basic and auxiliary functional elements of a measurement system.**Static and Dynamic Characteristics of Instruments:** Static Characteristics**,**Range and span, accuracy and static error, reproducibility and drift, sensitivity and dead zone, Dynamic Characteristics**,** Speed of response and lag, fidelity and dynamic error, dead time.**Temperature measurement:**Bimetallic thermometers, filled-in system thermometers. Thermo couples, metal resistance thermometers and thermistors, optical and radiation pyrometers, and radiation-receiving elements.**Pressure measurement:**Bourdon gauge, Bellows type gauge. Vacuum measurement– Mcleod gauge &Pirani vacuum gauge, Measurement of pressure in corrosive fluids**,** Diaphragm seal, liquid seal and purge system, **Viscosity measurement:**Float viscometer, rotational viscometer.**Liquid level measurement:**Direct measurement of liquid level–Float & tape liquid level gauge, float and shaft liquid level unit, hydraulic remote transmission of liquid level. Level measurement in open vessels**:** Bubbler system, diaphragm box system, air trap system, Level measurement in pressure vessels– Differential pressure manometer, use of liquid seals with a manometer, displacement float liquid level gauge.**Conductivity measurement** with and without electrodes**.Density measurement:** Liquid level method, displacement meter and hydrometer.**Weight measurement:**Spring scale, pneumatic force meter & hydrostatic force meter.**Process Instrumentation:** Recording instruments, indicating and signalling instruments, control centre transmission of instrument reading, instrumentation diagrams.

6. **PROCESS DYNAMICS & CONTROL:**

Introduction: Incentives for chemical process control, Design aspects of a process control system, Hardware elements of a control system, Feedback and Feed-forward control configurations. Transfer function, Forcing functions. **Laplace transform:** Inversion by partial fractions, Properties on transforms, Dynamic behaviour of first-order system**:** Response of Mercury thermometer, Liquid level tank, Pure capacitive system, Mixing process, Linearization of nonlinear systems.**Dynamic behaviour of higher order systems:** Response of First order systems in series, Interacting and non-interacting systems, Second order system, transportation lag**:** dead time, Approximation of transport lag.**The control system:** Block diagram, Negative and positive feedback, Servo and Regulator problem.**Controllers:** P, PI, PD, PID and On-off controllers. **Closed loop transfer functions:** Block diagram reduction, Transient response.**Stability analysis of feedback control systems:** The characteristic equation, Routh-Hurwitz criterion for stability,

Theorems of Routh test, Root locus, Frequency response analysis of linear processes, Bode diagrams.**Control system design:** Bode stability criterion, Gain margin and phase margin, Ziegler-Nichols controller settings.**Introduction to advanced control techniques**: Cascade control, feed-forward control, ratio control, inferential control.

7. **TRANSPORT PHENOMENA:**

Introduction:Mechanisms of momentum transport and their transport properties. Development of mathematical modelling and differential equations through shell momentum balance for solving problems of momentum transporting one dimension and solving these problems by using the equation of change-flow of a falling film, flow through the circular tube, annulus, Couette viscometer etc. **Momentum transport**: definition of friction factor for flow in tubes, around spheres, **Energy transport**: Mechanisms of energy transport and their transport properties, Development of mathematical modelling and differential equations through shell energy balance for solving problems of energy transport-heat conduction with an electrical heat source, nuclear and viscous source, composite wall, cooling fin. Interphase transporting on–isothermal system. **Mass transport**: Mechanisms of mass transport and their transport properties, Development of mathematical modelling and differential equations through shell mass balance for solving problems of mass transport-diffusion through stagnant gas film, heterogeneous and homogeneous chemical reaction. Interphase transport in non-isothermal system. Emphasis on the analogy between momentum, heat and mass transfer with respect to the transport mechanism and their governing equations.

8. **PROCESS ENGINEERING ECONOMICS:**

Cost estimation: Factors affecting investment and production costs. Capital investments, fixed investments and working capital. **Cost indices**: Estimating equipment costs by scaling 6/10 factor rule.**Methods for estimating capital investment**: Estimation of the total product cost, Different costs involved in the total product costs, Different costs involved in the total product for a typical chemical process plant.**Interest and Investment Costs:** Simple and compound interest, Nominal and effective rates of interest, Continuous interest ordinary annuity, Perpetuities and capitalized costs.**Taxes and Insurance:** Types of taxes and tax returns, types of insurance and legal responsibility.**Depreciation:** Types of depreciation. Service life salvage value, present value and methods of determining depreciation, single unit and group depreciation. Profitability, Alternative Investments and Replacements**:** Mathematical methods of profitability evaluation. Cash flow diagrams. Determination of acceptable investments, Alternatives when' an investment must be made and analysis with small increment investment, replacement. Breakeven analysis, Balance sheet and income statement.**Optimum Design:** Procedure with one variable, optimum reflux ratio in distillation and other examples.**Preliminary Steps in Plant Design:** Plant design factors, project organization, plant location, preliminary data collection, and process engineering.

{Bachelor of Engineering (Civil) level}

PART-I

1. **Engineering Mathematics:-**

Matrix: Algebra Matrices, Related Matrices, Complex matrices (Hermitian and Skew-Hermitian matrices, Unitary matrix), Rank of a matrix, Gauss-Jordan method, Normal form of a matrix, Linear dependence and independence of vectors, Consistency of linear system of equations, solution of linear system of equations, Characteristic equation, Eigen values, Eigen vectors, Properties of eigen values, Cayley-Hamilton theorem and its applications, Reduction to diagonal form, Quadratic form and their reduction to canonical form, **Differential Calculus:** Review of Limits, Continuity and Differentiability, Mean Value Theorem, Partial Differentiation and its geometrical interpretation, Homogeneous functions, Euler's theorem and its extension, Total differentials, Composite function, Jacobian, Taylor's and Maclaurin's infinite series, Indeterminate forms, Errors and increments, Maxima and minima of functions of two variables, Method of undetermined multiples, curve tracing, **Integral Calculus:** Double integrals (Cartesian and Polar), Change of order of integration, Change of Variables, Applications of Double Integrals, Triple Integrals, Change of Variables, Applications of Triple Integrals, Beta and Gamma functions, **Vector Calculus:** Differentiation of vectors, Curves in space, Velocity and Acceleration, Relative velocity and acceleration, Scalar and Vector point functions, Vector Operator 'Del'- Del Applied to Scalar Point Functions (Gradient) and its Geometrical Interpretation- Directional Derivative, Del Applied to Vector Point Function (Divergence and Curl) and their Physical Interpretation, Del Applied Twice to Point function, Del Applied to Products of Point Functions, Integration of Vector, Tangential Line Integral, Normal Surface Integral, Volume integrals, Theorems of Green, Integration of Vector, Tangential Line Integral, Normal Surface Integral, Volume Integrals, Theorems of Green, Stokes and Gauss (without proofs) and their verification and applications, Rotational Fields, Solenoidal Fields, **Fourier Series:** Euler's formula, Dirichlet's Conditions, Functions having points of discontinuity, Change of interval, Expansion of odd and even periodic functions, Half-range series, Typical wave-forms, Parseval's formula, Practical harmonic analysis, **Ordinary Differential Equations:** Brief review of ordinary differential equations, Exact equations, Equations reducible to exact equations, Equations of the first order and higher degrees, Clairaut's equation, Applications of ODEs in concerned engineering branch, Linear differential equations with constant co-efficient, Complimentary functions and particular integral, method of variation of parameters, Equations reducible to linear equations with constant co-efficient (Cauchy's and Legendre's linear equations), initial and Boundary value problems, Simultaneous linear equations with constant co-efficient, Applications of differential equations in concerned engineering branch, **Partial Differential Equations:** Formulation of Partial Differential Equations (PDE), Solution of PDE, Linear PDE of First Order (Lagrange's Linear Equation), Non-linear Equation of First Order (Standard Forms), Homogenous Linear Equation with Constant Coefficients, Non-homogenous Linear Equations, Applications of PDE: Method of separation of variables, Solution of one dimensional wave and heat equation and two dimensional Laplace's equation, **Transforms Theory:** Laplace Transform: Laplace Transforms and their properties, Inverse Laplace Transforms, General Properties of inverse Laplace transforms and Convolution Theorem, Laplace Transforms of periodic functions, Solution of ODE and linear simultaneous differential equations using Laplace transforms, **Fourier Transform:** Fourier integral representation, Fourier sine, cosine and complex transform, Finite Fourier Transforms and their applications, Probability and Statistics: Review of probability, Conditional probability and sampling theorems, Discrete and Continuous Probability Distribution, Probability Mass & Probability Density

Functions, distribution Function, Discrete and Continuous probability distributions, Binomial, Poisson and Normal distributions, **Functions of Complex Variable:** Applications of De Moivre's theorem, Exponential, Circular, Hyperbolic and logarithmic functions of a complex variable, Inverse Hyperbolic functions, Real and imaginary parts of Circular and Hyperbolic functions, Summation of the series- 'C+iS' method, Limit and derivative of complex functions, Cauchy-Riemann equations, Analytic functions and its applications, Complex integration, Cauchy's theorem, Cauchy's integral formula, Series of complex function, Taylor series, singularities and Laurent's series, Cauchy's residue theorem and its application for the evaluation of real singularities and Laurent's series, Cauchy's residue theorem and its application for the evaluation of real definite integrals, **Interpolation:** Lease square curve fit and trigonometric approximations, Finite differences and difference operators, Newton's interpolation formulae, Gauss forward and backward formulae, Sterling and Bessle's formulae, Lagrange's interpolation, **Numerical integration:** Integration by trapezoidal and Simpson's rules 1/3 and 3/8 rule, Romberg integration and Gaussian quadrature rule, Numerical integration of function of two variables, **Numerical Solution of Ordinary Differential Equations:** Taylor series method, Picard's method, Euler's method, Modified Euler's method, Runge-Kutta method, Predictor corrector methods, Adam Bashforth and Milnes method, convergence criteria, Finite difference method, **Numerical Solution of Linear and Non-Linear Equations:** Non-Linear Equations: Bisection Method, Regula Falsi Method, Newton-Raphson Method, Iteration Method, Linear Equations: Jacobi and Gauss Seidal Iteration methods, Relaxation method.

2. **Engineering Graphics:-**

Introduction: Importance of Engineering drawing, Engineering Drawing instruments and uses, B.I.S. and I.S.O. Conventions for drawings, Use of plane scales and Representative Fraction, **Projection of Points and Straight Lines:** Introduction to principal planes, Notation System, Projection of line parallel/perpendicular to principal plane, Concept of true length of line, **Projection of Planes:** Concept of different planes, Projections of planes with its inclination to one principal plane and with two principal planes, Concept of auxiliary plane method for projections of the plane, **Projections of Solids and Sections of Solids:** Classifications of Solids, Projections of right and regular solids with their axis parallel to two and perpendicular to one of the principal planes, axis parallel to one and inclined to two principal planes, axis inclined to all the three principal planes, Section of solids, **Orthographic Projections & Isometric Projection:** Principle of projection, Principal planes of projection, Projections from the pictorial view of the object on the principal planes using firs angle projection method and third angle projection method, Full Sectional View, Isometric Projection, **Autocad's Workspaces and User Interface:** The Drawing Area, Accessing Autocad Commands, Starting, Saving, and Opening Drawings, Closed User Interface, User Interface and Start-up Tutorial, Coordinates, World Coordinate System/User Coordinate System, Coordinate Systems tutorial, Drawing Using Coordinates Tutorial, Drawing Commands, Text & Modifying Commands, Object Snap Commands.

3. **Engineering Physics:-**

Semiconductor Device Physics: Energy bands in solids, the E-k diagram, Density of states, Occupation probability, Fermi level and quasi Fermi levels, Fermi-Dirac Statistic, Effective mass, conductivity as a function of temperature p-n junctions, Schottky junction and Ohmic contacts, **Laser Physics:** Concept of laser, spontaneous and simulated emission, elementary idea about Lasers, basic principles involves in laser, three and four level laser system, coherence, characteristics of laser light; ruby; He-Ne, CO2 and semiconductor lasers, applications of lasers, **Fibers Optics and photonics:** Optical Fiber, Physical structure and basic theory, modes in optical fibers, step index fibers, losses in optical fibers, sources and sensors for optical fibers, applications of optical fibers in communication, **Electrostatics and Electrodynamics:** Gauss's Law in dielectric medium, Equation of continuity, displacement current, Maxwell's equations, wave equation for electromagnetic radiation, Electromagnetic wave propagation in free space

and isotropic dielectric medium, Poynting theorem & Poynting vector, **Quantum Mechanics:** Need of quantum mechanics, Compton effect, Born's concept of wave function, eigen function and eigen values, operators in quantum mechanics, expectation values, time dependant Schrodinger's wave equations and its applications viz., particle in one dimensional potential well, **Superconductivity andUltrasonics:** Introduction and discovery of superconductivity, superconductivity materials, Meissner effect, critical magnetic field and critical current, type-1 and type-2 superconductors, isotope effect, theory of superconductivity ultrasonic's, generation, properties and applications.

4. **Applied Mechanics:-**

Introduction to Statics: Particle and Rigid body, Types of forces, Transmissibility of a force, Vector algebra, **Two dimensional force system:** Resolution of forces, Moment of forces, Couple, Resolution of a coplanar force by its equivalent force-couple system, Resultant of forces, free body diagram, equilibrium, **Centre of Gravity and Moments of inertia**: Centroid ofplane, curve, area, volume and composite bodies MI with respect to different axis, parallel axis theorem, Mass moment of inertia, **Virtual work and Energy method:** Principle of virtual work; Application of virtual work principle to machines; Mechanical efficiency; Work of a force/couple, potential energy and equilibrium, **Concept of Friction:** Law of Coulomb friction, Angle of Repose, Coefficient of friction, large and small contact surfaces, Belt friction, Equilibrium of a belt, Bearing friction, **Kinematics of Rigid body**: Introduction, Plane Motion of Rigid Body, Velocity and Acceleration under Translation and Rotational Motion, Relative Velocity, **Kinetics and Rigid Body:**Introduction, Force, Mass and Acceleration, Work and Energy, Impulse and Momentum, DÁlembert's Principles and Dynamic Equilibrium, **Impulse Momentum Principle:** Impulsive force, Conservation of Linear momentum and Angular momentum, Impact between bodies, **Simple Stresses and Strains:** Normal stress, Shear stress, Bearing Stress, Normal strain, Shearing Strain; Hook's law; Poisson's ratio, Factor of safety, **Bending stress of Beams**: Introduction, Simple Bending Theory, Stress in beams of different cross sections, shear stress, combined stresses, **Torsion:** Introduction, Torsion of shafts of circular section, torque and twist, shear stress due to torque, **Analysis of Truss:** Method of joints, Method of Sections, **Analysis of Frames:** Shear force and bending moment diagram of determinate beams and frame.

5. **Engineering Chemistry:-**

Environmental Science: Specification of domestic and industrial water, water treatment, water quality parameters, waste/sewage water treatment, BOD, COD, Air quality standard, air pollution and its control, smog formation, Photochemical smog, green house effect and Global Warming, Chemical pollutants, Carbon Credit, Climate Change, Introduction to Environment impact assessment, **Characterisation Techniques:** Introduction to spectroscopy, UV-Visible spectroscopy- Absorption laws, Instrumentation, formation of absorption bands, Chromophore and auxochrome concept, application of UV-Visible Spectroscopy, IR spectroscopy- Principle, Selection rules, spectral features of some classes of compounds, important features of IR spectroscopy and application, Introduction to Thermal methods, instrumentation and applications (TGA, DTA, DSC), **Nanochemistry:** Introduction to nanochemistry: Dependency of optical, electrical and magnetic properties on size of materials, various nanostructures, spherical nanoparticles, nanotubes, nanofibers, nanorods, etc, synthesis, properties and applications of following nanomaterials- Carbon based nanostructures- CNTs and graphene, semiconductors nanoparticles- Tio2, Characterisation of nanomaterials: atomic force microscopy (AFM), Scanning electron microscopy (SEM), **Corrosion and its control:** Introduction, Types of corrosion-chemical and electrochemical, Mechanism of corrosion, factors affecting corrosion and different protection methods for corrosion control, **Lubricants:** Introduction, Mechanisms of lubrication, Types of lubricants, properties and different methods for testing of lubricant oils and greases.

6. **Fluid Mechanics:-**

Introduction: Flow characteristics, Classification, Fluid properties, Fluid Pressure and its measurement, hydrostatic forces on submerged bodies, buoyancy and floatation, **Fluid Kinematics and Dynamics:** Continuity equation, rotational and irrotational flow, circulation and vorticitty, velocity potential and stream function, flow net, Euler's equation, Bernoulli's equation and its applications, **Flow through pipes:** Darch-Weisbach equation, energy losses in pipelines, equivalent pipes, multiple pipe system, siphon, three reservoir problem, **Laminar and Turbulent flows:** Reynolds experiment, Laminar flow between parallel plates, Laminar flow in pipes, characteristics of turbulent flow, Turbulent flow in smooth and rough pipe, Concepts of boundary layer, Boundary layer thickness, momentum integral equation, boundary layer separation and its control, **Dimensional analysis and similitude:** Dimensional homogeneity, Buckingham's π theorem, geometric, kinematic and dynamic similarity, model studies, **Open Channel Flow:** Types of open channels, classification of flows, continuity equation, concept of specific energy, Critical depth, Chezy's and Mannings equation, roughness coefficients, equivalent roughness, Hydraulically efficient channel cross sections.

7. **Engineering Geology and Rock Mechanics:-**

Introduction: Dynamic Earth; Origin, Age, Interior, Materials of Earth; Silicate Structures and Symmetry Elements, Physical properties, Formation of Rocks; Igneous, Sedimentary and Metamorphic processes and structures, Characterisation; Weathering Processes, Geological work of Rivers, Glaciers, Wind and Sea/Oceans, Deposits and Landforms, Formation of Soils; Engineering Properties of Rocks, Rock as Construction material, Structural Features, Attitude of beds, True and apparent dips, Folds, Joints, Faults, Unconformities, Plate tectonics, Continental drift and sea floor spreading, Geological time scale, topographic maps, outcrops, Three point problems, Depth and thickness problems, **Hydrogeology:** Ground water, Zone of ground water, water table and perched water table, water bearing properties of rocks; occurrence of ground water, springs, selection of sites for well sinking and geophysical investigations (Electrical and Seismic methods), **Earthquake and landslides:** Classification, causes and effects of Earthquake and landslides, seismic curve, seismographs, seismograms, accelograms, seismic problems of India, seismic zones of India, remedial measures to prevent damage for engineering structures, case histories, **Geology of dams and reservoirs:** Types of dams, requirements of dam site, preliminary and detailed geological investigation for dam site, failures of dams and their causes, factors affecting seepage and leakage of the reservoir and the remedial measures, silting of reservoir, **Tunneling:** Purpose of tunnelling and geological problems connected with tunnelling, basic design and Principles of tunnels in rocks, Types and design of tunnel lining.

8. **Surveying & Quantity Surveying:-**

Basics of surveying: Introduction, concept of Geoids and reference spheroids, coordinate systems, plane and geodetic surveys, methods of location of a point, errors in measurements, surveying instruments, maps, scales and uses, topographic maps, map layout, **Distance measurements:** Direct and Indirect methods, Chain and tape measurements, Optical methods-tacheometers, sub tense bar, Electronic methods- EDMs, **Levelling:** Methods of height determination, levels and staves, booking and reduction of data, classification and permissible closing error, profile levelling and cross sectioning, errors, reciprocal levelling, Contour-characteristics, uses and methods of contouring, **Measurement of Directions:** Bearing and angles, compass surveying, magnetic bearings, declination, local attraction errors and adjustments, Theodolites-types, uses, methods of observation and booking of data, total station, **Traversing and Triangulation:** Compass and Theodolite traverses- balancing and adjustment of traverses, computation of coordinates, omitted measurements Triangulation-network, strength of figures, selection of stations, inter-visibility, satellite stations, measurements and computations, **Plane Tabling:** Accessories, orientations, and resection, methods, three point problem and solutions, errors in plane tabling, **Curves:** simple circular curves, compound and reverse curves, transition curves and vertical curves, **Earthwork:** area of a traverse, determining

area from plans, area of x-section, volume from X-section, corrections, mass haul diagram, **Modern Surveying methods:** Aerial photogrammetry, geometry of aerial photograph, stereoscopy, GPS principles, Satellite navigation system, GPS segment, Receivers, Static, Kinematic and Differential GPS, remote sensing/GIS techniques and application in mapping, **Estimate:** Principles of estimation, Units, Items of work, Different kinds of estimates, different methods of estimation, estimation of materials in single room building, Two roomed building with different sections of walls for foundation, floors and roofs, R.B. and R.C.C. works, plastering, white-washing, distempering, painting, doors and windows, and lump sum items, estimates of canals and roads, **Specification of works:** Necessity of specifications, types of specifications, general specifications, specification of bricks, cement, sand, water, lime, reinforcement; detailed specifications for earthwork, cement, concrete, brick work, floorings, D.P.C., R.C.C., cement plastering, white and colour washing, distempering, painting, **RateAnalysis:** Purpose, Preparation of rate analysis, procedure of rate analysis for items: earthwork, concrete works, R.C.C. works, reinforced brick work, plastering, painting, white-washing and distempering, **Valuation:** Gross income, net income, outgoings, scrap values, salvage value, obsolescence, annuity, sinking fund, depreciation, valuations of buildings, **Public Works Account:** Regular and work change establishment, earnest money, security money, retention money, muster roll, measurement book, cash book, examination and payment of bills, first and final bills, administrative sanction, technical sanction.

9. <u>Water Resource Engineering:-</u>

Introduction: Hydrological cycle, Water budget equation, Watershed, **Abstractions:** Precipitations-Types, Measurement, Computation of average rainfall over a basin, Evaporation, Transpiration, infiltration, Φ-index, weather systems, **Runoff:** Factors affecting, runoff computation, rainfall-runoff correlation, flow mass curve, flow duration curve, **Hydrographs:** Flood hydrograph, base flow separation, Unit and S-hydrograph from simple and complex storms, synthetic and instantaneous unit hydrograph, **Floods:** flood discharge estimation, flood control, reservoir and channel routing, **Groundwater Hydrology:** Darcy's Law- concept and applications, Well Hydraulics- Steady and unsteady state, **Open Channel Flow:** Types of open channels, classification of flows, continuity equation, concept of specific energy, critical depth, Chezy's and Mannings equation, roughness coefficients, equivalent roughness, Hydraulically efficient channel cross sections, **Gradually Varied Flow:** Equations of GVF, Slope Profiles, Computations of GVF Profiles, **Rapidly Varied Flow:** Hydraulic Jump- Concept and computations, Principles of energy dissipation, Jump as Energy dissipaters, tail water rating curve and jump height curves, **Irrigation:** water requirements of crops: Soil moisture and crop-water relations, Consumptive use of water, duty and delta, irrigation efficiencies, computation of channel and reservoir capacity based on crop water requirements, irrigation methods, irrigation scheduling, **Canals:** Canal classification, Design of stable channels, regime theory and design of unlined canals, Water logging: Causes, preventive and curative measures, **Water Resources Management:** Water resources availability and demand; Water use sectors- Domestic, Industries and Agriculture; Sustainable water resources development, Integrated Water Resources Management (IWRM).

10. <u>Soil Mechanics:-</u>

Soil Properties: Soil mechanics, rock mechanics, foundation engineering, soil formation, soil structure, soil map of India, Basic definitions phase diagram, water content, specific gravity, void ratio, porosity, unit weight, weight volume relationships, index properties of soil and their determination, classification of soils, degree of saturation, density index, **Permeability, Seepage:** Darcy's law and its validity, seepage velocity, discharge velocity, constant and variable head permea-meter, pumping in & out tests, permeability of stratified soils, factors affecting permeability, laplace's equation flow potential flow net and its properties, different methods of drawing flownets, seepage pressure, quick sand, exit gradient, piping, design of filter, principle of total and effective stresses, capillarity conditions in soil, effective and pore

pressures, **Stress Distribution:** Effective and pore pressures, Effective stress principle, Stress distribution in soil, assumption in elastic theories, **Compaction:** Mechanism of compaction, objective of compaction, measurements of compaction, factors affecting compaction, optimum moisture content, Standard Proctor test, Modified Proctor test, effect of moisture content and compactive effort on dry density, zero air void curve, compaction of cohesion less soils, filed compaction, filed control of compaction, **Consolidation:** Mechanism of consolidation, (e-log) curves, basic definitions, estimation of pre consolidation pressure, normally consolidation and over consolidation ratio, Terzaghi's theory of one dimensional consolidation, assumption, governing equation, standard solution, laboratory determination of consolidation properties of soil, magnitude and rate of consolidation, settlements, secondary consolidation, compression characteristics of clays and settlement analysis, **Shear strength:** Normal, shear and principal stresses, Columb's equation, Mohr's stress circle, Mohr-Columb failure criteria, laboratory determination of shear parameters of soil by direct shear tests, triaxial test, unconfined compression test, Vane shear test, Consolidated drained, consolidated undrained and unconsolidated undrained shear test, pore pressure parameters, Lambe's p-q diagram.

11. <u>Building Materials and Construction:-</u>

Basic Structural Building Materials: Principle Properties of Engineering materials: Physical & Mechanical, Clay product- Clay Brick and Tiles: Classification, tiles, Limes: Classification and applications, Cement: Composition, Types, Manufacturing of Ordinary Portland Cement, rate of hydration, special types, Fine and Coarse aggregate, Source, impurities, Classification, Characteristics, Timber: Classification, seasoning, defects, wood product and its applications, **Transformed Material:** Mortars: Classification, characteristics, functions of ingredient, Cement concrete and Special concrete: Types, Physical properties, **Service Material:** Ceramic products: Classification, refractories, glass, properties of ceramic materials, Ferrous and non-ferrous Metals and alloys: Properties, Uses, Paints, Distemper & Varnishing, Basic Constituents, Types, Composition, Defects, application, **Structural Components of building and building specification:** Foundation: Type, application, Masonry: Stone, brick and Confined, Types, Bonds, defects, Walls, Design Consideration, Constructional details, Types of load bearing and non-load bearing walls, Floor and Roofs, Type, Ground/ Upper; Flat/Slopped, Beam/Band-Plinth, sill, Lintel-Types and details, Stairs, Ramps- classification, application, Form work; Requirements, Load Applied, Scaffolding, **Non Structural Components of building and building specification:**Plastering, Pointing: Type, methods, defects, Doors and Windows, Ventilators: Locations, Sizes, types, Dampness and Water Proofing: Causes, Prevention methods, damp- proofing treatment, Materials used, **Building service:** Plumbing-Fitting, Fixture, System, Termite Proof; Materials used and Method of application, Fire protection, Fire safety requirement, Fire extinguishing equipment, Thermal Insulation: Basic definitions, Materials used, methods, Acoustics & Sound insulation: characteristics, sound insulation, Acoustical design, ventilation: functional requirement, systems.

12. <u>GIS and Remote Sensing:-</u>

Remote Sensing: Remote sensing system; Physics of remote sensing, EMR characteristics and interaction in atmosphere and with ground objects, spectral properties of water bodies, vegetation, soil etc., resolution, sensors and platforms, types of resolution, image processing, classification, geometric and radiometric distortions, geo-referencing, digital image processing, image enhancement, transformations and classification, visual interpretation techniques, applications of remote sensing for earth resource management, applications of optical and microwave remote sensing techniques in civil engineering, **Geographic Information System:** introduction to GIS, spatial data models, databases and database management systems, coordinate systems and georeferencing, GIS analysis functions, statistical modelling, digital elevation models and their applications, data visualization methods, exporting data modern trends in GIS, applications of GIS.

13. Earthquake Resistant Design of Structures:-

Introduction: Seismic design Philosophy- Earthquake ground motions, inelastic seismic response**, Theory of vibrations:** Conversion of Structures into equivalent mathematical model for vibration analysis, Vibration of single, two and multi storey building frames, **Earthquake resistant Reinforced concrete buildings:**Codal provisions for design against earthquake IS: 1893-2016, IS: 13920-2016, **Earthquake resistant Masonry buildings:** Behaviour of masonry during earthquakes, codal provisions for earthquake resistant masonry, IS: 4326-2013, IS: 3827-1993, IS: 13828-1993.

14. Bridge Engineering:-

Elements of bridge engineering: Definitions, components of bridge, classification, importance and Site Selection, water way, Site Selection, data drawing, design discharge linear water way, economical span, location of piers and abutments, vertical clearance above HFL scour depth, Traffic projection, investigation report choice of bridge type, selection of Bridge cross-section and longitudinal form, Characteristics of each type, Introduction to bridge codes, Design loads for Road and Railway bridges; General design consideration, **Culverts:** Design of R.C.C. slab culvert (Design of deck slab), Pipe culvert and Box culvert based on variety of IRC vehicle loading, **RC Slab and Tee Girder Bridges:** Design of solid deck slab, Longitudinal beam and Cross beam based on variety of IRC vehicle loading, **Bridge Piers, Abutments, Wing-wall and approaches:** Types and stability analysis of piers and abutments, Loads, abutments and wing wall design, **Bridge Foundations:** Types of Bridge foundations, Pile and well foundations, **Bridge Bearings and expansion joints:** Necessity of bearings, Types of bearings and expansion joints, Design of Elastomeric Bearings, Necessity and types of expansion joints.

15. Building Services:-

Planning of building services: Classification of Buildings base on Occupancy, Consideration in Building Design, Standard of Accommodation, **Plumbing:** Common sanitary fixtures, Layout of Sanitary Fixtures, Water Pipe Sizing in Buildings, Foul Water Drainage in Buildings, Buildings Services Detailing, **Lift and Escalator:** Classification (Types), Lift codes and Rules, Structural Provisions, Design Features of Escalator, **Acoustics and Ventilation:** Material properties, acoustical design of assembly halls and buildings, noise and its control, measuring equipment, Ventilation: Ventilation systems, health and comfort ventilation, natural ventilation and its measurement, Fire protection and equipment, **Illumination:** Laws and principles of illumination, artificial and day lighting, Energy conservation in buildings, Electrical Wiring: Requirements in domestic, office and commercial buildings, Electric light sources- brief description, characteristics, **Thermal Aspects of Building Services:** Thermal environment in building and its control, factors involved, heat transfer building fabric, thermal properties of building and insulation materials, air conditioning systems, types, design, installation, Solar passive building planning.

16. Geo-synthetics & Ground Improvement Techniques:-

Introduction: Geosynthetics, Types, Advantage and disadvantage, Basic characteristics, Raw material, Manufacturing processes, functions, Selection, Physical properties, Mechanical properties, Hydraulic properties, Endurance and degradation properties, Test and allowable properties, **Applications:** Retaining walls, Embankments, Shallow foundations, Roads, Unpaved roads, Paved roads, Railway tracks, filters and drains, Slopes, Erosion control, Stabilization, Containment facilities, Landfills, Ponds, Reservoir, Canals, Earth dams, Tunnels, Installation survivability requirements, **Analysis and design concepts:** Design methodologies, Retaining walls, Embankments, Shallow foundations, Roads, Unpaved Roads, Paved Roads, Railway tracks, Filters and drains, Slopes, Erosion control, stabilization, Containment facilities, Landfills, Ponds, reservoir, canals, Earth Dams, Tunnels, **Application guidelines:** General guidelines, care and consideration, Geosynthetic selection, Identification and inspection, Sampling and test methods, Protection before installation, Site preparation, Geosynthetic installation, Joints/seams,

Cutting of geosynthetics, Protection during construction and service life, Damage assessment and correction, Anchorage, Prestressing, Maintenance, Certification, Handling the refuse of geosynthetics, Specific guidelines related to Retaining walls, Embankments, Shallow foundations, Unpaved Roads, Paved roads, Railway tracks, Filters and drains, Slopes- erosion control, slopes- stabilization, Containment facilities and Tunnels, **Quality Field Performance Monitoring and Economic Analysis:** Concepts of quality and its evaluation, Field performance monitoring, Economic evaluation- Concepts of cost analysis, Experiences of cost analysis, Selected case studies, **Dewatering:** Need and objectives of Ground Improvement, Classification of Ground Modification Techniques, Suitability and feasibility, Emerging Trends in ground improvement, methods of dewatering-sumps and interceptor ditches- single, multi stage well points- vacuum well point- Horizontal wells- foundation drains- blanket drains- criteria for selection of fill material around drains- Electro-osmosis, **Grouting:** Chemical grouting, commonly used chemicals, grouting systems, grouting operations, applications, compaction grouting, application and limitation, plant for preparing grouting materials, jet grouting, jet grouting process, geometry and properties of treated soils and applications, **Compaction:** Principles of compaction, Engineering behaviour of compacted clays, field compaction, techniques static vibratory, impact, Earth moving machinery, compaction control, Application to granular soils, cohesive soils, depth of improvement, Environmental considerations, induced settlements, compaction using vibratory probes, vibro techniques, vibro equipment, vibro compaction and replacement process, vibro systems and liquefaction, soil improvement by thermal treatment, preloading techniques, surface compaction, introduction to bio technical stabilization, **Stabilization:** Introduction to soil improvement by adding materials, lime, flyash, cement and other chemicals and bitumen, sand column, stone column, sand drains, prefabricated drains, lime column, soil-lime column, stabilization of soft clay or slit with lime, bearing capacity of lime treated soils, settlements of lime treated soils, improvement in slope stability, control methods, **Expansive Soils:** Problems of expansive soils- tests for identification- methods of determination of swell pressure, Improvement of expansive soils- Foundation techniques in expansive soils- under reamed piles.

17. <u>Disaster Management:-</u>

Understanding Disasters: Understanding the concepts and definitions of Disasters, Hazard, Vulnerability, Risk, Capacity- Disaster and Development and disaster management Types, Trends, Causes, Consequences and Control of Disasters, Geological Disasters; Hydro-Meteorological Disasters, Biological Disasters and man-made Disasters Global Disaster Trends- Emerging Risks of Disasters- Climate change and Urban Disasters, **Disasters Management Cycle and Framework:** Disaster Management Cycle- Paradigm shift in Disaster Management Pre-Disaster- Risk Assessment and Analysis, Risk Mapping, Zonation and Microzonation, Prevention and mitigation of Disasters, Early warning system; Preparedness, Capacity Development, Awareness During Disaster- Evacuation- Disaster Communication- Search and Rescue- Emergency operation centre- Incident Command System- Relief and Rehabilitation- Post-disaster- Damage and Needs Assessment, Restoration of Critical Infrastructure- Early Recovery- Reconstruction and Redevelopment; IDNDR, Yokohama Strategy, Hyogo Framework of action, **Disaster Management in India:** Disaster Profile of India- Mega Disasters of India and Lessons Learnt Disaster Management Act 2005- Institutional and Financial Mechanism National Policy on Disaster Management, National Guidelines and Plans on Disaster Management, Role of Government (local, state and national), Non-Government and inter-Governmental Agencies, **Application of Science and Technology for Disaster Management:** Geo-informatics in Disaster Management (Rs, GIS, GPS and RS) Disaster Communication System (Early Warning and its Dissemination) Land use Planning and Development Regulations Disaster Safe Designs and Constructions Structural and Non Structural Mitigation of Disasters S&T Institutions for Disaster Management in India.

18. Air Pollution Control:-

Sources and effects of air pollutants: Classification of air pollutants- Particulates and gaseous pollutants- Sources of air pollution- Source inventory- Effects of air pollution on human beings, materials, vegetation, animals- global warming-ozone lay depletion, Sampling and Analysis- Basic Principles of Sampling- Source and ambient sampling- Analysis of pollutants- Principles , **Dispersion of air pollutants:** Elements of atmosphere- Meteorological factors- wind roses- Lapse rate- Atmospheric stability and turbulence- Plume rise- Dispersion of pollutants- Dispersion models- Applications, **Air Pollution Control:** Concepts of control- Principles and design of control measures- Particulates control by Gravitational, centrifugal, filtration, scrubbing, electrostatic precipitation- Selection criteria for equipment- gaseous pollutant control by adsorption, absorption, condensation, combustion- pollution control for specific major industries.

PART-II

1. RCC Design:-

Introduction: Type of loads and load combinations, Properties of concrete and reinforcing steel, design philosophies, limit state, ultimate load method, working stress method, **Design of Flexural members (Beam and Slab) by Limit state Method:** Design of Beams: Singly reinforced, doubly reinforced, rectangular, Flanged beams and lintels, Design of Slabs; One way, two way, flat slab, **Design of Columns by limit state method:** Design of short and long columns subjected to eccentric and axial loading, **Design of Stair Cases:** Types terms used, design of stairs spanning horizontally & longitudinally, Circular/ spiral doglegged, Open well stair, **Design of Footings:** Isolated and Combined footings.

2. Water Supply and Treatment:-

Introduction: Scope and importance of Environmental Engineering and management- Introduction to Environmental pollution- Impact on human health- Significant water quality parameters for Municipal water supplies, Standards and guidelines for water quality parameters, **Demand and Sources of Water:** Water Demand- population forecast- Water quality requirements- Sources and its yield for water requirements- Intake structures- water quality parameters and their significance in domestic use, **Water Treatment:** Design of treatment units such as aeration, sedimentation, coagulation and flocculation, filtration, Disinfection, water softening- Advanced water treatment methods, **Water Distribution Systems:** Pumps and pumping system- Pipes- Pipe appurtenances- Testing of water main- Distribution reservoirs- Distribution methods- Pipe network analysis- Planning of water supply project, **Plumbing and fittings for Water Supply:** House water connection, Design consideration for water piping system and storage of water in building, **Rural Water Supply and Treatment:** Water demand and treatment, techniques for rural area, water problems and remedial measures.

3. Foundation Engineering:-

Stability Analysis: Stability of finite and infinite slopes, Types of failure, different factors for safety, determination of factor of safety by method of slices, Swedish circle, friction circle, Bishop method, Morgenstern Price method, Taylor's stability number, location of critical circle, stability analysis of earth dam slopes for different conditions, design of filters and rock toe, **Earth Pressure:** Different types of earth pressure, States of plastic equilibrium, Rankine's theory and Coulomb's theory, influence of water table, surcharge, wall friction and deformation on earth pressure, application of Rankine's theory and Coulomb's theory to cohesionless and cohesive soils, Culmann's graphical method, stability considerations for retaining walls, effect of earthquakes, design of retaining walls, **Sheet Pile Walls:** Different types of sheet pile walls, fixed and free earth support, design principles of anchored bulkheads, arching in tunnels, open cut strutting and sheeting, **Foundations:** Different types of loads on foundations, types of shallow and deep foundations, footings, rafts, piles, wells, selection of foundation type, dewatering of foundations, types of exploration, methods of boring, soil samples and sampling,

Shallow Foundations: Bearing capacity, Terzaghi's theory, effect of foundation size, shape, ground water table, determination bearing capacity from building codes, plate load test, penetration test, static and dynamic cone tests, Housel's approach, bearing capacity of sands and clays, settlements analysis of foundation, permissible settlements, design principles, depth of foundation, principles of floating raft, foundations on non-uniform soils, **Pile Foundations:** Types of pile based on function, Materials and methods of construction, friction and end bearing piles, static formula, Engineering News and Hiley's formula, group action, block failure, settlement of pile group in sand and clays, pile load test, negative skin friction, under-reamed piles, **Well Foundations:** Elements, forces on well, Lateral stability analysis, problem in sinkingof wells and remedial measures.

4. **Highway Engineering and Transport Planning:-**

Road Development and Planning: Necessity of transportation planning, Classification of roads, Road patterns, Planning surveys, Highway planning and development in India, **Highway Location and Alignment:** Ideal alignment and factors controlling, Engineering survey for highway location, Drawing and reports, Highway projects, **Highway Geometric Design:** Highway cross-section elements, Sight distances, Design of horizontal alignment, Transition curves and vertical alignment, Design aspects of hill roads, **Traffic Engineering:** Traffic characteristics, Traffic Operation, Traffic studies and data collection, Design of intersections & rotaries, Signalling, Road markings and parking facilities, **Pavement Design:** Design factors, Pavement materials and their characteristic, Design of flexible pavement by CBR method, Group index and Burmister methods, Design of rigid pavements, **Construction of Roads:** Construction of water-bound macadam roads, Bituminous pavements, Cement concrete roads, Construction of joints in cement concrete pavement, **Highway Maintenance:** Pavement failure, maintenance techniques, Evaluation and strengthening of existing pavements.**Elements of Traffic Engineering:** Road user, vehicle and road way, Vehicle characteristics, Design speed, volume, Highway capacity and levels of service, PCU Concept and its limitations, Road user facilities- Parking facilities, Cycle tracks and cycleways, Pedestrian facilities, **Traffic Volume Studies:** Traffic volume studies, origin destination studies, speed studies, travel time and delay studies, Parking studies, Accident studies, **Traffic Regulation and control:** Signs and markings- Traffic System Management- Design of at-grade, intersections, Channelization, Design of rotaries, Traffic signals, **Urban Transportation Planning:** Trip generation, Trip distribution, Modal Split, Traffic assignment, **Public Transportation:** Role and design concept of various modes of public transportation within an urban area, **Application of probability and Statistics in Transportation Planning:** Common probabilistic and statistical distribution functions, Concept of Traffic flow modelling and simulation, **Introduction to ITS:** Benefits of ITS, ITS Data collection techniques- Detectors, Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), Geographic Information Systems (GIS), video data collection.

5. **Steel Structure:-**

Design of connections in steel structures: Bolted and welded connections, assumptions, Different types of joints, design of various types of bolted and welded connections subjected to direct loads and eccentric loads, **Design of tension members:** Selection of section, I.S. specifications, design of axially loaded tension members, design of members for axial tension and bending, end connections, design of lug angles and tension splices, **Design of compression members:** Theory of buckling, design of column, cross section (single and built up sections), design of angle struts, eccentrically loaded columns, column splices, lacings and battens, **Design of beams:** Lateral stability, design of single and built up beams, plated beams and curtailment of flange plates, **Design of column bases and column footings:** Slab base, gusseted base, and Grillage Foundation subjected to Axial & Eccentric loads, **Design of Roof Trusses:** Types of trusses, roofs and side coverage, types of loadings and load combinations, design of members and connections, **Design of Plate Girder and Gantry Girder:** Design of section, stiffeners, splices, design of built up Gantry Girder.

6. **Railways and Airports:-**

Planning of Railways: Significance of Road, Rail, Air and Water transports Coordination of all modes to achieve sustainability, Route alignment surveys, Soil suitability analysis, Railway stations and yards, passengers amenities, **Railway Design:** Elements of permanent way Rails, Sleepers, Ballast, rail fixtures and fastenings, Track Stress, coning of wheels, creep in rails, signalling and interlocking, Geometric design of railways, gradient, super elevation, Points and Crossings, **Airport Planning:** Air transport characteristics-airport classification- airportplanning: Objectives, components, layout characteristics, criteria for airport site selection and ICAO stipulations, Typical airport layouts, Parking and circulation area, Airport Zones, Passenger facilities and Services, **Airport Design:** Runway Design: Orientation, Wind Rose Diagram, Runway length, Geometric design of runways, Configuration and Pavement Design Principles, Elements of Taxiway Design, Runway and Taxiway Makings and lighting.

7. **Waste Water Treatment and Management:-**

Wastewater Generation, Collection & Conveyance: Wastewater Quantity- Classification of wastewater- Sewerage system for domestic wastewater and storm water- Collections, and appurtenances- Design and layout of sewerage systems- Maintenance of sewerage systems- Physical, Chemical & Biological characteristics and their significance, **Primary Treatment of Wastewater:** Objectives of Wastewater treatment- Treatment methods: Unit Operations and Processes Design criteria- Design of primary treatment system, **Secondary Treatment of Wastewater:** Concepts of Biological treatment and removal mechanism- Aerobic and Anaerobic Systems- Design of suspended and attached growth processes- introduction to extended aeration processes and waste stabilization pond- Design of anaerobic system**, House Drainage & Environmental Sanitation:** General Principles, House drainage system- traps and sanitary fitting- Low cost sanitation system, **Wastewater Disposal:** Alternative disposal methods- Self Purification of stream- Standards for disposal alternatives, Natural purification of polluted streams, **Sludge Handling:** Quantity and quality of sludge, Methods of sludge treatment: sludge digestion and drying beds- Disposal of sludges.

8. **Design of Hydraulic structures:-**

Reservoir Planning: Investigations, layout, selection of site for hydraulic structures, life of Reservoir, **Structures of Permeable foundations:** Bligh's creep theory, limitations, Khoslas's theory of independent variable, Khosla's corrections, Canal head Works, Design of Weir and Barrages, **Canal structures:** Design of canal falls, Regulators, Cross drainage works: Selection, design aspects of aqueducts, siphon aqueducts, supper passages, canal siphon and level crossings, **Earth Dams:** Types, causes of failure, soils suitability for earth dam construction, typical earth dam sections, estimation of seepage through and below the dam, seepage control, stability of slopes, **Gravity dams:** Design Criteria, forces acting on gravity dams, elementary profile, Forces on gravity dams, stability analysis, **Spillways and Energy dissipaters:** Purpose, different types, details of ogee, siphon, shaft, chute and side channel spillways, design aspects, Principles of energy dissipation, Energy dissipaters based on water curve and jump height curves.

9. **CPM and PERT:-**

Construction Management: Significance, Objectives and functions, resources for construction industry, stages in construction, Civil Engineering drawings, work breakdown structure, Pre-tender stage planning, contract stage planning, scheduling, bar charts, limitations of bar charts, milestone charts, preparation of material, equipment, labour, and finance schedule, **Construction Contracts & Specifications:** Types of contracts, contract document, specifications, important conditions of contract, arbitration, **Construction Organization:** Principles of organization, communication in organization, types of organization, temporary services, job layout, **Critical Path Method:** Network techniques, element of a network, rules for developing networks, development logics, numbering events, times computations, activity floats, network updating,

Resources profile, resources smoothing and resources levelling, **Cost-Time Analysis:** Cost versus time, direct cost, indirect cost, total project cost, optimum duration, contracting network for cost optimization, **Programme Evaluation and Review Technique:** Probability concept in network, optimistic time, Pessimistic time, most likely time, variance, standard deviation, slack, central limit theorem, probability of achieving completion time.

10. Harbor Dock and Tunnel Engineering:-

Planning of Harbor: Classification of harbours, major ports in India, administrative set up, harbour economics, Harbor components, ship characteristics, characteristics of good harbour, and principles of harbour planning, size of harbour, site selection criteria and layout of harbors, **Natural Phenomena:** Wind, waves tides and currents phenomena, their generation characteristics and effects on marine structures, silting, erosion and littoral drift, **Marine Structure:** General design aspects, breakwaters- functions, types general design principles, wharves, quays, jetties, piers, pier heads, dolphin, fenders, mooring accessories- functions, types, suitability, design and construction features, **Docks and Locks:** Tidal basin, wet docks-purpose, design consideration, operation of lock gates and passages, repair docks- graving docks, floating docks, marine railway, **Port Amenities:** Ferry, transfer bridges, floating landing stages, and transit sheds, and transit sheds, ware house , cold storage, aprons, cargo handling equipments, purpose and general description, **Navigation Aids:** Channel and entrance demarcation, buoys, beacons, light house electronic communication devices, **Harbor Maintenance:** Costal protection- purpose and devices, dredging-capital and maintenance dredging, purpose, methods dredgers- types, suitability, disposal of dredged material, **Tunneling:** Alignment, drainage, methods of construction, lighting and ventilation.

11. Solid Waste Management:-

Evolution of Solid Waste Management: Introduction: Solid waste- A consequence of life, Municipal Solid Waste: Generation, Rate Variation, Characteristics (Physical, Biological & Chemical); **Engineering Principles:** Management Options for Solid Waste, Waste Reduction at the Source, Collection Techniques, Materials and Resources Recovery/Recycling, **Waste Handling and Separation:** Transport of Municipal Solid Waste, Routing and Scheduling, Treatment, Transformations, **Disposal of Solid waste and Residue Matter:** DisposalTechniques (Composting, Vermi Composting, Incineration, Refuse Derived fuels, Landfilling), **Sources, Types and Properties of Hazardous waste:** Hazardous Solid Waste: Generation, RateVariation, Characteristics (Physical, Biological & Chemical), Hazardous Waste Management: **Hazardous waste management:** Exposure and risk assessment, environment legislation, characterization and site assessment, waste minimization, incineration, transportation, storage, landfill disposal.

12. Environmental Impact Assessment:-

Introduction: Environment and its components; Concept of Ecological imbalances, Elements of Environmental Analysis; Current screening process in India; Carrying capacity and sustainable development, evolution of Environmental Impact Assessment (EIA), A step by-step procedure for developing; EIA; Pubic construction; Post monitoring; Impact Case Studies of Industrial EIA and Water resources projects; Brief introduction about Environment legislation and Environment Audit, **Methodologies:** Criteria for the selection of EIA Methodology, EIA Methods, Predictive Models for impact assessment, **Prediction and Assessment of impacts on Soil and Ground Water Environment:** Soil and Ground water, Methodology for the Predictive and Assessment of Impact on soil and Ground water, **Prediction and Assessment of Impacts on Surface Water Environment:** Sources which create Impact concern for the Surface water Environment, Systematic Methods for Evaluation of Impact of Various Developmental Activities on Surface Water Environment, **Prediction and Assessment of Impacts on Biological Environment:** Methodology for the Assessment of impacts on Biological Environment, Systematic Approach for Evaluation Biological Impacts, **Prediction and Assessment of Impacts on Air Environment:** Sources of Air Pollution, Methods for Assessment of Air pollution impact,

Prediction and Assessment of Impacts on Noise Environment: Types of Noise, measurements, Effects, and Methods of Assessing Impact of Noise, **Prediction and Assessment of Impacts of Socio-Economic and Human Health Impacts:** Social Assessment, Conceptual Frame work for Socio- Economic Assessment, Assessment of Impacts of Project activities on Human Health, Methodology, Assessment of Impacts of Project Activities on Traffic and Transport Systems, **Application of Remote Sensing and GIS for EIA:** Concepts of Environmental Remote Sensing, GIS Concept and techniques, Application of Environmental Remote Sensing for EIA, Application of GIS for EIA, GIS Environmental Impact Assessment, Possible Approaches, Resource Implications, GIS in Screening, Scoping and Baselines Studies, Database for GIS.

13. <u>Groundwater Engineering:-</u>

Hydrogeological Parameters: Introduction- Water bearing Properties of Rock- Type of aquifer- Aquifer properties- permeability, specific yield, transmissivity and storage coefficient- Methods of Estimation- Ground water table fluctuation and its interpretations- Groundwater development and potential in India, **Well Hydraulics:** Objectives of Groundwater hydraulics- Darcy's Law- Groundwater equation- steady state flow- DupuitForchheimer Assumption- Unsteady state flow- Theis method- Jacob method- Slug test- Image well theory- Partial penetrations of wells, **Groundwater Management:** Need for management model- Database for groundwater management- groundwater balance study- Introduction to Mathematical model conjunctive use- Collector well and Infiltration gallery, **Groundwater Quality:** Ground water chemistry- Origin, movement and quality- water quality standards- Health and aesthetic aspects of water quality- Saline intrusion- Environmental concern and Regulatory requirements.

14. <u>Hydro Power Engineering:-</u>

Turbo Machinery: Governing Equations, Hydrodynamic forces of jets on vanes, Turbines, Classification, impulse and reaction turbines, characteristics curves, draft tubes, governing of turbines, specific speed, unit quantities concept, cavitations, Pumps: classification, work done, minimum starting speed, losses and efficiencies, specific speed, multistage pumps, Cavitation in pumps, **Hydro Power Development:** Sources of energy and their comparative study, investigations and studies for hydropower development, estimation of available water power, flow and power duration curves, firm power and secondary power, plant capacity, installed capacity, constraints in hydropower development operation and maintenance of hydropower plants, small hydropower development, Classification of hydro-power plants based on storage characteristics, operating head, load, capacity, Principle components of hydro-electric scheme, Storage and pondage, economic analysis of storage capacity, aspects of cost allocation for different purposes, reservoir operation using flow duration and flow mass curves, **Hydroelectric Plants:** Layout of hydropower plants, types of power houses, various components, investigations and studies, safety requirements, Storages zones of a reservoir, reservoir sedimentation, trap efficiency, life of a reservoir, principle of desilting, design of desilting basins, Alignment and location of various type of intakes, trashracks, design of intake structures, Conveyance channels and tunnels, water harmer, surge tanks, design of surge tanks, penstocks classification and layout, hydraulic design of penstocks, hydraulic valves and gates, tail race channels, **Economics of Hydro power installation:** Engineering feasibility, political consideration, economic feasibility, analysis of cost of hydro power, preparation of pre-feasibility report, detailed project report, cost and estimate report.

{Bachelor of Engineering (Environmental) level}

PART-I

1. **MATHEMATICS:-**

Infinite series: Tests for convergence of series (Comparison, Ratio, Root, Integral, Raabe's, logarithmic), Alternating series, Absolute convergence, Conditional convergence. **Differential & Integral Calculus of single variable:** Taylor's & MaClaurin's expansion, Radius of curvature, Tracing of some standardcurves, Applications of definite integral to Area, Arc length, Surface area and volume (in Cartesian, parametric and polar co-ordinates). **Calculus of several variables**: Partial differentiation, Euler's theorem, Total differential, Taylor's theorem, Maxima-Minima, Lagrange's methodof multipliers, Application in estimation of error and approximation.**Multiple Integrals**: Double integral (Cartesian and polar co-ordinates), Change of order of integration, Triple integrals (Cartesian, cylindrical and spherical co-ordinates), Beta and Gamma functions, Applications of multiple integration in area and volume. **Vector Differential Calculus**: Continuity and differentiability of vector functions, Scalar and Vector point function, Gradient, Directional Derivative, Divergence, Curl and their applications. **Vector Integral Calculus**: Line integral, Surface integral and Volume integral, Applications to work done by the force, Applications of Green's, Stoke's and Gauss divergence theorems. **Matrices**: Rank of a matrix, Inverse of a matrix using elementary transformations, Consistency of linear system of equations, Eigen- values and Eigenvectors of a matrix, Cayley Hamilton theorem, Diagonalization of matrix. **Ordinary differential equations:** Second & higher order linear differential equations with constant coefficients, General solution of homogenous and non - homogenous equations, Method of variation of parameters, Euler-Cauchy equation, Simultaneous linear equations, Applications to simple harmonic motion. **Special Functions**: Power series method, Frobenious method, Legendre equation, Legendre polynomials, Bessel equation, Bessel functions of first kind, Orthogonal property. **Laplace Transforms**: Basic properties, Laplace transform of derivatives and integrals, Inverse Laplace transform, Differentiation and Integration of Laplace transform, Convolution theorem, Unit step function, Periodic function, Applications of Laplace transform to initial and boundary value problems. **Fourier series** : Fourier series, Fourier Series of functions of arbitrary period, Even and odd functions, half range series, Complex form of Fourier Series, Numerical Harmonic analysis. **Fourier Transforms**: Fourier Transforms, Transforms of derivatives and integrals, Applications to boundary value problem in ordinary differential equations (simple cases only).

2. **PHYSICS:-**

RELATIVITY: Review of concepts of frames of reference and Galilean transformation equation, Michelson – Morley experiment and its implications, Einstein's special theory of relativity, Lorentz transformation equations, Law of addition of velocities, Mass variation with velocity, Concept of energy and momentum, Mass energy relation. **OSCILLATIONS & WAVES:** Damped and forced oscillations, Resonance (amplitude and power), Q – factor, Sharpness of resonance, Equations of longitudinal and transverse waves and their solutions, Impedance, Reflection and transmission of waves at a boundary, Impedance matching between two medium. **PHYSICAL OPTICS:** Interference by division of wave front and amplitude,

Multiple beam interference and Fabry-Perot interferometer, Fresnel diffraction through a straight edge, Zone plate, Fraunhoffer diffraction, single slit and N-slit / grating, Resolving power of telescope, prism and grating. Polarization by reflection and by transmission, Brewster's law, Double refraction, elliptically and circularly polarized light, Nicol prism, Quarter and half wave plates. **OPTICAL INSTRUMENTS:** Cardinal points of co-axial lens systems, spherical and chromatic aberrations and their removal, Huygens and Ramsden's eyepiece. **Lasers:** Coherence and coherent properties of laser beams, Brief working principle of lasers, Spontaneous and stimulated Emission, Einstein's co-efficient, Ruby laser, He-Ne laser. **Optical Fiber:** Classification of optical fibers, Refractive index profile, Corecl adding refractive index difference, Numerical aperture of optical fiber, Pulse dispersion in optical fiber (ray theory). **Quantum Physics :** Failure of classical physics ,Compton effect ,Pair production, de-broglie relation, wave function, Probability density, Schrodinger wave equation, operators, expectation values and eigen- value equation, particle in a box, simple harmonic oscillator problem, concept of degeneracy. **Classical Statistics:** Microscopic-macroscopic systems, concept of phase space, basic postulates of statistical mechanics, Maxwell— Boltzmann distribution law. **Quantum Statistics:** Fermi—Dirac and Bose–Einstein Distribution, Fermi-Dirac probability function, Fermi energy level. **Nuclear Physics:** Nuclear properties, constituent of the nucleus, binding energy, stable nuclei, radioactive decay law (alpha and beta spectrum), Q-value of nuclear reaction , nuclear models: liquid drop and shell model, nuclear fission and fusion, elementary ideas of nuclear reactors. **Electrodynamics:** Maxwell's equations, concept of displacement current, Derivation of wave equation for plane electromagnetic wave, Poynting vector. Poynting theorem, Energy density, wave equation in dielectric & conducting media, **Semiconductor Physics:** Concept of intrinsic and extrinsic semiconductors, Fermi level, characteristics of PN Junction, static anddynamic resistance, zenar diode and LED, diode as a rectifier, transistor(PNP and NPN) characteristics, current and voltage gain.

3. CHEMISTRY:-

Conventional Analysis: Volumetric Analysis, Types of Titrations, Theory of Indicators. **Spectral Methods of Analysis**: UV-visible, IR, NMR & MS: Principles and Applications. **Thermal Methods of Analysis**: Thermo-gravimetry, Differential thermal analysis and Differential Scanning Calorimetry: Principles and Applications. **Polymers & Plastics**: Functionality and Degree of Polymerization, Mechanism of Polymerization, Molecular Weights of Polymers,Methods of polymerization, Functional Polymers, Industrial applicationsof Polymers. **Electrochemistry**: Electrochemical cells, components, characteristics of batteries, Primary and Secondary battery systems, Zinc-Carbon cells, Lead storage and lithium batteries, Fuel Cells, Electro-deposition, Electrical and chemical requirements, Electroplating bath and linings, Agitation, Circulation and filtration equipment, **Phase Equilibrium**: Definitions of Phase, component and degree of freedom, Gibb's phase rule. One component systems: Water and sulphur. Two component systems: Pb-Ag and Cu-Ni. **Green Chemistry**: Principles of Green Chemistry, Examples of Green Methods of Synthesis, Reagents and Reactions, Evaluation of feed stocks, Future trends in Green Chemistry.

4. BASIC MECHANICAL ENGINEERING:-

Introduction: Introduction to Thermodynamics, Concepts of systems, control volume, state, properties, equilibrium, quasi-static process, reversible & irreversible process, cyclic process.

Zeroth Law and Temperature, Ideal Gas. Heat and Work. First Law of Thermodynamics for closed & open systems. Non Flow Energy Equation. Steady State, Steady Flow Energy Equation. Second Law of Thermodynamics-Kelvin and Plank's Statements, Clausius inequality, Definition of Heat Engines, Heat pumps, Refrigerators. Concept of Energy and availability. Carnot Cycle; Carnot efficiency, Otto, Diesel, Dual cycle and their efficiencies. Principles of power production, basic introduction about thermal powerplant, hydroelectric power plant and nuclear power plant. Properties & Classification of Fluids, Ideal & real fluids, Newton's law of viscosity, Pressure at a point, Pascal's law, Pressure variation in a static fluid, General description of fluid motion, stream lines, continuityequation, Bernoulli's equation, Steady and unsteady flow. Introduction to engineering materials for mechanical construction. Composition, mechanical and fabricating characteristics and applications of various types of cast irons, plain carbon and alloy steels,copper, aluminum and their alloys like duralumin, brasses and bronzes cutting tool materials, super alloys thermoplastics, thermosets and composite materials. Introduction to Manufacturing processes for various machine elements. Introduction to Casting & Welding processes. Sheet metal and its operations. Introduction to machining processes – turning, milling,shaping, drilling and boring operations. Fabrication of large and small assembles – examples nuts and bolts, turbine rotors etc. Introduction to quality measurement for manufacturing processes; standards of measurements, line standards, end standards, precision measuring instruments and gauges: vernier calliper, height gauges, micrometer, comparators, dial indicator, and limit gauges.

5. <u>BASIC ELECTRICAL ENGINEERING:-</u>

Introduction: Role and importance of circuits in Engineering, concept of fields, charge, current, voltage, energy and their interrelationships. V- Icharacteristics of ideal voltage and ideal current sources, various typesof controlled sources, passive circuit components, V-I characteristics and ratings of different types of R, L, C elements. DC Network: Series and parallel circuits, power and energy, Kirchhoff's Laws, delta-star transformation, superposition theorem, Thevenin's theorem, Norton's theorem, maximum power transfer theorem, Tellgen's theorem. **Single Phase AC Circuits:** Single phase emf generation, average and effective values of sinusoids, complex representation of impedance, series and parallel circuits, concept of phasor, phasor diagram, power factor, complex power, real power, reactive power and apparent power,resonance in seriesand parallel circuits, Q-factor, bandwidth and theirrelationship, half power points. **Three-Phase AC Circuits:** Three phase emf generation, delta and star connection, line and phase quantities, solution of three phase circuits: balanced supply and balanced load, phasor diagram, three phase power measurement by two wattmeter method. **Magnetic Circuits and Transformers:** Amperes circuital law, B-H curve, concept of reluctance, flux and mmf, analogies between electrical and magnetic quantities, solution of magnetic circuits, hysteresis and eddy current losses, mutual inductance and dot convention, single phase transformer – construction and principle of working, auto transformer and their applications. **Measuring Instruments:** Analog indicating instruments, PMMC ammeters and voltmeters, damping in indicating instruments, shunt and multipliers, moving iron ammeter and voltmeters, dynamometer type instruments, multimeters, AC watt-hour meters. digital voltmeters,ammeters and watt meters.

6. ENGINEERING GRAPHICS:-

General: Importance, Significance and scope of engineering drawing Lettering, Dimensioning, Scales, Sense of Proportioning, Different types of Projections, B.I.S. Specification, line symbols, rules of printing. **Projections of Points and Lines:** Introduction of planes of projection, Reference and auxiliary planes, projections of points and lines in different quadrants, traces, inclinations, and true lengths of the lines, projections on auxiliary planes, shortest distance, intersecting and non-intersecting lines. **Planes Other than the Reference Planes:** Introduction of other planes(perpendicular and oblique), their traces, inclinations etc., projections of points lines in the planes, conversion of oblique plane into auxiliary plane and solution of related problems. **Projections of Plane Figures:** Different cases of plane figure (of different shapes) making different angles with one or both reference planes and lines lying in the plane figures making different given angles(with one or both reference planes). Obtaining true shape of the planefigureby projection. **Projection of Solids:** Simple cases when solid is placed in different positions, Axis, faces and lines lying in the faces of the solid making given angles. **Isometric andOrthographic Views:** First and Third angle of system of projection, sketching of Orthographic views from pictorial views and vice –versa, Sectional views. Principles of dimensioning. Development of lateral surfaces of simple solids. Introduction to available drafting softwares likeAutoCAD.

7. INTRODUCTION TO ENVIRONMENTAL SCIENCE:-

Introduction to Environment: Definition, Scope, and importance of environmental studies; need for public awareness; Segments of environment- lithosphere, hydrosphere, atmosphere, and biosphere; Environmental degradation; Role of individual in environmental conservation; sustainable lifestyle, **Natural Resources:** Forest Resources : Deforestation, mining, dams and their effects on forest and tribal people; Water resources: over-utilization, floods, drought, conflicts over water, dams-benefits and problems; Mineral resources: Use and exploitation, environmental effects; Food resources: World food problems, changes caused by modern agriculture, fertilizer-pesticide problems, water logging, salinity**;** Energy resources : Growing energy needs, renewable and non renewable energy sources; Land resources : Land as a resource,land degradation, man induced landslides, soil erosion and desertification **Ecosystems and Biodiversity:** Concept of an ecosystem, Structure and function, Energy flow, Ecological succession, ecological pyramids; Types, characteristic features, structure and function of the Forest, Grassland, Desert, and Aquatic ecosystems**,** Concept of Biodiversity, definition and types, Bio-geographical classification of India; Value of biodiversity; Biodiversity at global, national and local levels; India as a mega-diversity nation; Hot-sports of biodiversity; Threats to biodiversity, Endangered and endemic species of India, Conservation of biodiversity. **Environmental Pollution:** Definition, Cause, effects and control measures of: Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, Nuclear hazards Solid waste Management: Causes, effects and control measures of urban and industrial wastes, Role of an individual in prevention of pollution, Pollution case studies, Disaster management: floods, earthquake, cyclone and landslides **Social Issues and Environment:** Sustainable development, Urban problems related to energy, Water conservation, rain water harvesting, watershed management, Resettlement and rehabilitation of people; its problems and concerns. Environmental ethics: Issues and possible solutions. Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Wasteland reclamation, Consumerism and waste products, Environment Laws and Acts, Issues involved in enforcement

of environmental legislation, Public awareness. Population growth, variation among nations, Family Welfare Programme.

8. PROGRAMING FUNDAMENTALS:-

Introduction: Concepts of algorithm, flow chart, Introduction to different Programming Languages like C, C++, Java etc. Elementary Programming in C: Data types, assignment statements, Arithmetic, unary, logical, bit-wise, assignment and conditional operators, conditional statements and input/output statements. Iterative programs using loops- While, do-while, for statements, nestedloops, if else, switch, break, Continue, and goto statements, comma operators, Concept of subprograms, Array representation, Operations on array elements, using arrays, multidimensional arrays, Structures & Unions: Declaration and usage of structures and Unions, Defining and operations on strings. Pointers: Pointer and address arithmetic, pointer operations and declarations, using pointers as function argument, File: Declaration of files, different types of files. File input/ output and usage-, File operation: creation, copy, delete, update, text file, binary file.. Concept of macros and pre-processor commands in C, Storage types: Automatic, external, register and static variables, Sorting and searching algorithms: selection sort, bubble sort, insertion sort, merge sort, quick sort and binary search. Introduction to Object Oriented Programming: OOPS concepts: class, encapsulation, inheritance, polymorphism, overloading etc., C++ introduction, Concept of class, methods, constructors, destructors, inheritance.

9. BUILDING MATERIAL & CONSTRUCTION:-

Building Materials: Stone, Lime, Glass, Plastics, Steel, FRP, Ceramics, Aluminum, Fly Ash, Basic Admixtures, Timber, Plywood, Bricks and Aggregates: Classification, properties and selection criteria, IS specification, **Cement:** Types, Composition, Properties, Uses and specifications. Tests on cement-normal consistency, initial setting, final setting, tensile and compressive strengths, unsoundness, fineness, heart of hydration. Aggregates: Classification, properties, porosity and absorption, bulking of sand, sieve analysis; grading curves, fineness modulus, impurities and tests on aggregates. Lime and Cement Mortars **Concrete:** Properties, workability-Slump Test, Compaction-factor test and Vee-Bee consistometer test; bleeding, shrinkage and creep, mixingand placing of concrete, compressive and tensile strengths, effects ofwater-cement ratio, compaction, age, curing temperature on strength of concrete, Modules of elasticity. Poisson's ratio, Design of concrete mixes: Proportioning of aggregates, IS, ACI and other methods of mix design, **Building Construction:** Building byelaws, Loads on buildings. Types of foundations and selection criteria. Brick masonry, stone masonry, bonds. Types of walls, partition and cavity walls, design criteria. Prefabricated construction. Plastering and pointing. Dampness in buildings, its causes and effects. Damp proofing materials and techniques. **Floors Construction:** Construction details and selection criteria. Typesof roofs and roof covering, treatment for water proofing. Doors and windows: sizes and locations, materials. Stair and staircases: types, materials, and proportions. Lifts and escalators. White washing, colour washing, painting, distempering. Shuttering, scaffolding and centering. Expansion and construction joints. Acoustics & sound and fire proof construction, I.S. specifications.

10. STRENGTH OF MATERIALS:-

Stress and Strain: Introduction, Mechanical properties, simple stress and stains, elastic constants, principal stress. Mohrs' circle, simple bending and shear of the beam. **Bending**

Moment and Shear Force Diagrams: Introduction, Shear force and bending moment diagrams of cantilever beams, simplysupported beam, over hanging beams of different types of loadings. **Deflection:** Introduction, Deflection due to bending, moment curvature relation, Double integration method, Macaulay's method, moment area method, and conjugate beam method. **Columns and Struts:** Introduction, types of columns, Modes of failure of columns, Effective length, slenderness ratio, Eulers Theory, Rankines's theory. Torsion of Shaft: Introduction, Torsion of shafts: Introduction, Torsion of circular shafts,Assumptions, Resisting torque, Power transmitted, Design of shafts

11. ENGINEERING & ENVIRONMENTAL SURVEYING:-

Introduction to Surveying: Introduction: Object & scope of surveying, classification of Surveying, principles of surveying, surveying instructions, Basic Surveying Techniques: Chain Surveying ; Instruments of chain surveying, corrections to measured lengths, measurement of offsets, limiting length of offsets, field work of chain surveying, booking of field notes, conventional symbols, obstacles in chain surveying, errors in chainsurveying & their corrections, Compass surveying: instructions in compass surveying, system of recording the bearing, determination of meridian compasses, traversing & graphical method of adjustment. **Plain table Surveying and Leveling:** Plane table Surveying: Plane table and its accessories, methods of plane tabling, two point problem, three point problems by different methods, Leveling: Introduction, types of leveling, leveling instruments, operations and adjustments of levels, ordinary leveling, errors of leveling, effect of earth's curvature and atmospheric refraction in leveling , precise leveling, modern leveling instruments, contouring: characteristics and uses of contour, modern methods of depicting relief on map. **Areas and Volume:** Areas , Volume and Earthquake Computations : Different methods of determination of areas from plan, areas of irregular boundaries, areas of field notes by latitudes and departure methods, instrumental methods of determining areas, areas of cross section, determination of earthquake volumes. **Theodolite Traversing:** Theodolite Traversing : Transit theodolites, operation and adjustment oftheodolites, horizontal angle by the method ofrepetition and reiteration, permanent adjustments oftheodolite, theodolite traversing, traverse computations, sources of errors, check in a traverse, closing error and its adjustments, omitted measurements. **Tacheometric Surveying:** Tacheometric surveying : principle of stadia method, instrument constants, Anallatic lens, Distance and elevation of stations, sub tense method, tangential method, errors, sub tense bar andits use.

12. ENVIRONMENTAL CHEMISTRY & MICROBIOLOGY:-

Aquatic chemistry: Chemical structure of water molecule, unusual properties of water, solubility of solids and gases in water, Carbonate cycle, pH of water, Chemical Equilibrium, Redox reactions. Application ofprinciples of chemistry for solving environmental engineering problems Water Pollution: Chemistry of pollution due to nutrients (CNP), Oxygen demanding wastes,salts, detergents, heavy metals, pesticides, hydrocarbons, PCBs, radioactive compounds. Atmospheric Chemistry: Composition of atmospheric layers, sources of air pollution, major pollutants of air, chemistry of photochemical smog formation, acid rain, ozone depletion; green house effect and global warming. Environmental Microbiology: Microbial taxonomy, Classification of morphological aspects of bacteria,algae, fungi, protozoa, and other aquatic micro flora; microbial growth and dynamics; pure and mixed cultures; Aerobic and Anaerobic metabolism; microbial transformation of organic matter (CNPS), acclimatization of waste; microbial inhibition mechanisms. **Role of Microbes in Environment:** Role of micro-organisms

in wastewater treatment, and air pollutioncontrol (bio-scrubbers); microbial degradation of ligno-cellulosic material,pesticides, hydrocarbons; microbial precipitation of heavy metals.

13. ENIGNEERING ANALYSIS & DESIGN:-

Design of Beam: Reinforced Cement Concrete, concrete making materials, workability of the concrete, Types of steel reinforcement, types of concrete mixes, characteristics strength of steel and concrete, design principles, Limit state of collapse in flexure, shear and bond. Singly and doubly reinforced beam rectangular and T- Beam. Design of Column: Introduction, classification of columns. Effective length of column, reinforcement in column, design of axially loaded short column, IS 456: 2000 specification of the columns. One Way and Two Way Slab :Introduction, one way and two way slab,load distribution in a slab, IS 456: 2000 recommendations of the slab, design of one way and two way slabs Foundations: Introductions, classifications of Foundations, analysis of isolated footings, design steps of isolated rectangular footings, Design of strip footings, design of combined footings Steel Structure :Introduction, Steel elements, Riveted and Weldedjoints, Simple tension and compression member.

14. STRUCTURAL ANALYSIS:-

Classification of Structures, Stress Resultants, Degree of Freedom pernode, Static and Kinematic degrees of indeterminacy. Work and Energy.Strain energy of deformable systems, Betti's theorem of reciprocal workand Maxwell's theorem. Principle of virtual work and complementary virtual work, Principle of total minimum stationary potential energy, Stable and unstable equilibrium, Castigliano's Theorem I and II. Analysis of determinate beams and plane frames. BM, SF and Axial thrust diagrams, Rolling loads, Influence lines diagrams Reaction, SF, BM, for detrminate beams. Floor beams. ILD for Slope and Deflectionsin simple beams. Classification of pin jointed determinate trusses. Analysis of plane, complex, compound and simple space trusses. Method of tension coefficient, graphical method of substitution. Maxwell's diagram to analyse simple trusses. Deflection due to bending: The moment curvature relation, Macaulay'smethod, Moment area and Conjugate beam method, Deflection ofdeterminate plane frames using strain energy and unit load method, Elastic curve sketch). Analysis of arches: Linear arch, Eddy's theorem, three hinged parabolic arch, Spandrel braced arch. Influence line diagrams for Horizontal thrust, BM RSF,NT. Stability of Columns: Study of ideal rigid columns, two bar and three bar systems. Euler's formula for long columns, Columns with eccentric axial loads, Rankine's formula.

15. GEOTECHNICAL ENGINEERING:-

Phase Diagram and Functional Relationships, Index properties and their determination, Soil classification systems, Soil Water, Effective and Neutral Stresses, Permeability and its laboratory determination, Seepage Analysis and Flow Nets, Design principles of Filters. Stress Distribution in Soil Mass due to surface loading. One dimensional consolidation, Terzaghi's theory Consolidation test and analysis, Consolidation settlement, Compaction, Laboratory test, Field compaction and control. Shear Strength of Soil: Theory and Laboratory tests, cohesive and Non- cohesive soils. Stability of slopes: analysis of finite and infiniteslopes. Theories of Earth Pressure including graphical methods, Bearing capacity of Shallow Foundations, Pile Foundations including pile groups and well foundations, and deep foundations.

16. WATER ENGINEERING: DESIGN & APPLICATION:-

Water supply engineering : water demand, design period, population forecasting, source of water, hydrological concepts, ground water and its development, conveyance of water, pipe materials, corrosion, laying of pipes, pipe appurtenances , pumps for water supply, distribution system, planning of water supply projects. Characteristics of Water: Physical, Chemical and Microbiological quality parameters. Drinking water quality criteria and standards. Coagulation, common coagulants and coagulant aids and their reactions. Mixing and flocculation basin design. Sedimentation, designprinciples, discrete and flocculant suspensions, sedimentation tank details. Filtration, gravity and pressure filters, single and multimedia filters. Water softening by chemical precipitation and ion exchange. Aeration of water to remove iron and manganese and taste and odour. Disinfection, disinfectants, chlorination of water supplies. Miscellaneous methods ofwatertreatment O & M of Water treatment plants.

Part-II

1. ENGINEERING GEOLOGY, GIS & REMOTE SENSING:-

Introduction to Geology: Introduction: Definition, scope and importance of geology, branches of geology, origin, age and interior of earth, earth movements: continental drift and plate tectonics. Minerals and Rocks: Minerals: Definition, Physical and optical properties, sources, Groups of rock & ore forming minerals. Study of rocks: igneous, sedimentary, and metamorphic. Geological Agencies. Weathering, erosion by running waters, glaciers, wind, and oceans and their engineering importance. Structural Geology and Geo Chemistry: Structural Geology: Dip, strike, folds, faults & joints and their engineering aspects. Geo Chemistry: Sources of salinity in groundwater, Effect of rocks and minerals on the quality of ground water GIS : Introduction and Definition of GIS, Components of GIS, GIS Data Types, Data Representation, Geo- referencing of GIS Data, Spatial Data Models, Raster Geo processing, Vector Geo-processing, GIS Databaseand Database Management System, Spatial Data Analysis, GIS Software Packages,GIS Applications Remote Sensing: Introduction to Remote Sensing, Remote Sensing System, Multi-Concept of Remote Sensing, Electromagnetic Radiation, Remote Sensors, Data Reception, Transmission and Processing, Digital Data Products, Image Interpretation, Digital Image Processing, Application of Remote Sensing.

2. FLUID MECHANICS & HYDRAULIC MECHANICS:-

Introduction: Properties of fluids, types of fluids and continuum principle. Fluid Statics: Basic definition, hydro statics law, Pascal's law, manometers, hydro statics forces on submerged surfaces, buoyancy Kinematics of flow: Types of flow, streamline, pathline, principleof conservation of mass, velocity, acceleration, velocity potential and stream function, vorticity and circulation. Fluid dynamics: Euler's equation, Bernoulli's equation, and its application, Pitot tube, venturimeter, Orifices and mouth pieces. Laminar and turbulent flow in pipe: Laminar flow through pipes, velocity distribution, turbulent flow, Reynolds equation, prandtl's mixing length theory, velocity distribution in pipe flow and plate flow, Darcy's weisbach equation, friction factor, water hammer. Dimensional analysis and models: Dimensional homogeneity, Rankines and Buckingham's pie theorem, dimensionless numbers, Types of models and model analysis. Boundary layer theory: Concept of boundary layer, laminar and turbulent boundary layers, boundary layer thickness, laminar sub- layer,

hydrodynamically smooth and rough boundaries, cavitations. Hydraulic Machines: Introduction, Dynamics forces on curved and bends, Elements of hydroelectric power plants, head and efficiencies of hydraulic turbines, classification of turbines, Pelton wheel turbine, working proportions of Pelton wheel, DESIGN OF Pelton wheel runner, study and design Francis turbine, Draft tube theory, Kaplan turbine, working proportions of Kaplan turbine, Efficiency, specific speed and unit quantities, centrifugal and reciprocating pumps.

3. **WASTE WATER ENGINEERING: DESIGN & APPLICATIONS:-**

Types of wastewater & their characteristics, Design of various primary units in a Sewage Treatment Plant, Coarse screens, Fine screens, Oil & Grease Trap, Grit Chamber, types of settling, design of primary and secondary clarifier, Design of secondary treatment units, Aerobic & Anaerobic treatment, activated sludge process, Trickling filter, Oxidation ditch, oxidation pond. Design of Imhoff Tank, Septic Tank, RBC etc. Upflow Anaerobic Sludge Blanketreactor, Design of sludge digestor, sludge drying bed. Application of the concepts of nonlinear optimization to waste water treatment design. Sewerage, types of sewerage, Design of sewer, Design of sewer networks & optimization, pumping of sewage.

4. **INSTRUMENTATION TECHNIQUES FOR ENVIRONMENTAL MONITORING:-**

Fundamentals: The Significance and Application of Measurement. Functional Elements of Generalized Measuring System. Classification of Measuring Instruments, Introduction of Microprocessors and advantages of Microprocessor based instrumentation. Management of Data in quantitative analysis: Accuracy, precision, types of errors, Minimization of error, statistical analysis and curve fittings. Standards of Measurement and its classification. Calibration of instruments and its importance. Transducers, measurement of non electrical quantities like pressure, temperature, flow and level etc. Spectro-analytical Method: Colorimetry, Spectrophotometer, Flurometry, Nephlometry, Turbidimetry, Flame Photometry, Atomic, absorption andemission Spectrophotometer. Chromatography Method: Classification, Principal and application of Chromatography –Gas chromatography, GC-MS, HPLC, Ion Chromatography, Paper chromatography and thin layer Chromatography Electro Analytical Method: Conductometry Potentiometry, Coulometry and Polarography.Continuous Monitoring instruments and their principals: NDIR for CO, Chemiluminescence analysis for NO_X and fluorescence analysis for SO_2.

5. **SOLID WASTE MANAGEMENT:-**

Sources, Composition & Properties of Municipal solid waste. Handling & Separation of solid waste, Municipal Waste (Management & Handling Rules, 2000), Integrated solid waste management (SWM) System, Hierarchical approach for SWM. Solid Waste Collection & Transportation: Types of collection systems (Hauled- container system & Stationary container system), Collection routes & their Layouts, Solid waste generation and collection rates; Waste handling and separation, solid wastes collection methods, separation, processing, Storage and processing at source, and transportation of solid wastes, optimization of transfer routs, design of transfer stations, Methods of Disposal of Municipal Solid Waste, Transformation and recycling of waste materials; Composting: Theory of composting, Manual and mechanized composting, Design of composting plan, Recovery of bioenergy from organic waste. Landfills: Classification, Types & methods, Site selection, Site preparation, Composition, Characteristics, Generation, & Control of Landfill gases; Composition, Formation, Movement & control of

leachate in landfills; landfill design. Reclamation of closed landfill sites, Long-term post closure plan, Groundwater monitoring during & after closure, Thermal Conversion Technologies: Incineration, Pyrolysis & Gasification Systems. Types & design of Incinerators.

6. AIR POLLUTION & CONTROL:-

Sources and classification of Air Pollution, Primary and secondary pollutants, Effects of Air Pollution on Human health, plants, Animals and Property. Sampling and measurement of ambient air quality, stack monitoring. Meteorology- Concept of Atmosphere, wind movements, Windrose Diagram and Measurement of Meteorological Variables. Atmospheric lapse rates, Adiabatic lapse rate and their consequences, Plume behavior. Plume rise-equation, estimation of stack height. Pollution control Method of a Particulate matter: Types of Particulate control methods-Settling chambers, cyclone separators, scrubbers, filters and Electrostatic precipitators-Mechanism, Their design and application. Gaseous Pollution control method and Automobile Pollution: Types of gaseous Pollution Control method- absorption, adsorption and combustion process. Automobile pollution- Sources of pollution, composition of auto exhaust & control method. Air Pollution Legislation and Global Problem: Ambient Air Quality Standard andEmission standard. Air Pollution, legislation and regulation in India. Air Pollution Indices. Global problem of air pollution and its remedial measure. Air Pollution from major Industrial Operations- Case study.

7. HYDROLOGY & GROUND WATER ENGINEERING:-

Precipitation: Hydrologic cycle, World water balance, India's water balance, Types and forms of precipitation, Measurement of precipitation, Types of rain gauges, Adequacy of rain gauges, Adjustment and filling in of missing dada, Average rainfall over an area, Basic statistics and frequency analysis. Evaporation: Evaporation and its measurements, Estimation of evaporation. Formulae of Penman, Thornthwaite and Blaney-Criddle method. Evaporation control. Infiltration: Factors affecting infiltration, Infiltrometers, Infiltration indices. Run Off: Surface run off, factors affecting run off, Hydrographs, flow rating curves and flow duration curves. Mass curve. Rainfall run-off relationship. Stream gauging, measurement of stage and velocity, Unit Hydrograph: Unit hydrograph. Derivation of unit hydrograph. Synthetic UH, IUH.Floods: Flood flow formulae, Frequency analysis using external type and log Pearson type III distribution, flood routing through reservoirs, Ground Water: Elements of Ground Water modeling: Darcy's law, types of aquifers, and their properties, steady and unsteady flow in wells, ground water quality, sources of pollution, remedial and preventive measures, ground water budgeting and recharging of ground water.

8. PROJECT MANAGEMENT:-

Importance of estimation, different types of estimates, specification: general and detailed. Methods of estimation, Estimates of RC works, Estimates of building. Analysis of rates, prime cost, work charge establishment, quantity of materials per unit of work for major civil engineering items, Resource planning through analysis of rates, market rates, PWD schedule of rates and cost indices for building material and labour. Introduction to valuation. Project cycle, organization, planning, scheduling, monitoring, updating and management system in construction Bar chart, Milestone chart, Work down structure and preparation of networks. Application of network, Techniques like PERT, GERT, CPM, AON and AOA techniques.

Project monitoring; cost planning, resources allocation through network techniques. Time value of money, present economy studies, Equivalent concept, financing of projects, economic comparison, present worth method, equivalent annual cost method, discounted cash flow method, depreciation and break even cost analysis. Quality Control, Productivity, Operation Cost. Legal aspects of contracts, their relative advantages and disadvantages, Different types of contracts, their relative advantages and disadvantages, Elements of tender preparation, process of tendering, pre-qualification of contracts, Evaluation of tender preparation, process of tendering, Evaluation of tender, contract negotiation and award of work, Land acquisition, Labour safety and welfare.

9. VIBRATION ANALYSIS & CONTROL OF NOISE POLLUTION:-

Basics of Sound, Sound propagation in air, Indoor sound propagation, Fundamentals of Noise, Difference between sound and noise, Sound Power, Sound Intensity, Sound Pressure Levels, Measurement of noise,Sources of noise, Outdoor and Indoor Noise Propagations, Ambient noise level standards Noise pollution in India, Factors Affecting Noise Pollution, Road Traffic Noise Monitoring, Ambient Noise Monitoring, Occupational Noise Monitoring, Vibration monitoring, traffic noise data analysis, health effects of noise, Highway Traffic Noise: noise from vehicles, effects of operating conditions on vehicle noise levels, individual sources of vehicle noise, assessment of road traffic noise, traffic noise rating, practical aspects of traffic noise measurement, prediction of noise levels due to highway traffic, Noise Control Measures, Industrial noise control, Principles of Noise Pollution Control, Sound Absorption, Basics about Noise Barrier, Design of Noise Barrier, Vibration Damping, Muffling, Green Belt for Noise Attenuation.

10. INDUSTRIAL WASTE MANAGEMENT:-

Management of Industrial Wastes :Solid, Liquid and Gaseous waste, Management of Industrial Wastewater, Management of Solid & liquid Wastes originated from Industries, Characteristics of Industrial Wastewater, Effluent discharges standards (IS2490), Characteristics of Solid Waste Streams from Industries, Wastes from Industries: Textile Wastes; Dairy wastes; Slaughterhouse, Poultry and fish processing waste; Tannery Wastes; Sugar Mill Wastes; distilleries, Pulp and Paper Mill Waste; Fermentation Industry Waste; Engineering Industry Waste; Petroleum and Petrochemical wastes; Fertilizer and Pesticides Industry waste; Wastes from vegetable, food and allied industries, Rubber Waste, Pollution Prevention: General Approach, Source Reduction, Waste minimization, strength and volume reduction, segregation, reuse, recycle, material conservation, recovery, Benefits of Pollution Prevention, Methods for Treating Wastewaters from Industry: Wastewater Treatment Mechanisms, Waste Equalization, pH Control, Chemical Methods of Wastewater Treatment, Biological Methods of Wastewater Treatment, Physical Methods of Wastewater Treatment. Treatment and Disposal of Solid Wastes from Industry: Land filling, Incineration, Composting Industrial Wastes, Solidification and Stabilization of Industrial Solid Wastes.

11. ENVIRONMENTAL IMPACT ASSESSMENT & AUDIT:-

Definition and history of environmental impact assessment, Environmental laws & EIA notifications, Objectives of Environmental Impact Assessment, Process for EIA, TOR, IEE, Components of EIA Reports. Tools for assessment of environmental impacts:

checklist, networks, matrices, overlays, baseline study, scoping & scales, network overlays, index methods.Prediction and assessment of impacts on air and noise; water, soil and land use. Environmental Impact statement, Mitigation and monitoring process for environmental impact assessment, Environmental management plan, Public hearing, Forest policy & clearance, stages& procedure for obtaining forest clearance Elements of Environmental Auditing, ImpactAnalysis of hydropower, thermal power projects, etc.

{Bachelor of Engineering (Mechanical) level}

PART-I

1. **APPLIED PHYSICS:-**

Theory of Relativity: Inertial and non- inertial frames of reference, earth as an inertial frame of reference, Michelson and Morley experiment, Postulates of special theory of relativity, Galilean and Lorentz transformations, Time dilation and length contraction, Relativistic kinematics and mass-energy equivalence, **Laser:** Introduction, Characteristics of lasers, Spontaneous and stimulated emission of radiation Einstein's coefficients, Population inversion, Ruby laser, Helium- Neon lasers & Semiconductor Lasers Applications of laser in industry, Scientific and medical fields, **Oscillations:** Simple harmonic motion (SHM), Differential equation of SHM, Energy of SHM, Damped and Forced Oscillations, Relaxation Time, Quality, Factor, Resonance, Sharpness of Resonance, **Fiber Optics:** Fundamental ideas about optical fiber, Propagation mechanism, Acceptance angle and acceptance cone, Numerical aperture, Propagation Mechanism and communication in fiber, Single and Multi-Mode Fibers, Step index and Graded index fiber, Attenuation and losses, Applications of optical fibers, **Quantum Mechanics:** De Broglie waves, Phase and Group velocity concept, Uncertainty principle and its applications, Wave function, Postulates of quantum mechanics, Derivation of Schrodinger equation for time independent and time dependent cases and its applications viz. Particle in one dimensional box, **X-rays:** X-rays production, hard and soft x-rays, Continuous and characteristics x rays, Bremsstrahlung effect, **Electrodynamics:** Equation of continuity, displacement current, Maxwell's equations, wave equation for electromagnetic radiation, electromagnetic wave propagation in free space and isotropic dielectric medium, Pointing vector & Pointing theorem. **Superconductivity:** Introduction and discovery of super conductivity, Meissner effect, Type-I and type-IIP superconductors, Isotope effect, BCS theory (qualitative), High temperature superconductors, Applications of superconductivity.

2. **BASIC ELECTRONICS ENGINEERING:-**

DC Circuits: Kirchhoff's voltage and current laws; power dissipation; Voltage source and current source; Mesh and Nodal analysis; Star-delta transformation; Superposition theorem. Thevenin's theorem; Norton's theorem; Maximum power transfer theorem; Millman's theorem and Reciprocity theorem; Transient response of series RL and RC circuits. **Steady state analysis of DC Circuits:** The ideal capacitor, permittivity; themulti-plate capacitor, variable capacitor; capacitor charging and discharging, current-voltage relationship, time-constant, rise-time, fall-time, inductor energization and de- energization, inductance current-voltage relationship, time-constant; Transient response of RL, RC and RLCCircuits. **AC Circuits:** Sinusoidal sources, RC, RL and RLC circuits, Concept of Phasors, Phaso representation of circuit elements, Complex notation representation, Single phase AC Series and parallel circuits, power dissipation in AC

circuits, power factor correction, Resonance in series and parallel circuits, Balanced and unbalanced 3 -phase circuit - voltage, current and power relations, 3-phase power measurement, Comparison of single phase and three phase supply systems, **Electromagnetism:** Electromagnetic induction, Dot convention, Equivalent inductance, Analysis of Magnetic circuits, AC excitation of magnetic circuit, Iron Losses, Fringing and stacking, applications: solenoids and relays. **Single Phase Transformers:** Constructional features of transformer, operating principle and applications, equivalent circuit, phasor analysis and calculation of performance indices. **Motors and Generators:** DC motor operating principle, construction, energy transfer, speed torque relationship, conversion efficiency, applications, DC generator operating principle, reversal of energy transfer, EMF and speed relationship, applications, **Semiconductors:** Energy band concept of materials, difference between metal, insulator and semiconductor, Intrinsic and extrinsic semiconductors (n-type & p- type), current conduction in semiconductor, Photodiode, photo-transistor, LED and seven-segment display, **Semiconductor Diodes:** p-n junction diode, Depletionlayer, Energy diagramsof p-n junction and depletion region, Biasing of diode and V-I Characteristics; Rectifiers - half-wave, full-wave and bridge rectifiers; Filters - L, C, LC and π filters; Zener diode, V-I Characteristics and Zener diodeas voltage regulator, **Bipolar Junction Transistors (BJT):** Transistor operation and current components in p-n-p and n-p-n transistors, input/output characteristics of CB andCE configurations, Transistor as an Amplifier, transistor cutoff, saturation and active regions , Transistor biasing and bias stabilization: Operating point, Stability factor, Analysis of fixed bias, collector to base bias, Emitter resistance bias circuit and self bias circuit, **Field Effect Transistors(FET):**Basic construction, transistor action, concept of pinch off, maximum drain saturation current, input and transfer characteristics, MOSFET: Depletion and enhancement type MOSFET- Construction, operation and characteristics. **Oscillators:** Introduction, Criteria for oscillation, types of oscillators Hartley, Colpitt, RC Phase shift and Wein bridge oscillators, **Operational Amplifiers:** Concept of ideal operational amplifiers, ideal operational amplifier parameters, inverting, non-inverting and unity gain amplifiers, adders and subtractor, Differentiator, integrator and Comparator operational amplifiers, **Number System and LogicDesign:** Number systems, Conversions and code, conversion of bases(decimal, binary, octal and hexadecimal numbers), addition and subtraction, Boolean algebra, logic gates (AND, OR, NAND, NOR, XOR, XNOR), concept of universal gate, **Electronic Instruments:** Operation of CRO and its applications, Signal Generator, measurement of voltage, phase and frequency using CRO.

3. APPLIED MATHEMATICS:-

Sequences and Series: Introduction to sequences and Infinite series, Tests for convergence/divergence, Limit comparison test, Ratio test, Root test, Cauchy integral test, Alternating series, Absolute convergence and conditional convergence, **Series Expansions:** Power series, Taylor & Maclaurin's series, Convergence of Taylor series, Taylor & Maclaurin's Theorem, Error estimates (one variable) **Calculus:** Mean value theorem, Rolle's theorem, Lagrange's Cauchy mean value theorem, Application of definite integral to evaluate areas of bounded region, Arc length of a plane curve, volume of solids, surface areas of a solid revolution(Cartesian coordinates), Improper integrals, Beta and Gamma functions **Partial Differentiation and applications:** Functions of several variables, Limits and continuity ($\delta- \epsilon\ approach$), Partial derivatives, Euler's theorem (Homogeneous functions), Chain rule, change of variables, Jacobian, Maxima and minima by using second order derivatives, Lagrange's method of multipliers, Taylor's& Maclaurin's Theorem, Error estimation. **Multiple Integrals and applications:** Double

integral, change of order of integration in double integral, Polar coordinates, graphing of polar curves, Change of variables (Cartesian to polar), Applications of double integrals to areas and volumes, evaluation of triple integral. **Linear Algebra:** Review of matrices, Row reduced echel on form, Inverse using Gauss Jordan method and rank of a matrix, Solution of system of linear equations, Linear spaces, Subspaces, Basis and dimension, rank -nullity theorem, Linear transformation and its matrix representation, Eigen values, Eigen vectors and Diagonalization, Cayley-Hamilton Theorem (withoutproof), and Quadratic form and Orthogonal transformation, **Ordinary Differential Equations**: Review of first order differential equations, Exact differential equations, Second and higher order linear differential equations with constant coefficients, Cauchy's & Legendre's homogeneous differential equations, Variation of parameters method, Cauchy - Euler equation, Method of undetermined coefficients, Engineering applications of differential equations. **Laplace Transform:** Definition and existence of Laplace transforms and its properties, Inverse Laplace transforms using partial fraction, properties and convolution theorem (without proof), Laplace and inverse Laplace transforms of Unit step function and Impulse function, Applications tosolve initial and boundary value problems. **Fourier Series**: Introduction, Fourier series on arbitrary intervals, Even Odd functions, Half range expansions, Parseval's theorem, Complex Fourier series, Harmonic analysis, **Vector calculus:** Introduction to vectors, Vector addition and multiplication, Directional derivatives, gradient, divergence & curl with properties, Scalar line integrals, vector line integrals, scalar surface integrals, vector surface integrals, Green, Stokes and Gauss divergencetheorem (without proof).

4. ENERGY AND ENVIRONMENTAL:-

Ecosystems: Structure and function of an ecosystem–ecological succession–primary and secondarysuccession - ecological pyramids – pyramid of number, pyramid of energy and pyramid of biomass, **Conventions on Climate Change:** Origin of Conference of Parties(COPs), United Nations Framework Convention on Climate Change (UNFCCC) and Inter governmental Panel on Climate Change (IPCC); Kyoto Protocol, Montreal Action Plan; Paris Agreement and post-Paris scenario, **Environmental issues:** Global Environmental crisis, Current global environment issues, Global Warming, Greenhouse Effect, role of Carbon Dioxide and Methane, Ozone Problem, CFC's and Alternatives, Causes of Climate change, Carbon footprint, **Air Pollution:** Origin, sources, adverse effects and preventive measures related to air pollution. Case study for air pollution (London smog, Photochemical smog, Bhopal gas tragedy), **Water Pollution:** Origin, sources, adverse effects and preventive measures related to water pollution. Case study for air pollution (Minmata tragedy, Arsenic pollution at Punjab/UP, The Ganga river pollution), **Noise Pollution:** Origin, sources, adverse effects and preventive measures related to noise pollution, **Nuclear pollution:** Origin, sources, adverse effects and preventive measures related to radioactive pollution, Case study, **Environmental protection acts:** Important environmental protection acts in India– water, air (prevention and control of pollution) act, wild life conservation and forest act. **Renewable and non-renewable resources**: Coal, Petroleum, Solar energy, wind energy, hydrothermal energy, nuclear energy, Tidal energy, Bio energy etc. Role of individual in conservation of natural resources for sustainable life styles. Use and Over exploitation of Forest resources, Deforestation, Timber extraction, Mining, Dams and their effects on forest and tribal people. Use and over exploitation of Surface and ground water resources, Floods, Drought, Conflicts over water, Dams- benefits and problems. National green hydrogen mission. FAME India Scheme. **Environment and Disaster:** Introduction: Principles of Disaster Management. Natural Disasters such as Earthquake, Floods, Fire, Landslides, Tornado, Cyclones, Tsunamis,

Nuclear and Chemical Terrorism. Hazards, Risks and Vulnerabilities, Vulnerability of a location and vulnerable groups, National policy on disaster Management.

5. APPLIED CHEMISTRY:-

Water Technology: Introduction, Sources, common impurities, Hardness, Degree of hardness and units, water quality parameters and their analysis-Turbidity, TDS, Hardness, Chlorine, Arsenic Test, BOD and COD, Water Softening -Zeolite and Ion-exchange process, Drinking water purification and domestic water purifiers, **Electrochemistry:** Specific, equivalent and molar conductivity of electrolytic solutions, Reference Electrodes-Calomel electrode and Ag-AgCl electrode, Ion- selective electrode-Glass electrode, determination of pH of solution using glass electrode, Construction and working of Batteries-Lead acid storage battery, Ni-Cd Storage cell, Lithium batteries, fuel cell and Solar cell, **Corrosion Science:** Introduction, Chemical and Electrochemical Corrosion, Theory of electrochemica corrosion, Types of Electrochemical Corrosion-Differential aeration corrosion Pitting Corrosion. Stress Corrosion e.g., Caustic embrittlement. Factors affecting rat of corrosion-Related to metal & related to environment. Control of corrosion, **Spectroscopy Techniques: UV-Visible Spectroscopy**-principle, Lambert-Beer's Law, instrumentation Electronic Transitions, Auxochromes, Chromophores, Effect of conjugation and solvents on transition of organic molecules, applications, **IR**: - Principle, Instrumentation, Fundamental vibrations, Hooke's Law, effect of masses of atoms, bond strength, nature of substituent and hydrogen bonding on Vibrational frequency, applications. **Fuels:** Classification of fuels, Calorific value-Definition, HCV, LCV, determination of calorific value of solid and liquid fuels using Bomb calorimeter, Ultimate analysis of coal and numerical problems, Petroleum cracking -fluidized bed catalytic cracking. Reformation of petrol, Quality of liquidfuels-Cetane and Concept of hydrogen as fuel-types, synthesis by water electrolysis and natural gas reforming, **Chemistry in ICT**: Introduction and applications of metal and metal oxides like Si, Ge, Al,, Ti, Ni, Cu, SiO_2, $La_2O_3$and ZrO_2in communication and Display devices (liquid crystals based, LED, CRT, alumina-silicate glass based, touch screen). Disposal of harmful chemicals used in ICT; Hg, Pb, Cd and flame retardant materials. **Engineering Materials Polymers:** Introduction, Classification, Glass transition temperature, factors affecting Tg and its significances, Synthesis, properties and applications of PP, PVC PMMA, polyurethanes, Epoxy resins, Silicon Rubber, PET, Lexan, Kevlar, **Conducting Polymers:** Introduction-Definition, applications, Mechanism of conduction in poly acetylene, **Nano-Materials:** Introduction, Properties of nano materials, Graphene, Fullerenes, Carbon nano tubes, nano wires, nano cones, Application of nano-materials.

6. COMPUTER PROGRAMMING:-

Introduction to C++: C++ character set, C++ Tokens (Identifiers, Keywords, Constants, Operators,), Structure of a C++ Program (include files, main function), use of I/O operators (<>), Cascading of I/O operators, compilation, linking and execution. Concept of Data types: Built-in Data types: char, int, float and double; Constants: Integer Constants, Character constants - \n, \t,

\b), Floating Point Constants, String Constants; Access modifier: const; Variables of built-in-data types, Declaration/Initialization of variables, Assignment statement, Type modifier: signed, unsigned, long Operator and Expressions: Operators: Arithmetic operators (-,+,*,/,%), Unary operator (-), Increment (++) and Decrement (--) Operators, Relation operator (>,>=,<=,=,!=), Logical operators (!,&&,||), Conditional operator: ?; Precedence of Operators; Automatic type conversion in expressions, Type casting; C++ short hands (+=,-=,*=,/=,%=).Conditional

statements: ifelse, Nested if, switch case default, use of conditional operator, Nested switch case, break statement; Loops: while, do - while, for and Nested loops. Defining a function; function prototype, Invoking/calling a function: callby value, callby reference, returning values from a function, scope rules of functions and variables local and **Array, Structure and Class**: One Dimensional Array: Declaration/initialization of One-dimensional array, inputting array elements, accessing array elements, Two dimensional Array: Declaration/initialization of a two-dimensional array, inputting array elements accessing array elements, Defining a Structure, declaring structure variables, accessing members of structure, Defining a class, declaring object and Accessing class members **File Handling:** Defining and Opening a File, closing a File, reading from a File, Writing into a File. **Templates:** Need of template, Function templates, **Exception Handling:** Exception handling mechanism, Catch Blocks, Catch Throw an exception,

7. PROBABILITY AND STATISTICS:-

Probability and Random Variables: Introduction, Basic concepts–Sample space, Events, Counting sample space, Conditional Probability and Independence, Permutations and Combinations, Rules of Probability, Bayes' Theorem. Random Variables – Concept of Random Variable, Percentiles, Probability Distributions – Discrete & Continuous, Mean, Variance and Covariance of Random Variables, Chebychev's inequality. **Standard Probability Distributions:** Discrete distributions - Uniform, Binomial, Multinomial, Hyper geometric, Poisson, Negative Binomial, Poisson; Continuous distributions - Normal, Exponential, Gamma, Weibull and Beta distributions and their properties -Function of Random variables. **Sampling Distributions:** Random sampling, Sampling Distributions of Means, Estimation, Properties of point estimators, Confidence interval, Maximum likelihood and Bayes estimators, Prediction intervals. **Testing of Hypothesis:** Sampling distributions – testing of hypothesis for mean, variance, proportions and differences using Normal, t, Chi-square and F distributions, tests for independence of attributes and Goodness of fit, **Linear Correlation and Regression Analysis:** Introduction, Linear Regression model, Regression coefficient, Lines of correlation, Rank correlation.

8. INDUSTRIAL ECONOMICS AND MANAGEMENT:-

Introduction to Engineering Economics - Technical efficiency, economic efficiency - cost concepts: elements of costs, opportunity cost, sunk cost, private and social cost, marginal cost, marginal revenue and profit maximization, **Supply and Demand:** Determinants of demand, law of demand, determinants of supply, law of supply, market equilibrium - elasticity of demand - types of elasticity, factors affecting the price elasticity of demand**, National Income Concepts:** GDP and GNP, per capita income, methods of measuring national income. Inflation and deflation: **Value Analysis** - Time value of money - interest formulae and their applications: single-payment compound amount factor, single-payment present worth factor, equal-payment series compound amount factor, equal-payment series sinking fund factor, equal-payment series present worth factor, equal-payment series capital recovery factor, effective interest rate, **Investment Analysis:** Payback period—average annual rate of return, net present value; Internal rate of return criteria, price changes, risk and uncertainty. **Principles of Management:** Evolution of management theory and functions of management organizational structure - principle and types - decision making - strategic, tactical & operational decisions, decision making under certainty, risk & uncertainty and multistage decisions & decision tree, **Human Resource Management:** Basic concepts of job analysis, job evaluation, merit rating, wages, incentives, recruitment, training and industrial relations. **Financial Management**: Time value of money and comparison of alternative methods;

costing – elements& components of cost, allocation of overheads, preparation of cost sheet, break even analysis - basics of accounting - principles of accounting, basic concepts of journal, ledger, trade, profit & loss account and balance sheet, **Marketing Management:** Basic concepts ofmarketing environment, marketing mix, advertising and sales promotion, **Project Management:** Phases, organization, planning, estimating, planning using PERT & CPM.

9. STRENGTH OF MATERIALS:-

Simple Stresses and Strains: Stress & Strain, Types of stresses and strains, elastic limit, Hooke‘s law, Stress-Strain diagram for ductile and brittle, Factor of Safety, Poisson‘s ratio, Elastic constants, Young‘s Modulus, Shear Modulus, and Bulk Modulus, Relationship between elastic constants. Introduction to thermal stresses and strains, **Compound stresses & strains**: Concept of surface and volumetric strains, two – dimensional stress system, complementary shear stresses at a point on a plane. Principal stresses & strains and principal planes. Mohr‘s circle of stresses, Numerical problems. **Bending Stresses in Beams:** Bending stresses in Beams with derivation of Bending equation and its application to beams of circular, rectangular, I & T sections, Composite Beams, **Torsion of Circular Shaft:** Theory of Pure Torsion, Derivation of Torsionequation for a circular shaft subjected to torsion, assumptions, derivation of maximum torque transmitted by a solid shaft, and hollow shaft. **Shear and combined stresses in beams**: Shear stresses in beams with derivation of shear stress in rectangular I, T, circular and hollow circular sections. Combined bending, torsion & axial loading of beams. Numerical problems, **Slope & Deflection**: Relationship between bending moment, slope & deflection, Method of integration, Macaulay‘s method, Mohr‘s theorem-moment area method, ,. Calculations for slope &deflection of (1) cantilevers and (2) simply supported beams with or without overhang, under concentrated loads, uniformly distributed loads, uniformly distributed loads, or combination of any two or all of these types of loads. distributed loads. Numerical problems. **Theories of Elastic Failure**: Various theories of elastic failure with derivations and graphical representations, applications to problems of two-dimensional stresssystems with (i) Combined direct loading and bending and (ii) combined torsional and direct loading. Numerical problems, **Strain Energy & Impact Loading**: Definitions, expressions for strain energy stored in a body when load is applied (i) gradually, (ii) suddenly and (iii) with impact. Strain energy of beams in bending, beam deflections. Strain energy of shafts in twisting. Energy methods in determining spring deflection, Castigliano‘s & Maxwell‘s theorems, Numerical problems, **Thin Walled Vessels**: Derivation of Hoop & Longitudinal stresses & strains in cylindrical & spherical vessels under internal pressure. Change in volume of vessel under pressure, Numerical problems, **Columns & Struts**: Columns under axial load, concept of instability and buckling, slenderness ratio. Derivation of Euler‘s formulae for the elastic buckling load. Euler‘s, Rankine Gordon‘s formulae ,Johnson‘s empirical formula for axial loading of columns and their applications, eccentric compression of a short strutof rectangular & circular sections, Numerical problems, **Springs**: Stresses in closed and open coiled helical springs subjected to axial loads and twisting couples. Leaf springs, flat spiral springs. Numerical Problems. **Bending of Curved Bars**: Stresses in bars of initial large radius of curvature, bars of initial small radius of curvature. Stresses in crane hooks, rings and chain links of circular & trapezoidal sections. Numerical Problems, **Unsymmetrical bending:** Introduction to unsymmetrical bending, Shear Center, Numerical problems.

10. FLUID MECHANICS:-

Introduction: Fluid Definition and properties, Newton‘s law of viscosityconcept of continuum, Classification of fluids. **Fluid Statics:** Definition of body and surface forces, Pascal‘s law, Basic hydrostatic equation, Forces on surfaces due to hydrostatic pressure, Buoyancy and Archimedes‘ principle, Meta center, stability of floating and submergedbodies. **Fluid Kinematics:** Eulerian and Lagrangian approach to solutions; Velocity and acceleration in an Eulerian flow field; Definition of streamlines, path lines and streak lines; Definition of steady/unsteady, uniform/non-uniform, one- two and three dimensional flows; Definition of control volume andcontrol surface, stream function,velocity potential function , irrotationalflows; Definition and equations for source, sink, irrotational vortex, circulation, **Fluid Dynamics I :**Integral equations for the control volume: Reynold‘s Transport theorem, equations for conservation of mass, energy and momentum, Momentum and Energy correction factors, Bernoulli‘s equation and its application in flow measurement, mouth pieces , pitot tube, venture, orifice and nozzle meters. **Fluid Dynamics II:** Differential equations for the control volume: Mass conservation in 2 and 3 dimension in rectangular and cylindrical co- ordinates, Euler‘s equations in 2, 3dimensions and subsequent derivation of Bernoulli‘s equation; Navier-Stokes equations, Couette flow, plane Poiseuille flow, **Real fluid flows:** Definition of Reynold‘s number, Laminar flow through a pipe (Hagen Poiseuille flow), velocity profile and head loss; Prandtl mixing length theory; velocity profiles for turbulent flows, Velocity profiles for smooth and rough pipes Darcy‘s equation for head loss in pipe, Moody‘s diagram, pipes in series and parallel, major and minor losses in pipes **Boundary Layer Flows:** Concept of boundary layer and definition of boundary layer thickness, displacement, momentum and energy thickness; laminar and turbulent boundary layers, laminar sub-layer; Von Karman Momentum Integral equation for boundary layers, analysis of laminar and turbulent boundary layers, drag, boundary layer separation and methods to control it, streamlined and bluff bodies, **Dimensional analysis**: Buckingham‘s Pi theorem, Non-dimensionalnumbers & their application, similitude, scale effects.

11. ENGINEERING THERMODYNAMICS:-

Introduction and Basic Concepts: Application areas of thermodynamics, Systems and Control volumes, Properties of system, Continuum, State and equilibrium, Processes and cycles, Temperature and Zeroth law of thermodynamics, Heat and thermodynamic, concept of work, **First Law of Thermodynamics:** Statement, Heat and work calculations, Application of first law to non- flow and flow systems, steady flow energy equation as applied to boiler, condenser, throttle, nozzleand turbine **Second Law of Thermodynamics:** Statements and their equivalence, thermal energy reservoirs, concept of heat engine, refrigerator, heat pump and perpetual motion machines, Carnot cycle and principles, **Entropy:** Concept of entropy, Temperature- entropy plot, Clausius inequality theorem, Principle of Increase of entropy, entropy balance, entropy generation in daily life, first and second law combined, entropy changes of an ideal gas during reversible processes, Available and unavailable energy, Irreversibility, second law efficiency **Property Relations:** Introduction to Maxwell relations, Clausius-Clapeyron equation, volume expansively and isothermal compressibility, Mayer relation, Joule-Thomson coefficient, **Properties of Steam:** Dryness fraction, enthalpy, internal energy and entropy, steam table, polynomial form of steam equations and Mollier chart, First law applied to steam processes **Power Cycles:** Vapour power Cycles: Carnot vapour cycle, Rankin cycle, Ideal reheat Rankine cycle, Introduction to co-generation. Gas Power Cycles**:** Air standard assumptions, Otto cycle,

Diesel cycle, dual cycle, Stirling cycle, Ericsson cycle, Brayton cycle, **Reactive Systems:** Combustion, theoretical and actual combustion processes, enthalpy of formation and enthalpy of combustion, adiabatic flame temperature, first law analysis of reactive system.

12. <u>HUMAN VALUES AND PROFESSIONAL ETHICS:-</u>

Introduction –Need and Basic Guidelines, Understanding the need, basic guidelines, content and process ofvalue Education, Self-Exploration – purpose, content and process, ‗Natural Acceptance' and Experiential Validation – as the mechanism for self-explanation Process for Value Education, Continuous Happiness and Prosperity – A look at basic Human Aspirations, Right Understanding, Relationship and Physical Facilities – basic requirements for fulfilment of aspirations of every human being with their correct priority, Understanding Happiness and prosperity – A critical appraisal of the current scenario, Method to fulfil the human aspirations; understanding and livingin harmony at various levels Harmony in Human Beings, Understanding human being as a co- existence of the self and the body, Understanding the needs of Self (‗I') and ‗Body' – Sukh and Suvidha, Understanding the Body as an instrument of ‗I' (I being the doer,seer and enjoyer) Harmony in Myself and body, Understanding the characteristics and activities of ‗I' and harmony in 'I', Understanding the harmony of I with the Body: Sanyam and Swasthya: correct appraisal of Physical needs, meaning of Prosperity in detail. Harmony in Family, Society and Nature Understanding harmony in the family, society and nature, Understanding values in human relationship; meaning of Nyaya and Program for its fulfilment to ensure Ubhay-tripti, Trust (Vishwas) and Respect (Samman) as the foundational values ofrelationship.

13. <u>MANUFACTURING TECHNOLOGY:-</u>

Introduction to Manufacturing and Manufacturing Processes, Classification of Manufacturing Processes, Metal Casting Processes: Introduction, Basic steps in Casting Processes, Advantage and limitations, sand mold making procedure,Patterns and Cores. Pattern materials, pattern allowances, types of pattern, colour coding, Moulding material, Moulding sand composition, and preparation, sand properties and testing type of sand moulds. Types of cores, core prints, chaplets, chills. Gating systems and Casting Defects, Gates and gaiting systems risers, melting practice, Cupola, charge calculation, **Casting cleaning and casting defects** Fettling, defects in castings and theirremedies, methods of testing of castings for their soundness. **Special Casting Processes:** Shell molding, precision investment casting, permanent mold casting, die casting, centrifugal casting, and continuous casting. **Metal forming Processes:** Introduction to Forming, Nature of plastic deformation, hot working and cold working. Principles of rolling roll passes roll pass sequences. Forging: Forging operations, smith forging, drop forging, press forging, forging defects, **Extrusion and other processes:** Extrusion principle, hot extrusion, cold extrusion, wire drawing, swaging, tube making, **Sheet metal operation**: Press tool operations, shearing action, drawing dies, spinning, punching, piercing, bending, stretch forming, embossing and coining. **Welding and Welding Defects:** Introduction to Welding, Gas and Arc Welding, Classification: Oxyacetylene welding equipment and techniques. Electric arc welding: Electrodes, Tungsten inert gas welding (TIG), metal inert gas welding (MIG), submerged arc welding (SAW), Resistance Welding: Principle & types, Welding Defects and Remedies, **Other Joining Processes:** Thermit welding, electro slag welding, electron beam welding, forge welding, friction welding, diffusion welding, brazing and soldering and Mechanical joining, Joining Plastic **Plastic Manufacturing Processes** Classification of plastic materials, Manufacturing of plastic products, casting, compression moulding, transfer moulding, Injection Moulding, Extrusion, calendering, blow moulding, forming shaping methods, laminating methods, reinforced plastic moulding. **Powder**

Metallurgy: Introduction, Operation in powder metallurgy, Production of Metal powders, Properties of metal powder, Blending of metal powders, Compaction of metal powders, Sintering and secondary operation, Application of powder Metallurgy, **Metal Cutting & Tool Forces:** Introduction, basic tool geometry, single point tool nomenclature, mechanism of metal cutting: deformation of metal during machining, mechanics of chip formation, built-up edges, mechanics of orthogonal and oblique cutting, merchant cutting force circle and shear angle relationship in orthogonal cutting, surface finish, factors affecting tool forces, **Relationships and Economics of Machining:** Relationship of velocity, forces, and power consumption, cutting speed, feed, and depth of cut. Temperature distribution at tool chip interface. Economics of metal machining, introduction, elements of machining cost, tooling economics,machining, optimization, numericals. **Cutting Tool Materials & Tool Life:** Characteristics of tool materials, various types of cutting tool materials, coated tools, cutting tool selection, tool life relationship-taylor equation, types of tool wear, tool life, factors governing tool life, purpose and types of cutting fluids, basicactions of cutting fluids, selections of cutting fluid, effect of cutting fluidon tool life, definition of machinability and its and evaluation, economics of machining, numerical, **Gear Manufacturing:** Introduction, methods of manufacturing, gear generation and forming: gear cutting by milling, single point form tool, gear hobbing and shaping, gear finishing operations: gear shaving, gear burnishing, gear grinding, lapping. **Jigs & Fixtures**: Principles of locations, locating and clamping devices, jigs, bushes, drilling jigs, milling fixtures, turning fixtures, boring and broaching fixtures, welding fixtures, different materials for jigs and fixtures, economics of jigs and fixtures, **Press Working Tools & Dynamometry**: Introduction, classifications of presses and dies, shear action in die cutting operations, centre of pressure, mathematical calculation of centre of pressure, clearances, cutting forces, punch dimensioning, need for measuring forces, basic requirements of measuring techniques, design requirements of dynamometers, 3-divisional turning dynamometer and its calibration,drill dynamometers. **Abrasive Processes:** Introduction, grinding wheel-designation and selection, types of grinding machines, grinding processes, grinding processes parameters, creep feed grinding, honing, lapping, other finishing processes. other machine tools: sawing, broaching, **Unconventional Machining Processes:** Need for unconventional processes, types of unconventional machining processes, usm: ultrasonicmachining, ecm: electrochemical machining, edm : electrical discharge machining, lbm: laser beam machining their process parameters, principle of metal removal, applications, advantages, and limitations.

14. I.C. ENGINES:-

Introduction Heat engines; Internal and external combustion engines; Classification of I.C. Engines; Cycle of operations in four strokes and two- stroke IC engines and their comparative study; Fuels**:** SI and CI engine fuels, Rating of fuels, Scavenging and scavenging blowers, Air standard cycles and Fuel air cycles, Variable specific heat and its effects, Dissociation and other losses, Actual cycles, Deviation of actual engine cycle from ideal cycle, TDC, BDC, Torque, Power, **Compression Ignition Engines** Combustion phenomenon in C I engines, Stages of combustion, Delay period, Knocking, Pressure-Crank angle diagram, Factors affecting combustion and knocking, Types of combustion chambers. **Spark Ignition Engines** Combustion**:** Combustion phenomenon in SI Engines, Ignition delay, Flame propagation, Pressure-Crank angle diagram, Abnormal combustion, Auto ignition, Detonation and Knocking, Factors affecting combustion and detonation, Types of combustion chambers **Fuel System – SI Engines: Theory** of carburetion, Simple carburettor, Essential parts of modern carburettor, Types of carburettors, Types of fuel injection systems in SI engines, Continuous injection system, Timed injection

system, Electronic Fuel Injection systems (EFIs)/MPFi, Working of Sensors, Functions of ECU in Petrol Engine. Spark Plug and its requirements, Battery, Magneto, Electronic ignition systems. GDI Technology, Turbo in Petrol Engines, **Fuel System – CI Engines:** Fuel Injection Systems**:** Unit Pump, Inline Pump, Rotary Pump, Engine Governors: necessity and characteristics, Types of nozzle, Electronic Diesel Control, CRDi Technology, System Layout, Function of ECU in diesel engine, Working of Sensors, Turbocharger and its types, VGT, Twin-turbo. **Engine lubrication:** Types of lubricants and their properties, SAE rating of lubricants, Types of lubrication systems, Engine Cooling**:** Necessity of enginecooling, disadvantages of overcooling, Cooling systems and their comparison: Air cooling, Liquid cooling, Supercharging/Turbo-charging**:** Objectives, Effects on power output and engine efficiency **Engine Testing and Performance:** Measurement of Break Horse Power, Indicated Power, Fuel Consumption, Air flow, BMEP, Performance characteristic of SI and CI Engines, Effect of load and Speed on mechanical, indicated thermal, break thermal and volumetric efficiencies, Heat balance sheet **After-treatment technologies: -**Working of Catalytic Converter & its types, SCR, DPF, DOC, POC, LNT. **Exhaust Emissions:** Homologation, Emission Standards, Applicable Standards in India, Future Norms, and Significance of Fuel in meeting emissions. Classification of Segments, Emission Test Cycles, COP, Emission Measurement Techniques, On board Diagnosis, OBDI, OBDII, **Alternate Fuels:** Alcohol - Hydrogen - Natural Gas and Liquefied Petroleum Gas – Biodiesel- Biogas Properties - Suitability - Engine Modifications - Merits and Demerits as fuels.

15. <u>TURBO MACHINES:-</u>

Impact of Jets and Water Turbines Impact of jet on flat and curved plates Types of hydro turbines - impulse and reaction, definition of various turbine parameters like gross head, discharge, work done, input power, output power, efficiencies etc., Euler‘s equation applied to a turbine, turbine velocities and velocity triangles, expression for work done, **Pelton Turbine:** Components of Pelton turbine, definition of design parameters like speed ratio, jet ratio, and estimation of various parameters like head, discharge, and efficiency etc., determination of number of buckets, Performance Characteristic curves. **Reaction Turbines:** Types of reaction turbines – Francis Turbine, Kaplan Turbine, inward and outward flow, radial mixed and axial; elements of the turbine, estimation of various working and design parameters, Performance Characteristic curves of reaction turbines, **Similarity relations in turbines**: definition of unit quantities and specific quantities, selection of turbines, Cavitation in turbines - causes, effects and remedies, Thomas cavitation parameter, specific speed graphs, Determination of safe height of installation for the turbine, Draft Tube, typesof draft tube, governing of turbines. **Centrifugal Pumps**: Classification, velocity vector diagrams and work done, hydraulic and manometric efficiency, vane shape, head capacity relationship and pump losses, pressure rise impeller, minimum starting speed,multi-stage pumps, Similarity relations and specific speed, net positive suction head, cavitation and maximum suctions lift, performance characteristics, **Reciprocating Pumps:** Construction and operational details, discharge coefficient, volumetric efficiency and slip, work and power input, effect of acceleration and friction on indicator diagram (pressure – stroke length plot) air vessels and their utility. Centrifugal v/s reciprocating pumps. **Centrifugal fans - Blowers and Compressors** - construction details -Inducers – Backward and Radial blades - Diffuser - volute casing stage work- Stage pressure rise – Stage pressure co-efficient - Stage efficiency - Degreeof reaction - Various slip factors H-S diagram for centrifugal compressor. **Axial flow Fans and Compressors** – Construction detail - Stage velocity triangles - Blade loading and flow coefficient - Static pressure rise - H-S diagram - Degree of reaction - Work

done factors -Free and Forced Vortex flow performance - Stalling and Surging.

16. KINETICS OF MACHINES:-

Introduction: Mechanism and machines, kinematics links, kinematic pairs, kinematic chains, plane and space mechanism, kinematic inversion, equivalent linkages, four link planar mechanisms, straight line mechanisms, steering mechanisms, pantograph, **Kinematic Analysis of Plane Mechanisms:** Displacement analysis, general plane motion, instantaneous center of velocity, graphical and analytical methods of velocity and acceleration analysis. **Cams:** Classification of cams and followers, disc cam nomenclature, construction of displacement, velocity and acceleration diagrams for different types of follower motions, analysis of follower motions, determination of basic dimension, synthesis of cam profile by graphical approach, cams with specified contours, tangent and circular arc cams. **Belt, Rope and Chain drives**: Introduction to belts, ropes, law of belting, design of belt drives, flat & v-belt drives, conditions for transmission of max. Power **Gears:** Introduction, terminology, various types of gears and applications, fundamental law of gearing, Gear profile, involute, cycloidal, interference and undercutting. Spur gear: Path of contact, arc of contact, minimum teeth to avoid interference, introduction to helical, spiral bevel and worm gears, Synthesis of simple, compound and reverted gear trains, analysis of epicyclic gear trains. **Kinematic synthesis of Mechanisms:** Type, number and dimensional synthesis, function generation, path generation and body guidance two and three position synthesis of four bar and slider crank by graphical andanalytical methods, Freudenstein's equation precision position, structuralerror, Chebychev spacing, transmission angle.

17. HEAT TRANSFER:-

Steady State Heat Conduction: Introduction, 1-dimensional heat conduction through a plane wall,long hollow cylinder, hollow sphere, conduction equation in cartesian, polar and spherical co-ordinatesystems. steady state conduction with heat generation: introduction, 1 – dimensional heat conduction with heat sources, extended surfaces (fins), fin effectiveness 2-dimensional heat conduction. **Transient Heat Conduction:** systems with negligible internal resistance, biot number, transient heat conduction in plane wall, cylinders, spheres with convective boundary conditions, hiesler chart solution, relaxation method, **Convection:** Forced convection – Thermal and hydro-dynamic boundarylayers, equation of continuity, momentum and energy equations, flow over a flat plate and flow through tube, fluid friction and heat transfer (colburn analogy), free convection from a vertical flat plate, empirical relations for free convection from vertical and horizontal of planes and cylinders. **Thermal Radiation:** Introduction, Stefan-Boltzmann law, Wien Displacement Law, Kirchoff's Law, concept of black body and grey body, black body radiation, shape factors and their relationships, heat exchange between non-black bodies, equivalent electrical network for radiative exchange in an enclosure of two or three gray bodies, radiation shields. **Heat Exchangers:** Introduction, classification, fouling factor, overall heat transfer coefficient, analysis of a parallel/counter flow heat exchanger, heat exchanger effectiveness, LMTD, NTU effectiveness method.

18. MACHINE DESIGN:-

Introduction: To machine design, design process and design creativity, types of design, design synthesis, principles of design in aesthetics and ergonomics, standards in design, concurrent engineering, mechanicalproperties of the commonly used engg. materials, basic criteria of selection of materials, factor of safety under different loading conditions, concept of tearing,

shearing, crushing, bending etc., **Principles of design:** B.I.S. system of designation of steel, B.I.S System of designation of C.I. B.I.S system of fits &tolerances, standardization and inter-changeability, design considerations of casting, forging and machining, different types of fluctuating / variable stresses, study of stress concentration, concept of fatigue and endurance strength, fatigue design for finite and infinite life against combined variable stress using, Goodman and Soderberg's criterion, design for static loading, design for manufacture and assembly (DFMA). **Shafts and Keys :** Design of shafts subjected to twisting moment, bending moment and combined bending and twisting, shafts subjected tofluctuating loads, design of shafts on basis of rigidity, design of hollow, shafts, flexible shafts, critical speed of shafts, design of different types of keys, splines. **Riveted joints:** Methods of riveting, rivet materials, caulking and fullering, design of rivets for boiler joints, eccentrically loaded riveted joints, **Welded joints:** weld, design for various loading conditions in torsion, shear or direct load, eccentrically loaded welded joints. **Cotter and knuckle joints:** comparison between keys and cotters, design of socket and spigot cotter joint, gib and its use, gib and cotter joint, design procedure for knuckle joint. **ipe joints:** Introduction, stresses in pipes, designing of pipes, hydraulic pipe joint for high pressures, steam pipes, steam pipe fittings, oil piping, **Sliding contact Bearings:** Functions, classification, Selection of bearing type, types of lubrication – boundary, mixed and hydrodynamic lubrication, properties of lubricants, oil grooves, hydrostatic bearings, gas bearings, bearing characteristic number, critical pressure and heat generation in journal bearing, design procedure of journal bearing, Reynolds's equation, design of pivot and collar bearing. **Rolling contact bearings:** Classification, basic static load rating, basic dynamic load rating, static equivalent load, dynamic equivalent load, load life relationship, reliability, material and manufacture of ball and roller bearings, selection of bearing from manufacturer's catalogue, bearing failure, lubrication of rolling bearings. **Gears:** beam and wear strength of gear tooth-Lewis equation, form or Lewis factor for gear tooth, causes of gear tooth failures, dynamic loadon gear- Buckingham equation, force analysis and design of spur, helical, bevel & worm gears including the consideration for maximum power transmitting capacity, gear lubrication. **Springs:** Types of springs, design for helical springs against tension, compression and fluctuating loads, design of leaf springs, nipping, surging phenomenon in springs. **Design of IC engines parts and Crane Hook:** Design of cylinder, piston, connecting rod and crankshaft, design of crane hook.

PART-II

1. AUTOMOBILE ENGINEERING:-

Introduction to Automobiles: Classification, components, requirements of automobile body: vehicle frame. types, front engine rear drive & front engine front drive vehicles, four wheel drive vehicles, **Clutches:** Introduction to clutches, requirement of clutches – principle of friction clutch

– wet type & dry types: single plate clutch, multi plate clutch, centrifugal clutches, clutch linkages. **Power Transmission:** Object of the gear box, different types of gear boxes, sliding mesh, constant mesh, synchromesh gear boxes, drive lines, universal joint, propeller shaft, slip joint, front wheel drive, principle, function, construction & operation of differential, rear axles, types of load coming on rear axles, full floating, three quarter floating and semi floating rear axles **Suspension Systems:** Need of suspension systems, types of suspension, factors influencing ride comfort, leaf springs, shock absorber, **Steering System:** Front wheel geometry

& wheel alignment viz. caster, camber, king pin inclination, toe-in/toe-out, conditions for true rolling motions of wheels during steering: different type of steering gear boxes,steering linkages and layout, rack & pinion power steering gear. **Automotive Brakes, Tyres & Wheels:** classification of brakes, principle and construction details of drum brakes, disc brakes, mechanical, hydraulic, pneumatic brakes, power assisted brakes, tyres of wheels, types of tyre & their constructional details, tyre rotation, excessive tyre wear & their causes, **Automotive Electricals:** Purpose & operation of lead acid battery, capacity rating. purpose and operations of the starting system, and charging system.

2. MATERIAL TECHNOLOGY:-

Materials: Resources and their implications, materials and their applications in engineering, **Solid Solutions and Phase diagram:** Introduction and types of solid solutions, importance and types of phase diagram, systems, phase and structural constituents, cooling curves, Gibb‘s phase rule, lever rule, definition of eutectic, eutectoid, peritectic and peritectoid systems, iron carbon equilibrium diagram and TTT diagram. **Heat Treatment:** Purpose and classification of heat treatment processes, annealing normalizing, stress relieving, hardening, tempering, carburizing, nitriding, cyaniding, flame and induction hardening. properties of micro-constituents like austenite, ferrite, pearlite, martensite, **Deformation of Metals:** Elastic and plastic deformation, mechanism of plastic deformation, twining, conventional and true stress strain curves for polycrystalline materials, yield point phenomena, strain hardening, age hardening work hardening, Bauschinger effect, recovery, recrystallization and grain growth. **Mechanical Behavior of Materials:** Types of polymers, ceramics, composites, and glasses, mechanical behavior of polymers, ceramics, composites, and glasses, mechanical testing of materials, **Alloys and alloying elements:** Effect of various alloying elements on the mechanical properties. properties of important alloys used in mechanical engineering practice. **Failures of metals**: Failure analysis, fracture- process & its types and their characteristics, brittle fracture theories, cleavage fracture, methods to improve fracture strength, fatigue and characteristics of fatigue, **Creep & Corrosion:** Definition and concept, creep curve, mechanism ofcreep, impact of time and temperature on creep, creep fracture, creep testing and prevention against creep. corrosion: introduction, types of corrosion, mechanism and effect of corrosion, prevention of corrosion.

3. COMPUTER AIDED DESIGN AND MANUFACTURING:-

Introduction to CAD/CAM: Historical development, industrial look at CAD/CAM, introduction to CIM, design process, introduction to CAM/ CIMS, Importance and Necessity of CAD, applications of CAD, hardware and software requirement of CAD, **Geometric and Wire Frame Modeling:** Basic introduction of geometric and solid modeling coordinate systems. 2-D and 3-D wire frame models, hardware for drafting packages, command and menu driven software, features of a drafting package, drawing utilities, entities, edit commands, blocks and symbols, viewports. **Curves, Surfaces and Solids:** Algebraic and geometric forms, tangents and normal, blending functions re-parametrization, straight lines, conics, cubic splines, Bezier curves and B-spline curves. Ruled surface, surface of revolution, tabulated cylinder, bi-cubic surface, Bezier surface, B-spline surface, **Transformations:** Introduction, transformation of points and line, 2-D rotation, reflection, scaling and combined transformation, homogeneous coordinates, 3-D scaling, shearing, rotation, reflection and translation, combined transformations. **Solid Modeling:** Solid models and representation scheme, boundaryrepresentation, constructive solid geometry, sweep representation, cell decomposition, **Automation and Numerical Control:** Introduction, fixed,

programmable and flexible automation, types of NC systems, MCU and other components, NC manual part programming, coordinate systems, G & M codes, part program for simple parts, computer assisted part programming. **Group Technology (GT):** Part families, part classification and coding production flow analysis, machine cell design, advantages of GT, **Flexible Manufacturing Systems & Computer aided process planning:** Introduction, FMS components, types of FMS, FMS layouts, planning for FMS, advantages and applications conventional processplanning, types of CAPP, steps in variant process planning, planning for CAPP. Finite element method: introduction, basic procedure.

4. MEASUREMENT AND CONTROL:-

General Concept: Need and classification of measurements and instruments, basic and auxiliary functional elements of a measurement system, mechanical versus electrical/electronic instruments, primary, secondary and working standards, **Static and Dynamic characteristics of Instruments:** Range and span, accuracy and precision, calibration, hysteresis and dead zone, sensitivity and linearity, threshold and resolution: speed of response, lag, fidelity and dynamic error, dead time and dead zone. zero, first and second ordersystems and their response to step, ramp and sinusoidal inputsignals. error in measurement: sources of errors, systematic and random errors: statistical analysis of test data. **Functional Elements:** Review of Electro-mechanical sensors and transducers – variable resistance, inductance and capacitive pickups, photo cells and piezo-electric transducers, and application of these elements for measurement of position/displacement, speed/velocity/acceleration, force and liquid level etc, **Strain Gauges:** Resistances strain gauges, gauge factor, bonded and unbonded gauges, surface preparation and bonding technique, signal conditioning and bridge circuits, temperature compensation, application of strain gauges for direct, bending and torsional loads. **Pressure and Flow Measurement**: Bourdon tube, diaphragm and bellows, vacuum measurement – Mecleod gauge, thermal conductivity gauge and ionisation gauge, dead weight gauge tester. Electromagnetic flux meters, ultra-sonic flow meters and hot wire anemometer: Flow visualisation technique, **Temperature Measurement:** Thermal expansion methods – bimetallic thermometers, liquid-in-glass thermometer and filled-in-system thermometers, thermo-electric sensors-common thermo couples, reference junction considerations, special materials and configurations: metal resistance thermometers and thermistors, optical and radiation pyrometers, calibration, standards. **Speed, Force, Torque and Shaft Lower Measurement:** Mechanical tachometers, vibration and tachometer and stroboscope, proving ring, hydraulic a pneumatic load cells, torque on rotating shafts, absorption, transmission and driving dynamometers, **Controls:** Control system-open and closed loop system, elements of a control system, servo mechanism process control and regulators, transfer function, block diagram and overall transfer function of a multi loop control system, signal flow graph and Mason‘s Rule system stability – Routh and Harwitz criteria stability, Time and frequency domain, Nyquist plot for stability study.

5. OPERATION RESEARCH:-

Definition and characteristics of operations research (O.R.), Decision making, Scientific decision making, approach for scientific decision making in O.R., need and limitations of O.R. definition of models, classification of models, construction of models, approximations of O.R. models. **Linear Programmiong:** Graphical and Simplex method, Duality and degeneracy **Allocation Model:** Analysis of industrial situations to find characteristics like key decision objective, possible alternatives & restrictions – three categories of allocation type situation to be

considered general mathematical formulation for linear programmingfeasible and optimal solutions, **Network Models:** Transportation models, methods of finding starting solution Vogel's approximation method to find feasible solution in transportation models, methods for finding optimal solution. assignment model, Hungarian method to find optimal solution in assignment models. **Introduction to Queuing Theory:** Cyclic shortest route models, traveling salesman's problem and branch and bound method to solve it. acyclic shortest route models and their solution by graphical methods. queuing theory, various types of queuing situations and their solutions, **Theory of games**: introduction, Two-personzero-sum games, the maximum –minimax principle, games without saddle points – mixed strategies, 2 x n and m x 2 games – graphical solutions, dominance property, use of L.P. to games, algebraic solutions to rectangular games. **PERT & CPM:** Network situations where PERT & CPM can be applied, planning, scheduling & control, work-breakdown structure, **PERT Networks:** Events and activities, construction of network, forward & backward planning, Fulkerson's rules, optimistic, pessimistic & most likely time estimates, frequency distribution, Mean, variance and standard deviation, expected time and latest occurrence time, definitions of slack and critical path. **b) CPM Networks:** Similarity and differences of CPM and PERT construction of network, earliest event time, float, total float, free float, independent float, contracting the network so as to find an optimumproject schedule.

6. THERMAL ENGINEERING:-

Steam Boilers: Boilers and their classification, comparison between fire tube and water tube boilers, essentials of a good boiler. constructional and operational details of locomotive, Babcock-Wilcox, and Lamont boilers, boiler mountings and accessories, **Draft type and Heat Balance Sheet:** Natural draft from chimney, height of chimney, maximum draft and chimney efficiency, forced draft and induced draft, boiler heat balance Sheet. **Vapour Power Cycles:** Carnot and Rankine vapour cycles, effect of operating conditions on thermal efficiency of Rankine cycle, Rankine cycle with superheat, reheat cycle and regenerative feed heating cycle, binary vapour cycle, **Flow Through Nozzles**: Velocity and heat drop, mass discharge through a nozzle, critical pressure ratio and its significance, effect of friction and nozzle efficiency, supersaturated flow, nozzles off the design pressure ratio. **Steam Turbines:** Classification, flow through impulse blades, velocity diagram, calculation of power output and efficiency, maximum blade efficiency of single stage impulse turbine, blade friction, compounding of impulse turbine. Flow through impulse reaction blades, degree ofreaction, velocity diagram, calculations for power output, stage and overall efficiency, comparison of impulse and impulse reaction turbines, **Efficiency and Governing in Steam Turbines:** Losses in steam turbines, stage efficiency overall efficiency and reheat factor. Governing of steam turbines, throttle governing, nozzle control governing and by pass governing. Steam for heating and process work, back pressure turbines and pass out turbines. **Steam Condensers:** Elements of a condensing plant, types of condensers, comparison of jet and surface condensers. Condenser vacuum, air leakage and loss of vacuum, vacuum efficiency and condenser efficiency, Dalton's law and air vapour mixture, air pumps.

7. DYNAMICS OF MACHINERY:-

Static and Dynamic Force Analysis: Static force analysis of planar mechanisms, dynamic force analysis including inertia and frictional forces of planar mechanisms, **Balancing of Rotating Components:** Static balance, dynamic balance, balancing of rotating masses, two plane balancing, graphical and analytical methods, balancing machines. **Dynamics of Reciprocating Engines:** Engine types, indicator diagrams, gas forces, equivalent masses, inertia forces, bearing

loads in a single cylinder engine, crankshaft torque, engine shaking forces, **Balancing of Reciprocating Parts:** Balancing of single cylinder engine, balancing of multi cylinder, inline, radial and V type engines. **Governors:** Introduction, types of governors, characteristics of centrifugal governors, gravity controlled and spring controlled centrifugal governors, hunting of centrifugal governors, **Flywheel & Dynamometers:** Introduction, coefficient of fluctuation of energy and speed, design of flywheel – solid disk and rimmed flywheels, types of dynamometers, prony brake, rope brake and band brake dynamometers, belt transmission dynamometer, torsion dynamometer, hydraulic dynamometer. **Gyroscope:** precession angular motion and gyroscopic couple and their effects on aeroplane, ship during steering, rolling and pitching. Stability of four wheel vehicles moving on curved paths, **Vibration:** Single degree of freedom system, free and forced vibrations, spring-mass system, spring-mass damper system, logarithmic decrement.

8. INDUSTRIAL AUTOMATION AND ROBOTICS:-

Basic principles of automation, Hard automation, flexible automation extending the capabilities of conventional machines through improved devices and manipulators, transfer machines for assembly, multispindle automatics, **Introduction to Robotics:** Synthesis of elements with movability constraints, classification and specification of robots, laws of robotics, elements of robot anatomy, hydraulic, pneumatic and electrical manipulators, end-effectors and their design. **Robotic manipulation:** automation and robots classification – drive technologies work-envelope geometries, motion control method, application: robot specifications – no. of axes, capacity and speed, reach and stroke, tool orientation, repeatability, precision, accuracy, operating, environment. **Direct kinematics**: the arm equation homogenous Co-ordinates – frames, translation and rotations, composite homogenous transformations, screw transformations, link Co-ordinates, the arm equation, a five-axis articulated robot, a four-axis SCARA robot, a six- axis articulated robot. **Inverse Kinematics:** Solving the arm equation: the inverse kinematics problem general properties of solutions, tool configuration, inverse kinematics of a five-axis articulated robot, four-axis SCARA robot, six- axis articulated robot and three-axis planer articulated robot, **Performance analysis of industrial robots:** Performance Analysis and their manufacturing applications, Economics of robotics.

9. REFRIGERATION & AIR CONDITIONING:-

Introduction: Definition of refrigeration & air conditioning, Necessity, Methods of refrigeration, Coefficient of performance (COP), fundamentals of air-conditioning system, refrigerants-classification, nomenclature, desirable properties, comparative study, secondary refrigerants, Introduction to eco-friendly refrigerants and cryogenics, **Air Refrigeration Systems:** Carnot refrigeration cycle, Brayton refrigeration or the Bell Coleman air refrigeration cycle, Air craft refrigeration systems, Simple cooling and Simple evaporative types, Boot strap and Boot strap evaporative types, Regenerative type and Reduced Ambient type system, Comparison of different systems. **Vapour Compression (VC) Refrigeration Systems:** (a) Simple Vapour Compression (VC) refrigeration systems- limitations of reversed carnot cycle with vapour as the refrigerant, analysis of VC cycle considering degrees of sub cooling and superheating, , comparison ofVC cycle with air refrigeration cycle. (b) multistage refrigeration systems- necessity of compound compression, compound VC cycle , intercooling with liquid sub –cooling and / or water inter cooler: multistage compression with flash intercooling and / or water inter- cooling, systems with individual or multiple expansion valves, Individual compression system with individual or multiple expansion valves, individual compression systems with individual or multiple expansion

valves with and without intercoolers. **Other Refrigeration Systems**: (a) Vapour Absorption Refrigeration (VCR) systems – basic systems, actual COP of the system, performance, relative merits and demerits, properties of aqua ammonia, Electrolux refrigeration, Steam Jet Refrigerating (SJR) System- (c) Cascade refrigeratingsystems- necessity selection of pairs of refrigerants for the system concept of cascade temperature, analysis, comparison with V.C. systems, applications. **Psychrometry of Air & Air Conditioning Processes:** Properties of moist air-Gibbs Dalton law, basic terminology, psychrometric chart psychrometry of air-conditioning processes, mixing process, basic processes in conditioning of air, **Air- Conditioning Load Calculations:** Outside and inside design conditions, sources of heating load, sources of cooling load, heat transferthrough structure, solar radiation, electrical applications, infiltration and ventilation, heat generation inside conditioned space, apparatus selection, **Air Conditioning Systems with Controls & Accessories**: Classifications, layout of plants, equipment selection, air distributionsystem, duct systems design, filters, refrigerant piping, design of summer air conditioning and winter air conditioning systems, temperature sensors, pressure sensors, humidity sensors, actuators, safety controls, accessories.

10. <u>POWER PLANT ENGINEERING:-</u>

Introduction: Energy resources and their availability, Types of power plant, selection of the plants, review of basic thermodynamics cycles used in power plant **Hydro Electric Power Plants:** Rainfall and run-off measurements and plotting of various curves for estimating power plants, design, construction and operation of different components of hydro-electric power plant, siteselection, comparison of other types of power plants. **Steam Power Plants:** Flow sheet and working of modern-thermal powerplants, super critical pressure steam stations, site selection, coal storage, preparation, coal handling systems, feeding and burning of pulverized fuel, ash handling systems, dust collection-mechanical dust collector and electrostatic precipitator, **Gas TurbinePower Plants:** Types, open and closed gas turbine, work output & thermal efficiency, methods to improve thermal efficiency of gas turbine plant- reheating, inter- cooling regeneration & their combinations, advantage and disadvantages, comparison with steam power plant. **Nuclear Power Plants:** Principles of nuclear energy, basic nuclear reactions, nuclear power station, trouble shooting and remedies. Power Plant Economics: Effect of plant type on costs, fixed elements, energy elements, customer elements and investor‘s profit, depreciation and replacement.Economics of power plants. **Non-Conventional Power Generation:** Solar radiation, solar energy collectors, OTEC, wind power plants, geothermal resources, direct energy conversion systems in fuel cell, MHD power generation-principle thermoelectric power generation, thermionic power generation.

11. <u>INDUSTRIAL ENGINEERING & PRODUCTION MANAGEMENT:-</u>

Work study: Productivity definition, means of increasing productivity, productivity and work study work study - definition, aims, procedure for method study, selection of jobs, recording techniques, micro motion study, therbligs, cyclograph and chrono-cyclo-graph, principles of motion economy, design of work place layout, analysis in the form of chart, operation chart, flow process chart, flow diagram, string diagram, man machine chart, two hand chart, SIMO chart. – time study equipment, performance rating, allowances, number of cycles to be studied, determination of standard time, predetermined motion time systems, **Job evaluation, wages, incentives and welfare**: Job evaluation,objectives of job evaluation, Methods of job evaluation, non quantitative and quantitative. – characteristics of a good wage or a incentive systems,methods

of wage payments, concept of wage incentive schemes, financial and non financial, Halsey premium plan, Merric's multiple piece rate system. Working condition, service facilities, legal legislation– factories act, 1948. **Facilities layout and plant location:** Manufacturing facility layouts, analyzing manufacturing facility layouts, service facility layout. – factorsaffecting location decisions, multi facility location problem, ware house location problem, minimax location, gravity location problem, **Inventory management and PPC:** Views of inventories, nature of inventories, fixed order quantity systems, fixed order period systems, other inventory models, production planning and control- loading. scheduling, dispatching.

12. TOTAL QUALITY MANAGEMENT (TQM):-

Introduction - Need for quality, evolution of quality, definition of quality - dimensions of manufacturing and service quality - Basic concepts of TQM, Definition of TQM, TQM Framework, Contributions of Deming, Juran and Crosby – Barriers to TQM, **Quality Control and Improvement Tools**: Check Sheet, histogram, pareto chart, cause and effect diagram, scatter diagram, control chart, graph, affinity diagram, tree diagram, matrix diagram, process decision program chart, arrow diagram, acceptance sampling, process capability studies, zero defect program (POKA-YOKE). **TQM PRINCIPLES:** Leadership – strategic quality planning, quality statements, customer focus, customer orientation, customer satisfaction, customer complaints, customer retention - employee involvement, motivation, empowerment, team and teamwork, recognition and reward, performance appraisal, continuous process improvement – PDSA cycle, 5s, Kaizen - supplier partnership – partnering, supplier selection, supplier rating. **TQM TOOLS& TECHNIQUES**: The seven traditional tools of quality, new management tools, six-sigma concepts, methodology, applications to manufacturing, service sector including IT – bench marking– reason to bench mark, bench marking process – FMEA – Stages, Types. Quality circles – Quality Function Deployment (QFD) – Taguchi quality loss function – TPM – concepts, improvement needs – cost of quality – performance measures. **Quality Management System & Quality Audit**: Quality Systems, Quality management principles, ISO-9000:2000, ISO 9001 : 2000, ISO 14000, Future of quality system audit, Audit objectives, types of quality audit, Quality Auditor, Audit performance. Case studies of TQM implementation in manufacturing and service sectors including IT.

Or

NON CONVENSIONAL ENERGY RESOURCES:-

Introduction: Trends of energy consumption sources of energy conventional and renewable, fossil fuel – availability and limitations, need develop new energy sources, **Solar Energy:** Solar radiation characteristic, solar collectors, flat plate and concentrating types, their comparative study, design and material selection, efficiency, selective paints and surfaces, heating of air and water forbuilding and other uses.

thermal storages, solar ponds, solar pumps, solar cookers etc. direct conversion of solar energy to electricity and its various uses, materials, limitations and costs. **Bio-conversion:** Generation of bio gas, digesters and then design, selection of material, feed to digester, paralytic gasification, production of hydrogen, algae production and the their uses, **Wind Energy:** Types of rotors, horizontal axis and vertical axis system, system design and site selection. **Geo-thermal Energy:** Sites, potentiality and limitation, study of different conversion system, **Tidal Energy:** Sites potentiality and possibility of harnessing from site,limitations. **Ocean thermal energy**: Principal of utilization and its limitation,description of various systems, **Other non-conventional energy**

sources: Fluidized bed combustions,heat from waste and other sources.

Or

PRODUCTION PLANNING AND CONTROL:-

PPC performance: PPC – Requirements, benefits, factors influencing PPC performance, 3 types of decisions – 3 Phases of PPC – Aggregate and Disaggregate Planning, Master Production Schedule (MPS) –techniques & hour glass principle – Bill of Material (BOM) structuring **MRP Material Requirements Planning (MRP):** MRP System, inputs, outputs, benefits, technical issues – MRP system nervousness – Manufacturing Resources Planning (MRP II), resource planning, Final assembly scheduling **Capacity management**: Capacity Planning using overall factors (CPOF), Capacity Bills, Resource Profiles, Capacity requirements planning (CRP) – I/O Control - Shop floor control, Basic concepts, **Charts and rules:** Gantt Chart, Priority sequencing rules and Finite Loading – Inventory models. **Shop floor control**: Shop floor control – Just in time (JIT) – Key elements, techniques – JIT & PPC, pull & push systems – Kanban system-types, number of Kanban calculations, design, advantages and disadvantages, **ERP System** ERP systems

– Components, modules, implementation, advantages and disadvantages - technical aspects of SAP

- Supply Chain Management (SCM) – components, stages, decision phases – Supply chain macro processes in a firm.

13. MECHATRONICS:-

Introduction and Basics: Definition of mechatronics, a measurement system with its constituent elements, open and closed loop system, sequential controllers, micro-processor based controller, the mechatronic approach **Hardware of Measurement Systems:** Force fluid pressure, liquid flow, liquid level, temperature, light sensors along with performance terminology data presentation elements: magnetic recording, dataacquisition system, testing & calibration. pneumatic, hydraulic, mechanical and electrical actuation system: pneumatic and hydraulicsystem, mechanical systems, types of motion, kinematic chains, cams, gear, trains, ratehe t& pawl. belt & chain drivers, bearings. mechanical aspect of motor selection, electrical systems, mechanical & solid state switches, solenoids, d.c. & a.c. motors, stepper motors. **Digital Logic and Programmable Logic Controller:** A review of number system & logic gates, Boolean algebra, Kanaugh Maps, sequential logic, basic structure of programmable logic controller, input/ output processing, programming, timers, internal relays and counters, master & jump controls, data handling, analogue input/output, selection of a PLC. **Microprocessor and Input/Output System:** Control, microcomputer structure: microcontroller, applications, programming languages, instruction sets, assembly language program, subroutines, design and mechatronics: design process, traditional and mechatronics design: possible mechatronics design solutions for timed switch, wind screen wiper motion, bath room scale, a pick & place robot, automatic camera, engine management system &bar code recorder.

Or

GAS DYNAMICS:-

Compressible flow – fundamentals: The adiabatic energy equation, Energy and momentum equations for compressible fluid flows, various regions of flows, reference velocities, stagnation state, velocity of sound, critical states, Mach number, critical Mach number, types of waves, Mach cone, Mach angle, effect of Mach number on compressibility. **Flow through variable area ducts :** Isentropic flow through variable area ducts, T-s and h-s diagrams for nozzle and diffuser

flows, area ratio as a function of Mach number, mass flow rate through nozzles anddiffusers, effect of friction in flow through nozzles, **Flow through constant area ducts:** Flow in constant area ducts with friction (Fanno flow) - Fanno curves and Fanno flow equation, variation of flow properties, variation of Mach number with duct length. Flow in constant area ducts with heat transfer (Rayleigh flow), Rayleigh line and Rayleigh flow equation, variation of flow properties, maximum heat transfer. **Normal and oblique shock :** Governing equations, variation of flow parameters like static pressure, static temperature, density, stagnation pressure and entropy across the normal shock, Prandtl – Meyer equation, impossibility of shock in subsonic flows, flow in convergent and divergent nozzle with shock, **Flow with Oblique Shock** – Fundamental relations, Prandtl‟s equation, Variation of flow parameters **Propulsion:** Aircraft propulsion – types of jet engines – study of turbojetengine components – diffuser, compressor, combustion chamber, turbine and exhaust systems, performance of turbo jet engines – thrust, thrust power, propulsive and overall efficiencies, thrust augmentation in turbo jet engine, ram jet and pulse jet engines, **Rocket propulsion** – rocket engines thrust equation – effective jet velocity specific impulse – rocket engineperformance, solid and liquid propellants.

Or

VIBRATIONS:-

Basic Concepts of Vibrations: Importance and scope, definition and terminology, representation of harmonic motions, introduction to various types of vibrations and types of excitation. **Single Degree of Freedom Systems:** Un-damped Free Vibrations: D Alembert‟s Principle, Energy method, Rayleigh method, simple applications of these methods, equivalent spring stiffness, Damped Free Vibrations: Introduction to different types of damping, viscous damping, subcritical, critical and over-damping, logarithmic decrement, frequency of damped oscillations, Forced Vibrations: Solution for simple harmonic excitation, steady state vibrations, base excitation, vibration isolation and transmissibility, vibration measuring instruments, whirling of shaft without friction. **Two Degree of Freedom Systems:**Un-damped Fee Vibrations: Normal modes vibrations, natural frequencies, mode shapes, forced harmonic vibrations, torsional vibrations of two rotor system, Applications: Dynamic vibration absorber, centrifugal pendulum absorber, torsional vibration absorber, untuned vibration damper, gyroscopic effect on rotating shaft. **Multi-Degree of Freedom Systems:** Un-damped free vibrations: Reciprocity theorem, Rayleigh‟s and Dunkerley‟s method, three rotor and geared systems, **Continuous Systems:** Free vibration of the following for various end conditions: Vibration of a string, longitudinal vibrations of bar,transverse vibration of beam, torsion of vibrations of circular shaft.

{Bachelor of Engineering (Industrial) level}

PART-I

1. **MATHEMATICS:-**

Infinite series: Tests for convergence of series (Comparison, Ratio, Root, Integral, Raabe's, logarithmic), Alternating series, Absolute convergence, Conditional convergence. **Differential & Integral Calculus of single variable:** Taylor's & MaClaurin's expansion, Radius of curvature, Tracing of some standardcurves, Applications of definite integral to Area, Arc length, Surface area and volume (in Cartesian, parametric and polar co-ordinates). **Calculus of several variables**: Partial differentiation, Euler's theorem, Total differential, Taylor's theorem, Maxima-

Minima, Lagrange's methodof multipliers, Application in estimation of error and approximation. **Multiple Integrals**: Double integral (Cartesian and polar co-ordinates), Change of order of integration, Triple integrals (Cartesian, cylindrical and spherical co-ordinates), Beta and Gamma functions, Applications of multiple integration in area and volume. **Vector Differential Calculus**: Continuity and differentiability of vector functions, Scalar and Vector point function, Gradient, Directional Derivative, Divergence, Curl and their applications. **Vector Integral Calculus**: Line integral, Surface integral and Volume integral, Applications to work done by the force, Applications of Green's, Stoke's and Gauss divergence theorems. **Matrices**: Rank of a matrix, Inverse of a matrix using elementary transformations, Consistency of linear system of equations, Eigen- values and Eigenvectors of a matrix, Cayley Hamilton theorem, Diagonalization of matrix. **Ordinary differential equations:** Second & higher order linear differential equations with constant coefficients, General solution of homogenous and non - homogenous equations, Method of variation of parameters, Euler-Cauchy equation, Simultaneous linear equations, Applications to simple harmonic motion. **Special Functions**: Power series method, Frobenious method, Legendre equation, Legendre polynomials, Bessel equation, Bessel functions of first kind, Orthogonal property. **Laplace Transforms**: Basic properties, Laplace transform of derivatives and integrals, Inverse Laplace transform, Differentiation and Integration of Laplace transform, Convolution theorem, Unit step function, Periodic function, Applications of Laplace transform to initial and boundary value problems. **Fourier series** : Fourier series, Fourier Series of functions of arbitrary period, Even and odd functions, half range series, Complex form of Fourier Series, Numerical Harmonic analysis. **Fourier Transforms**: Fourier Transforms, Transforms of derivatives and integrals, Applications to boundary value problem in ordinary differential equations (simple cases only).

2. PHYSICS:-

RELATIVITY: Review of concepts of frames of reference and Galilean transformation equation, Michelson – Morley experiment and its implications, Einstein's special theory of relativity, Lorentz transformation equations, Law of addition of velocities, Mass variation with velocity, Concept of energy and momentum, Mass energy relation. **OSCILLATIONS & WAVES:** Damped and forced oscillations, Resonance (amplitude and power), Q – factor, Sharpness of resonance, Equations of longitudinal and transverse waves and their solutions, Impedance, Reflection and transmission of waves at a boundary, Impedance matching between two medium. **PHYSICAL OPTICS:** Interference by division of wave front and amplitude, Multiple beam interference and Fabry-Perot interferometer, Fresnel diffraction through a straight edge, Zone plate, Fraunhoffer diffraction, single slit and N-slit / grating, Resolving power of telescope, prism and grating. Polarization by reflection and by transmission, Brewster's law, Double refraction, elliptically and circularly polarized light, Nicol prism, Quarter and half wave plates. **OPTICAL INSTRUMENTS:** Cardinal points of co-axial lens systems, spherical and chromatic aberrations and their removal, Huygens and Ramsden's eyepiece. **Lasers:** Coherence and coherent properties of laser beams, Brief working principle of lasers, Spontaneous and stimulated Emission, Einstein's co-efficient, Ruby laser, He-Ne laser. **Optical Fiber:** Classification of optical fibers, Refractive index profile, Corecl adding refractive index difference, Numerical aperture of optical fiber, Pulse dispersion in optical fiber (ray theory). **Quantum Physics :** Failure of classical physics ,Compton effect ,Pair production, de-broglie relation, wave function, Probability density, Schrodinger wave equation, operators, expectation values and eigen- value equation, particle in a box, simple harmonic oscillator

problem, concept of degeneracy. **Classical Statistics:** Microscopic-macroscopic systems, concept of phase space, basic postulates of statistical mechanics, Maxwell— Boltzmann distribution law. **Quantum Statistics:** Fermi—Dirac and Bose–Einstein Distribution, Fermi-Dirac probability function, Fermi energy level. **Nuclear Physics:** Nuclear properties, constituent of the nucleus, binding energy, stable nuclei, radioactive decay law (alpha and beta spectrum), Q-value of nuclear reaction , nuclear models: liquid drop and shell model, nuclear fission and fusion, elementary ideas of nuclear reactors. **Electrodynamics:** Maxwell's equations, concept of displacement current, Derivation of wave equation for plane electromagnetic wave, Poynting vector. Poynting theorem, Energy density, wave equation in dielectric & conducting media, **Semiconductor Physics:** Concept of intrinsic and extrinsic semiconductors, Fermi level, characteristics of PN Junction, static anddynamic resistance, zenar diode and LED, diode as a rectifier, transistor(PNP and NPN) characteristics, current and voltage gain.

3. CHEMISTRY:-

Conventional Analysis: Volumetric Analysis, Types of Titrations, Theory of Indicators. **Spectral Methods of Analysis**: UV-visible, IR, NMR & MS: Principles and Applications. **Thermal Methods of Analysis**: Thermo-gravimetry, Differential thermal analysis and Differential Scanning Calorimetry: Principles and Applications. **Polymers & Plastics**: Functionality and Degree of Polymerization, Mechanism of Polymerization, Molecular Weights of Polymers,Methods of polymerization, Functional Polymers, Industrial applicationsof Polymers. **Electrochemistry**: Electrochemical cells, components, characteristics of batteries, Primary and Secondary battery systems, Zinc-Carbon cells, Lead storage and lithium batteries, Fuel Cells, Electro-deposition, Electrical and chemical requirements, Electroplating bath and linings, Agitation, Circulation and filtration equipment, **Phase Equilibrium**: Definitions of Phase, component and degree of freedom, Gibb's phase rule. One component systems: Water and sulphur. Two component systems: Pb-Ag and Cu-Ni. **Green Chemistry**: Principles of Green Chemistry, Examples of Green Methods of Synthesis, Reagents and Reactions, Evaluation of feed stocks, Future trends in Green Chemistry.

4. BASIC MECHANICAL ENGINEERING:-

Introduction: Introduction to Thermodynamics, Concepts of systems, control volume, state, properties, equilibrium, quasi-static process, reversible & irreversible process, cyclic process. Zeroth Law and Temperature, Ideal Gas. Heat and Work. First Law of Thermodynamics for closed & open systems. Non Flow Energy Equation. Steady State, Steady Flow Energy Equation. SecondLaw of Thermodynamics-Kelvin and Plank's Statements, Clausius inequality, Definition of Heat Engines, Heat pumps, Refrigerators. Concept of Energy and availability. Carnot Cycle; Carnot efficiency, Otto, Diesel, Dual cycle and their efficiencies. Principles of power production, basic introduction about thermal powerplant, hydroelectric power plant and nuclear power plant. Properties & Classification of Fluids, Ideal & real fluids, Newton's law of viscosity, Pressure ata point, Pascal's law, Pressure variation in a static fluid, General description of fluid motion, stream lines, continuityequation, Bernoulli's equation, Steady and unsteady flow. Introduction to engineering materials for mechanical construction. Composition, mechanical and fabricating characteristics and applications of various types of cast irons, plain carbon and alloy steels,copper,aluminum and their alloys like duralumin, brasses and bronzes cutting tool materials, super alloys thermoplastics, thermosets and composite materials. Introduction to Manufacturing processes for various machine elements. Introduction to Casting

& Welding processes. Sheet metal and its operations. Introduction to machining processes – turning, milling,shaping, drilling and boring operations. Fabrication of large and small assembles – examples nuts and bolts, turbine rotors etc. Introduction to quality measurement for manufacturing processes; standards of measurements, line standards, end standards, precision measuring instruments and gauges: vernier calliper, height gauges, micrometer, comparators, dial indicator, and limit gauges.

5. BASIC ELECTRICAL ENGINEERING:-

Introduction: Role and importance of circuits in Engineering, concept of fields, charge, current, voltage, energy and their interrelationships. V- Icharacteristics of ideal voltage and ideal current sources, various typesof controlled sources, passive circuit components, V-I characteristics and ratings of different types of R, L, C elements. DC Network: Series and parallel circuits, power and energy, Kirchhoff's Laws, delta-star transformation, superposition theorem, Thevenin's theorem, Norton's theorem, maximum power transfer theorem, Tellgen's theorem. **Single Phase AC Circuits:** Single phase emf generation, average and effective values of sinusoids, complex representation of impedance, series and parallel circuits, concept of phasor, phasor diagram, power factor, complex power, real power, reactive power and apparent power,resonance in seriesand parallel circuits, Q-factor, bandwidth and theirrelationship, half power points. **Three-Phase AC Circuits:** Three phase emf generation, delta and star connection, line and phase quantities, solution of three phase circuits: balanced supply and balanced load, phasor diagram, three phase power measurement by two wattmeter method. **Magnetic Circuits and Transformers:** Amperes circuital law, B-H curve, concept of reluctance, flux and mmf, analogies between electrical and magnetic quantities, solution of magnetic circuits, hysteresis and eddy current losses, mutual inductance and dot convention, single phase transformer – construction and principle of working, auto transformer and their applications. **Measuring Instruments:** Analog indicating instruments, PMMC ammeters and voltmeters, damping in indicating instruments, shunt and multipliers, moving iron ammeter and voltmeters, dynamometer type instruments, multimeters, AC watt-hour meters. digital voltmeters,ammeters and watt meters.

6. ENGINEERING GRAPHICS:-

General: Importance, Significance and scope of engineering drawing Lettering, Dimensioning, Scales, Sense of Proportioning, Different types of Projections, B.I.S. Specification, line symbols, rules of printing. **Projections of Points and Lines:** Introduction of planes of projection, Reference and auxiliary planes, projections of points and lines in different quadrants, traces, inclinations, and true lengths of the lines, projections on auxiliary planes, shortest distance, intersecting and non-intersecting lines. **Planes Other than the Reference Planes:** Introduction ofother planes(perpendicular and oblique), their traces, inclinations etc., projections of points lines in the planes, conversion of oblique plane into auxiliary plane and solution of related problems. **Projections of Plane Figures:** Different cases of plane figure (of different shapes) making different angles with one or both reference planes and lines lying in the plane figures making different given angles(with one or both reference planes). Obtaining true shape of the planefigure by projection. **Projection of Solids:** Simple cases when solid is placed in different positions, Axis, faces and lines lying in the faces of the solid making given angles. **Isometric andOrthographic Views:** First and Third angle of system of projection, sketching of

Orthographic views from pictorial views and vice –versa, Sectional views. Principles of dimensioning. Development of lateral surfaces of simple solids. Introduction to available drafting softwares likeAutoCAD.

7. INTRODUCTION TO ENVIRONMENTAL SCIENCE:-

Introduction to Environment: Definition, Scope, and importance of environmental studies; need for public awareness; Segments of environment- lithosphere, hydrosphere, atmosphere, and biosphere; Environmental degradation; Role of individual in environmental conservation; sustainable lifestyle, **Natural Resources:** Forest Resources : Deforestation, mining, dams and their effects on forest and tribal people; Water resources: over-utilization, floods, drought, conflicts over water, dams-benefits and problems; Mineral resources: Use and exploitation, environmental effects; Food resources: World food problems, changes caused by modern agriculture, fertilizer-pesticide problems, water logging, salinity**;** Energy resources : Growing energy needs, renewable and non renewable energy sources;Land resources : Land as a resource, land degradation, man induced landslides, soil erosion and desertification **Ecosystems and Biodiversity:** Concept of an ecosystem, Structure and function, Energy flow, Ecological succession, ecological pyramids; Types, characteristic features, structure and function of the Forest, Grassland, Desert, and Aquatic ecosystems**,** Concept of Biodiversity, definition and types, Bio-geographical classification of India; Value of biodiversity; Biodiversity at global, national and local levels; India as a mega-diversity nation; Hot-sports of biodiversity; Threats to biodiversity, Endangered and endemic species of India, Conservation of biodiversity. **Environmental Pollution:** Definition, Cause, effects and control measures of: Air pollution, Water pollution, Soil pollution, Marine pollution, Noise pollution, Thermal pollution, Nuclear hazards Solid waste Management: Causes, effects and control measures of urban and industrial wastes, Role of an individual in prevention of pollution, Pollution case studies, Disaster management: floods, earthquake, cyclone and landslides **Social Issues and Environment:** Sustainable development, Urban problems related to energy, Water conservation, rain water harvesting, watershed management, Resettlement and rehabilitation of people; its problems and concerns. Environmental ethics: Issues and possible solutions. Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Wasteland reclamation, Consumerism and waste products, Environment Laws and Acts, Issues involved in enforcement of environmental legislation, Public awareness. Population growth, variation among nations, Family Welfare Programme.

8. PROGRAMING FUNDAMENTALS:-

Introduction: Concepts of algorithm, flow chart, Introduction to different Programming Languageslike C, C++, Javaetc. Elementary Programmingin C: Data types, assignment statements, Arithmetic, unary, logical, bit-wise, assignment and conditional operators, conditional statements and input/output statements. Iterative programs using loops- While, do-while, for statements, nestedloops, if else, switch, break, Continue, and goto statements, comma operators, Concept of subprograms, Array representation, Operations on array elements, using arrays,multidimensional arrays, Structures & Unions: Declaration and usage of structures and Unions, Defining and operations on strings. Pointers: Pointer and address arithmetic, pointer operations and declarations, using pointers as function argument, File: Declaration of files, different types of files. File input/ output and usage-, File operation: creation, copy, delete, update, text file, binary file.. Concept of macros and pre-processor commands in C, Storage types: Automatic, external, register and static variables, Sorting and searching algorithms:

selection sort, bubble sort, insertion sort, merge sort, quick sort and binary search. Introduction to Object Oriented Programming: OOPS concepts: class, encapsulation, inheritance, polymorphism, overloading etc., C++ introduction, Concept of class, methods, constructors, destructors, inheritance.

9. KINEMATICS & DYNAMICS OF MACHINES:-

General concepts, Velocity and Acceleration Analysis: Introduction of Simple mechanism, Different types of Kinematics pair, Grublers rule for degree of freedom, Grashof‟s Criterion for mobility determination Inversions of 4R, 3R-P, 2R-2P chains, Kinematic analysis of planar mechanism by graphical and vectorial analysis, **Cams:** Classification, Analysis of Cams with uniform acceleration, and retardation, SHM, Cycloidal motion, oscillating followers and with specified contours, **Vibrations:** Vibration analysis of SDOF systems, natural, dampedforced vibrations, based excited vibrations, transmissibility ratio, **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, **Dynamic Analysis:** Slider-crank mechanism, turning moment computations and flywheel. **Balancing:** Static and Dynamic balancing, balancing of revolving and reciprocating masses, single and multi- cylinder engines, V engines, **Gyroscopes:** Gyroscopic law, effect of gyroscopic couple on automobiles, ships, aircrafts. **Mechanical governors-** Classification, characteristics, and properties.

10. ENGINEERING MATERIALS & METALLURGY:-

Structure of metal: Crystal structure, miller indices for cubic and HCP crystals. Crystal imperfections and their effect on Mechanical properties of the material, Plastic deformation of single and Poly crystalline materials. **Materials**: Plain Carbon steels, effect of alloying elements, properties and uses, tool steels, stainless, wear resisting steels. Composition, properties, and use of non-ferrous alloys e.g. Aluminum, Copper and Zinc alloys, **Corrosion**: Types of corrosion, Galvanic cell, rusting of Iron, Methods of protection from corrosion. Solidification: Phases in metal system, lever rule, solidification of metal and alloys, solid solution, eutectic, eutectoid and inter-metallic compounds, Iron carbon equilibrium diagram, TTT-diagram, Heat Treatment: Heat treatment of Ferrous and Nonferrous materials, case hardening. Strengthening mechanisms Fracture: Types of Fracture of metals and alloys, brittle and ductile, fracture, fatigue failure, effect of alloying elements, design consideration.Creep: Basic consideration in the selection of material for high and lowtemperature service, Creep curve, effect of material variables on creepproperties, brittle failure at low temperature **Composite materials:** Classification of the Composite material basedon the reinforcement, characteristics, application of composite materialsin industry, **Powder Metallurgy**: Principles, techniques, application and advantages. Surface treatment.

11. THERMAL ENGINEERING:-

Fundamentals: Properties of pure substance in Solid, Liquid and Vapour Phase, PVT Behavior of simple compressible system, T-S and H-S diagram, Steam Tables, determination of quality of steam, Throttling Calorimeter, Combined Separating & Throttling Calorimeter, Maxwell and other thermodynamics relations, mixture of non reactive ideal gases, Real gases, Compressibility chart, Law of corresponding state, Air watervapor mixture, calculation of properties of air water vapour mixture, **Rankine Cycle and Analysis:** Rankine cycle and its representation on T-S

and H-S diagrams; Effect of low back pressure and high entry pressure and temperature and its limitations; necessity of re-heating, ideal and actual regenerative feed water heating cycle and its limitations. Typical feed water heating arrangements for various capacity power plants, **Introduction to Boilers:** Classification of Boilers, Boiler mountings and accessories; draft systems, circulation system; Combustion and its calculations, and Boiler performance, **Steam Nozzles:** Types of Nozzles, Flow of steam through nozzles; Condition for maximum discharge through nozzle; Nozzle efficiency. Effect of friction and Supersaturated flow through nozzle, **Steam Turbines:** Working principle and types of steam turbines; Velocity diagrams for impulse and reaction turbines, compounding of impulse turbines; Optimum velocity ratio and maximum efficiency. Bladetwisting, comparison of impulse and reaction turbines. Condition line andreheat- factor, losses in steam turbines; governing of steam turbines, **Condensers and Cooling towers:** Types and working of condensers,types and performance of cooling towers, **Reciprocating Air Compressor:** Steady flow analysis, isothermal, adiabatic and polytropic compression; single and multi-stage compression, ideal intermediate pressure; compressor clearance, volumetric and isothermal efficiency; minimum work requirement of a compressor, **Centrifugal compressor:** Velocity diagrams, efficiency of compressor stage, choice of reaction, stage pressure rise, surging, multi-stage compressor, compressor performance, vaccum pump, **Gas Power Cycles:** Air standard cycle; Otto, Diesel and Dual Cycles, P-Vand T-s diagrams of these cycles. Efficiency,mean effective pressure.Comparison of Otto, Diesel, dual cycles for same compression ratio and heat input. Stirling cycles, Ericsson cycle, Atkinson cycle, Basic Gas turbine (Brayton) cycle (foropen and closed systems). Efficiency of gas turbine cycle, **Gas Turbines :** Simple open andclose cycle gas turbine,, efficiency and specific output of simple cycle, effects of – regeneration, re-heating and inter-cooling on efficiency and work output, effect of operating variables on thermal efficiency, air rate, work ratio; water injection, Advantages and disadvantages of gas turbine, gas turbine components, performance and application of gas turbine, **Heat Transfer:** Modes of heat Transfer, conduction, convention, radiation, one dimensional steady state conduction, Fourier law, thermal resistance, analogy with electrical circuits, critical thickness of insulation, Newton's law of cooling and significance of heat transfer coefficient, forced and natural convection, overall heat transfer coefficient, Physical mechanism of thermal radiation, definition of black body, lawsof radiation, emissivity, reflectivity, transmissivity and irradiation.

12. <u>MANUFACTURING MACHINES:-</u>

Introduction to machine tools, Classification, Cutting tools, Types of motions in machining, Lathe, Types of lathe machines, Lathe parts, Lathe accessories and attachments, Lathe operations, Shaper, Planer and Slotter, Difference between Shaping, Planning and Slotting machine, Machining parameters and related quantities in turning, shaping and planning, Turret, Capstan and Automatic machines, Turret and Capstan lathe ascompared to a centre lathe, Toolinglayouts on Turret and Capstan lathe, Features of other types of lathes like Copying lathe, Automatic lathes, Automatic screw cutting machine, NC and CNC lathes- Constructional features, CNC Chucker and Jig Boring machine, Drilling machine, Types of drilling machines, Geometry and nomenclature of a Twist drill, Drilling operations, Milling machines, Types of milling machines, Milling cutters, Milling accessories, Different milling operations, Machining parameters and related quantities in drilling and milling, Design Features of Machine Tools, Performance criteria of machine tools, Steps in design of machine tools, Design of machine tool drives,Design of machine tool spindle, Grinding, Different types of grinding machines, Grinding

wheel specifications, Machining parameters and related quantities in cylindrical grinding and surface grinding, Gear manufacturing machines, Gear forming, Gear hobbing, Gear shaper and Gear generator.

13. ENGINEERING ANALYSIS & DESIGN (MODELING AND SIMULATION):-

Introduction: Design, Specification of design objectives and constraints, Different phases of design process, **System modeling:** Modeling of multi-energy systems like mechanical,electrical, hydraulic, thermal etc. **Engineering Analysis**: Role of analysis, Design spiral, Computer Aided Engineering Analysis, Introduction to FEM software and simulation tools, Visualization, Iterative process in design, Analysis and testing of design projects, Instrumentation, **Learning from failure**: Types of failure, Failure of machine components, Famous case studies of failure, e.g., Liberty ships, Comet aircraft, Challenger space shuttle etc., **Engineering Design**: Projects for design of machine elements, **Communication of Technical information:** written and oralpresentation, posters, report writing, Engineering Ethics, Social responsibility, Sustainable design,Environmental issues, **Basics of statics:** Force, moment of a force, couple, equilibrium ofa particle and rigid body, free body diagram, equivalent force system, D'Alembert's principle, truss, inertia tensor. **Basics of stress analysis:** State of stress at a point, stress tensor, strain tensor, constitutive law, stress-strain diagram of structural steel, equilibrium equation, uniaxial loading in a bar, stresses for bending andtorsion, deflection, buckling.

14. FUNDAMENTAL MANAGEMENT:-

Definition of management, importance of management, management principles, managerial roles, managerial ethos, management vs administration, managerial functions, task and responsibilities, organizational structure, motivation: meaning, theories and techniques, Concept of business environment, corporate social responsibility and corporate governance, managerial values and ethics, Objectives and importance of financial management, basics of capital budgeting, cost of capital, emerging sources of funds for new projects, introduction to stock market, Functions of marketing, marketing Vs sales, interface of marketing with other departments, customer life time value, new product development, unethical issues in marketing, Introduction to knowledge management, knowledge society, knowledge economy, building knowledge assets, sources of knowledge, technology innovation process, E-governance: definition, objectives and significance; challenges in Indian context, Digital India programme.

15. MACHINE DESIGN:-

Introduction: Principles of mechanical design, systematic design process, aesthetic and ergonomic considerations in design, use of standards in design. Manufacturing consideration in design, casting, machining, and forging. Dynamic and fluctuating stresses, fatigue failure and endurance limit, stress concentration, causes and remediesin design, Factor of safety, Tolerances and types of fits. Selection of materials, **Design of Elements**: Cotter and knuckle joints; screwed fastenings, bolted and riveted joints under direct and eccentric loads, initial tightening loads in bolts, **Welded Joints:** Welded joints, strength of welded joints, eccentrically loaded joints, welded joints subjected to bending moment and torsion, **Shafts and Couplings:** Shafts, keys and couplings –design of rigid and pin bushed flexible couplings. Translation screws: force analysis and design of various types of power screws. Springs, uses and design of close coiled helical springs shot pining of springs, **Mechanical Drives**: Selection of transmission, helical, bevel and worm gears, belt and chain drives, **Friction Clutches & Brakes**: Common friction

materials, shoe, band,cone and disc brakes their characteristics and design, friction clutches.

16. INDUSTRIAL ENGINEERING & OPERATION RESEARCH:-

Product and Process Design: Product design and development processes, product life cycle, Process flow chart, Types of processes, Process performance, Learning curve, **Facility location and Layout:** Factors affecting the location decisions, methods of facility location- factor rating systems, centroid method, and profit volume analysis; Types of layout, Block diagram and Assembly Line Balancing. **Demand Forecasting:** Qualitative and quantitative forecasting, Time series and regression models, Measures of forecasting errors. **Inventory model:** Importance of inventory, under stocking and overstocking, fixed order quantity models and fixedtime period models (EOQ models), Selective inventory management- ABC, VED, and FSN analysis **Linear Programming:** Problem formulation, solution through graphical method, Simplex method and artificial variable method. **Transportation Models:** Transportation and transshipment problems, assignment and sequencing models.

PART-II

1. FLUID MECHANICS & MACHINERY:-

Fluid Mechanics: Prosperities of fluids, static pressure and its measurement, forces in fluids, fluid motions, streamlines, and stream-tubes, acceleration of a fluid particle; Bernouli's Theorem. Continuity, momentum and energy principles and their applications in fluid measurement, pitot tubes, venturimeters. Dimensional analysis and theory of similarity; Laminar and turbulent flow in pipes. Moody's diagram, flow over external surfaces-empirical formulae. Introduction to hydrodynamic machines: Pumps and Turbines, classification, elementary analysis, performance characteristics Hydraulic and pneumatic circuits, power unit, accumulators and intensifiers; valves for pressure, flow and direction control and compensations, PID controls of fluid systems Introduction to Computational fluid dynamics, Application of CFD for simple problems..

2. METAL CUTTING & TOOL DESIGN:-

Nomenclature of a single point cutting tool, Orthogonal and oblique cutting, Chip flow direction,Tool angles specification systems, Mechanics of chip formation, Types of chips, Chip control and chip breakers, Force relationship in orthogonal cutting, Forces on a single point tool in turning, Shear angle and its relevance, Theoretical models of shear angle solution, Limitations and modifications of Merchant"s theory, Ploughing forces and the, Size effect", Friction in metal cutting.Heat generation in metal cutting, Sources of heat generation in metal cutting, Calculation of temperature in primary and secondary deformation zones, Measurement of chip-tool interface temperature, Cutting fluids and their physical action, Selection of cutting fluids, Cutting tool materials, Tool wear, Tool wear mechanisms, Types of tool wear, Wear and chipping characteristics of different tool materials, Tool life, Tool life criteria, Machinability, Economics of machining, Grinding, Characteristics of grinding process, Effect of grinding conditions on wheel behaviour, Analysis of grinding processes, Equivalent diameter of grinding wheel, Thermal aspects of grinding, Grinding fluids, Grinding wheel wear, Analysis of milling processes, Tool Design, Tool design consideration, Selection of tool materials, Tooling economics and safety as related to tool design. Design of Single point cutting tools, Design of Carbide and Ceramic tipped tools, Design of Chip breakers, Design of Multi point cutting tools,

Design of Broaches, Twist drill, Reamers and Milling cutters. Jigs & Fixtures: General design principles, Location accuracy, Clamping and indexing devices, Designof drilling.

3. ENGINEERING ECONOMICS:-

Introduction: Nature and significance of economics, Goods and Utility, Basic Concept of Demand and Supply, Elasticity of Demand- Price elasticity of Demand, Cross elasticity of Demand, Production - Production Function, Production Process and Factors of Production, Market – Introduction to Monopoly, Perfect Competition, Oligopoly and Monopolistic Competition, Cost Concepts- Opportunity Cost, Total Cost, Average Cost; Marginal Cost; Life Cycle cost, Sunk Cost; Preparation of Cost Sheet Profit Maximisation- numerical problem, **Money- Its evaluation and function, Bank- Commercial Bank and Central Bank and brief idea about function of banking system:**. Tax and Subsidy, Type of Tax- Direct and Indirect, Monetary and fiscalpolicy, Inflation and Business cycle, International trade, terms of Trade,Gain from International Trade, Free Trade vs. Protection, Dumping, Balance of Payment, **Role of Science, Engineering and Technology in Economic Development:** Seven salient Feature of the Indian Economy; Inclusive Growth; relevance for the Indian Economy; Globalisation & opening up of the Indian Economy; GDP- definition and Its measurement; How knowledge of engineering and technology may be used to improvelife at slum; Green Revolution and White revolution. Reasons for their success and can we replicate them. Appropriate Technology & Sustainable Development. Entrepreneurship: Macro environment for promotion of entrepreneurship: How environment has changed after advent of IT and Globalisation, **Elementary Economic Analysis:** Interest formulas and their Applications; Calculations of economic equivalence, Bases for Comparison of Alternatives: Present Worth Method, Future worth method, Annual equivalent, Internal Rate of Return; Business Risk; Factors which should be taken care while deciding price of the productin the market.

4. CASTING TECHNOLOGY:-

Introduction to casting, casting terminology, solidification process, Pattern and its allowances, Design considerations in castings, economics of castings, Expandable mould casting processes:- Foundry sands, and their properties; moulding processes; clays: montmorillonite, kaolinite & Illite; Core types and core making processes; expandable- mould processes with permanent pattern, expandable- mould processes with single use pattern, Gating and Risering principles, Permanent Mould Casting Processes: Die casting- gravity die casting, Low pressure die casting, high pressure die casting and vacuumdie castings; squeeze casting, centrifugal casting, semi centrifugal, centrifuging; continuous casting, electromagnet casting, slush casting, Melting practices and melting furnaces, metal pouring; cleaning, Finishing, Foundry automation, Robots in foundry operation, process selection, automatic flaskless moulding, Heat treatment of castings, casting defects: causes and remedies.

5. WELDING TECHNOLOGY:-

Introduction to welding: General survey and classification of welding processes, Safety and hazards in welding, Power sources for arc welding. Welding consumables: fluxes, gases and filler materials, Electrodes: types, coatings and its functions, selection of electrodes, designation of electrodes as per Indian standard. Metal transfer and itsimportance in welding, various forces acting on a molten droplet, Gas welding processes and equipments. Arc welding processes: Shielded metal arc welding, Submerged arc welding Gas tungsten arc welding, Gas metal arc welding, & its variants, Electro slag welding and Electro gas welding, Plasma arc welding, Resistance welding, & its variants, Modern welding processes: Electron beam welding,

Ultrasonic welding, Laser welding, Explosive welding, Friction stir welding, Soldering and brazing, Weldability: Weldability of commonly used materials: Carbon steels, Stainless steels, Cast iron, Cu and its alloys, Al and alloys, Defects in welds, Non-destructive testing of welds.

6. PRECISION MANUFACTURING:-

PRECISION ENGINEERING -Introduction – Precision, Accuracy & Smoothness – Need – Development of overall machining precision- Classes of achievable machining Accuracy-Precision machining-High precision Machining-Ultra precision Machining-application of precision machining- Materials for tools and machine elements – carbides – ceramic, CBN & diamond-Tool and work material compatibility, PRECISION MACHINE ELEMENT-Introduction – Guide ways – Drive systems – Spindle drive – preferred numbers - Rolling 83 elements– hydrodynamic & hydrostatic bearings –Hybrid fluid bearings- Aero static and aero dynamic bearings-Hybrid gas bearings-materials for bearings, ERROR CONTROL- Error – Sources – Static stiffness – Variation of the cutting force – total compliance – Different machining methods– Thermal effects – heat source – heat dissipation – Stabilization – decreasing thermal effects – forced vibration on accuracy – clamping &setting errors – Control – errors due to locations – principle of constant location surfaces, PRECISION MANUFACTURING-Micro machining processes-diamond machining - micro engraving - Micro replication techniques-forming- casting-injection moulding - micro embossing - Energy assisted processes - LBM, EBM, FIB, Micro electro discharge machining- photolithography-LIGA process- Silicon micro machining-Wet and dry etching-thin film deposition, MEMS Introduction – MEMS – characteristics- principle – Design – Application: automobile, defence, health care, Industrial, aerospace etc.

7. HYDROLOGY & GROUND WATER ENGINEERING:-

Precipitation: Precipitation: Scope of hydrologic cycle, World water balance, India's water balance, Types and forms of precipitation, Measurement of precipitation, Types of rain gauges, Adequacy of rain gauges, Adjustment and filling in of missing dada, Average rainfall over an area, Basic statistics and frequency analysis. Evaporation: Evaporation: Evaporation and its measurements, Estimation of evaporation. Formulae of Penman, Thornthwaite and Blaney-Criddle method. Evaporation control. Infiltration: Factors affecting infiltration, Infiltrometers, Infiltration indices. Run Off: Surface run off, factors affecting run off, Hydrographs, flow rating curves and flow duration curves. Mass curve. Rainfall run-off relationship. Stream gauging, measurement of stage and velocity, Unit Hydrograph: Unit hydrograph. Derivation of unit hydrograph. Synthetic UH, IUH. Floods: Flood flow formulae, Frequency analysisusing external type and log Pearson type III distribution, flood routing through reservoirs, Ground Water: Elements of Ground Water modeling:-Darcy's law, unconfined and confined aquifers, and their properties, steady and unsteady flow in wells, ground water quality, sources of pollution, remedial and preventive measures, ground water budgeting and recharging of ground water.

8. METROLOGY & QUALITY ASSURANCE:-

Principles of measurement: Definition of Metrology, difference between precision and accuracy. Sources of errors: Controllable and Random Errors, Effects of Environment and Temperature, Effects of support, alignment errors, application of Least Square principles,

errorsinmeasurement of a quality which is function of other variables, **Length Standards:** Line standards, end standards and wavelength standards, transfer from line standards to end standards.Numerical based on line standards. Slip gauges, its use and care, methods of building different heights using different sets of slip gauges, **Limits, fits and tolerances**: Various definitions, IS919-1963, differenttypes of fits and methods to provide these fits. Numerical to calculate the limits, fits and tolerances as per IS 919- 1993. ISO system of limitsand fits; Gauges and its types, limit gauges – plug and ring gauges. Gauge Design – Taylor's Principle, wear allowance on gauges. Differentmethods of giving tolerances on gauges, **Comparators:** Characteristics, Uses, Limitation, Advantages and Disadvantages. Mechanical Comparators: Johanson Mikrokator and Signma Mechanical Comparator. Mechanical - optical comparator. Electrical and electronic comparators. Pneumatic comparators – Systems of Penumatic gauging: Flow type and back pressure type, different type of sensitivities and overall magnification. Solex Pneumatic gauge and differential comparators, **Angular Measurement**: Sine Bar – different types of sine bars, use of sine bars in conjuction with slip gauges, precautions and calibration of sine bars. Use of angle gauges, spirit level, errors in use of sine bars. Principle and working of Micro-optic autocollimator. Circular Division: dividing head and circular tables, circular division by precision Polygons. Caliper Principle, Calibration of polygons. Numerical based on circular division, **Straightness and flatness**: Definition of Straightness and Flatness error. Determination of straightness error of straight edge with the helpof spirit level and auto collimator. Determination of flatness error of a surface plate with the help of spirit level or auto collimator, **Screw Thread Measurement:** Errors in threads, Measurement ofelements of screw threads – major diameter, minor diameter, pitch, flank angle and effective diameter (Two and three wire methods). Effectof errors in pitch and flank angles and its mathematical derivation, **Gear Measurement**: Measurement of tooth thickness – Gear tooth vernier caliper, Constant chord method, base tangent method and derivation of mathematical formulae for each method. Test plugs method forchecking pitch diameter and tooth spacing. Measurement of Gear Pitch, Parkinson Gear Tester, **Machine Tool Alignment**: Machine tool tests and alignment tests on lathe. Alignment tests on milling machine. Alignment tests on a radial drilling machine. **Interferometry:** Principle of measurement, Interferometry applied to flatness testing, surface contour tests, opticalflats, testing of parallelism of a surface with the help of optical flat. Quantitative estimate of error in parallelism, Flatness Interferometer NPL-Gauge length interferometer for checking the error in slip gauges. Numericals based on Interferometry. **Surface texture**: Introduction, different types of irregularities, standard measures for assessment and measurement of surface finish.

9. METAL FORMING & PRESS WORKING:-

Introduction: Metal forming, Review of tensile test, strain hardening, plastic yield criteria, Flow of metals, classification of processes and their characteristic. Friction and lubrication in forming processes, Mechanics of forming processes, spring back, effect of various parameters Strip and disc forming – Mechanics, pressure distribution, total force, Drawing, drawing force, power, maximum allowable reduction. Extrusion, force required in extrusion, maximum reduction. Deep drawing, stress distribution effect of friction, blank to folding force, Rolling, roll pressure, roll

separating force, driving torque and power, roll pass design bending, Work load. High Energy Rate Forming : Introduction, Principle of operation, Advantages, Limitations, uses & applications of Explosive Forming, Electro Hydraulic Forming, Magnetic Pulse Forming, Presses and Press working-Introduction to mechanical hammering machine, dies design, and wear.

10. QUANTITATIVE TECHNIQUES:-

Introduction to statistics-Nature and role of statistics in management, Measures of central tendency, dispersion, Skewness and Kurtosis, Moments, Introduction to probability theory-Probability theory, jointly distributed random variables, distributions - continuous and discrete; Sampling distributions, Hypothesis Testing- Parameter estimation and hypothesis testing; Parametric tests; Z test, t-test, ANOVA; Non-parametric tests; Chi- square test, Correlation and regression analysis, Applications of statistical packages, Linear Programming-Introduction to Linear programming, duality, sensitivity analysis, Introduction to non-linear programming, Integer Programming- Introduction to Integer programming; pure integer case, mixed integer case, cutting plane method and branch andbound method, Decision Theory-Decision Tree, GameTheory-Minimax and Maximin,Dominance Principle and use of OR software packages.

11. TOTAL QUALITY MANAGEMENT:-

Introduction to Quality- Definition of Quality- product, user, value, and manufacturing based perspectives, Dimensions of Quality, Quality Planning, Quality costs- optimization of quality costs, seven tools of quality control; Philosophies of Quality Gurus- Deming, Juran, Crosby, Feigenbaum, Ishikawa, Taguchi. Comparison of Quality Philosophies, **Statistical Process Control-**Introduction to Quality characteristics- variables and attributes, Types and causes of variations, Control Chartsfor variables and attributes, Process capability, **Acceptance Sampling-** Sampling process and lots formation; Advantages and applications of acceptance sampling; characteristics of O.C. Curve; Single, double, multiple, sequential sampling; ASN, ATI, AOQL, AOQ, AQL, LQL, Producer's and Consumer's risks, **Six Sigma and ISO 9000:2000-** Principles of Six Sigma, Statistical basis, Tools and techniques, DMAIC principle, application of six sigmain manufacturing and service organizations, structure of ISO standards, Factors leading to ISO, Implementation and registration, Benefits of ISO, **Life Testing-Reliability-**Life testing: objective, failure data analysis, MTTF, MTBF, hazard rate, exponential and Weibull models, system reliability-series, parallel and mixed configurations, Markov model, **Reliability Design and Allocation-** Design for reliability, reliability improvement techniques, active redundancy and standby redundancy,K-out-of-N redundancy and maintenance policies.

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Section Officer (R-III)
H. P. Public Service Commission