# Syllabus for Written Examination of Junior Engineer (Civil)

## STRUCTURAL MECHANICS

**Review Of Basic Concepts**

Basic principle of mechanics: force, moment, support conditions, conditions of equilibrium, C.G & M.I, free body diagram, review of C.G and M.I of different sections.

**Simple Stresses and Strains**

Introduction to stresses and strains: mechanical properties of materials – rigidity, elasticity, plasticity, compressibility, hardness, toughness, stiffness, brittleness, ductility, malleability, creep, fatigue, tenacity, durability, types of stresses -tensile, compressive and shear stresses, types of strains - tensile, compressive and shear strains, complimentary shear stress - diagonal tensile / compressive stresses due to shear, elongation and contraction, longitudinal and lateral strains, poisson's ratio, volumetric strain, computation of stress, strain, poisson's ratio, change in dimensions and volume etc, Hooke's law - elastic constants, derivation of relationship between the elastic constants.

**Application of simple stress and strain in engineering field**

Behaviour of ductile and brittle materials under direct loads, stress strain curve of a ductile material, limit of proportionality, elastic limit, yield stress, ultimate stress, breaking stress, percentage elongation, percentage reduction in area, significance of percentage elongation and reduction in area of cross section, deformation of prismatic bars due to uni-axial load, deformation of prismatic bars due to its self weight.

**Complex stress and strain**

Principal stresses and strains: occurrence of normal and tangential stresses, concept of principal stress and principal planes, major and minor principal stresses and their orientations, Mohr's circle and its application to solve problems of complex stresses.

**Stresses In Beams and Shafts**

**Stresses in beams due to bending:** Bending stress in beams – theory of simple bending assumptions– moment of resistance – equation for flexure– flexural stress distribution – curvature of beam – position of n.a. and centroidal axis – flexural rigidity – significance of section modulus.

**Shear stresses in beams:** Shear stress distribution in beams of rectangular, circular and standard sections symmetrical about vertical axis.

**Stresses in shafts due to torsion:** Concept of torsion, basic assumptions of pure torsion, torsion of solid and hollow circular sections, polar moment of inertia, torsional shearing stresses, angle of twist, torsional rigidity, equation of torsion.

**Combined bending and direct stresses:** Combination of stresses, combined direct and bending stresses, maximum and minimum stresses in sections, conditions for no tension, limit of eccentricity, middle third/fourth rule, core or kern for square, rectangular and circular sections, chimneys, dams and retaining walls.

**Columns and Struts**

Columns and struts, definition, short and long columns, end conditions, equivalent length / effective length, slenderness ratio, axially loaded short and long column, Euler's theory of long columns, critical load for columns with different end conditions.

**Shear Force and Bending Moment**

**Types of loads and beams:** Types of loads: concentrated (or) point load, uniformly distributed load (udl), types of supports: simple support, roller support, hinged support, fixed support, types of reactions: vertical reaction, horizontal reaction, moment reaction, types of beams based on support conditions: calculation of support reactions using equations of static equilibrium.

**Shear force and bending moment in beams**

Shear Force and Bending Moment: Signs convention for S.F. and B.M, S.F and B.M of general cases of determinate beams with concentrated loads and udl only, S.F and B.M diagrams for cantilevers, simply supported beams and over hanging beams, position of maximum B.M, point of contra flexure, relation between intensity of load, S.F and B.M.

**Slope and Deflection**

**Introduction:** Shape and nature of elastic curve (deflection curve); relationship between slope, deflection and curvature (no derivation), importance of slope and deflection.

slope and deflection of cantilever and simply supported beams under concentrated and uniformly distributed load (by double integration method, Macaulay's method).

**Indeterminate Beams**

Indeterminacy in beams, principle of consistent deformation/compatibility, analysis of propped cantilever, fixed and two span continuous beams by principle of superposition, S.F and B.M diagram (point load and udl covering full span).

**Trusses**

**Introduction:** Types of trusses, statically determinate and indeterminate trusses, degree of indeterminacy, stable and unstable trusses, advantages of trusses.

**Analysis of trusses:** Analytical method ( method of joints, method of section).

## GEOTECHNIAL ENGINEERING

**Introduction**

Soil and soil Engineering, scope of soil mechanics, origin and formation of soil

**Preliminary Definitions and Relationship**

Soil as a three phase system, water content, density, specific gravity, voids ratio, porosity, percentage ofair voids, air content, degree of saturation, density index, bulk / saturated / dry / submerged density, inter-relationship of various soil parameters.

**Index Properties of Soil**

Water content, specific gravity, particle size distribution: sieve analysis, wet mechanical analysis, particle size distribution curve and its uses, consistency of soils, Atterberg's limits, plasticity index, consistency index,liquidity index.

**Classification of Soil**

General, I.S. classification, plasticity chart.

**Permeability and Seepage**

Concept of permeability, Darcy's law, co-efficient of permeability, factors affecting permeability, constant head permeability and falling head permeability test, seepage pressure, effective stress, phenomenon of quick sand.

**Compaction and Consolidation**

**Compaction:** Compaction, light and heavy compaction test, optimum moisture content of soil, maximum dry density, zero air void line, factors affecting compaction, field compaction methods and their suitability.

**Consolidation**: Consolidation, distinction between compaction and consolidation, Terzaghi's model analogy of compression/ springs showing the process of consolidation – field implications.

**Shear Strength**

Concept of shear strength, Mohr- Coulomb failure theory, cohesion, angle of internal friction, strength envelope for different type of soil, measurement of shear strength;- direct shear test, triaxial shear test, unconfined compression test and vane-shear test

**Earth Pressure on Retaining Structures**

Active earth pressure, passive earth pressure, earth pressure at rest, use of Rankine's formula for the following cases (cohesion-less soil only)

(i)Backfill with no surcharge (ii) backfill with uniform surcharge

**Foundation Engineering**

Functions of foundations, shallow and deep foundation, different type of shallow and deep foundations with sketches, types of failure (general shear, local shear & punching shear),bearing capacity of soil, bearing capacity of soils using Terzaghi's formulae & I.S code formulae for strip, circular and square footings, effect water table on bearing capacity of soil, plate load test and standard penetration test.

## BUILDING MATERIALS AND CONSTRUCTIONS TECHNOLOGY

**BUILDING MATERIALS**

**Stone**

Classification of rock, uses of stone, natural bed of stone, qualities of good building stone, dressing of stone, characteristics of different types of stone and their uses.

**Bricks**

Brick earth – its composition, brick making – preparation of brick earth, moulding, drying, burning in kilns (continuous process), classification of bricks, size of traditional and modular bricks, qualities of good building bricks.

**Cement, Mortar and Concrete**

Cement: Types of cements, properties of cements, manufacturing of cement, importance and application

of blended cement with fly ash and blast furnace slag.

Mortar: Definition and types of mortar, sources and classification of sand, bulking of sand, use of gravel, morrum and fly ash as different building material.

Concrete: Definition and composition- water cement ratio- workability, mechanical properties and grading of aggregates, mixing, placing, compacting and curing of concrete.

**Other Construction Materials**

Timber: Classification and structure of timber, seasoning of timber - importance, characteristics of good timber, clay products and refractory materials – definition and classification, properties and uses of refractory materials- tiles, terracotta, porcelain glazing iron and steel: uses of cast iron, wrought iron, mild steel and tor steel.

**Surface Protective Materials**

Composition of paints, enamels, varnishes, types and uses of surface protective materials like paints, enamels, varnishes,distempers, emulsion, french polish and wax polish.

**CONSTRUCTIONS TECHNOLOGY**

**Introduction**

Buildings and classification of buildings based on occupancy, different components of a building
site investigation – objectives, site reconnaissance and explorations.

**Foundations**

Concept of foundation and its purpose, types of foundations – shallow and deep.
shallow foundation- constructional details of : spread foundations for walls, thumb rules for depth and width of foundation and thickness of concrete block.
Deep foundations: Pile foundations-their suitability, classification of piles based on materials, function and method of installation.

**Walls & Masonry Works :**

Purpose of walls, Classification of walls – load bearing, non-load bearing walls, retaining walls. classification of walls as per materials of construction: brick, stone, reinforced brick,reinforced concrete, precast, hollow and solid concrete block and composite masonrywalls (Concept Only).
Partition Walls : Suitability and uses of brick and wooden partition walls.
Brick masonry : Definition of different terms.
Bond – meaning and necessity: English bond for 1and 1-1/2 Brick thick walls. T, X and right angled corner junctions, Thickness for 1 and 1-1/2 brick square pillars in English bond.
Stone Masonry :
Glossary of terms –String course, corbel, cornice, block-in-course, grouting, mouldings, templates, throating, through stones, parapet, coping, pilaster and buttress.

**Doors, Windows And Lintels**

Glossary of terms used in doors and windows, doors – different types of doors, windows – different types of windows, purpose of use of arches and lintels.

**Floors, Roofs and Stairs**

Floors: Glossary of terms ,types of floor finishes – cast-in-situ, concrete flooring(monolithic, bonded), terrazzo tile flooring, cast in situ terrazzo flooring, timber flooring (Concept only)
Roofs: glossary of terms, types of roofs, concept and function of flat, pitched, hipped and sloped roofs
Stairs: Glossary of terms; stair case, winder, landing, stringer, newel, baluster, rise, tread, width of stair case, hand rail, nosing, head room, mumty room, Various types of stair case – straight flight, dog legged, open well, quarter turn, half turn (newel and geometrical stairs), bifurcated stair, spiral stair, cantilever stair, tread riser stair.

**Protective, Decorative Finishes, Damp and Termite Proofing**

Plastering – purpose – types of plastering, Types of plaster finishes – grit finish, rough cast, smooth cast, sand faced, pebble dash, acoustic plastering and plain plaster etc., proportion of mortars used for different plasters, preparation of mortars, techniques of plastering and curing
Pointing – purpose –types of pointing
Painting – objectives – method of painting new and old wall surfaces, wood surface and metal surfaces – powder coating and spray painting on metal surfaces.
White washing – colour washing – distempering – internal and external walls.
Damp and Termite proofing – Materials and methods.

**Green Buildings, Energy Management and Energy Audit Of Buildings & Project**

Concept of green building, introduction to energy management and energy audit of buildings, aims of energy management of buildings, types of energy audit, response energy audit questionnaire, energy surveying and audit report.

## ESTIMATION & COST EVALUATION – I

**Introduction**

Types of estimates – Plinth area, floor area / carpet area, units and modes of measurements as per IS 1200, accuracy of measurement for different item of work.

**Quantity Estimate of Building**

Short wall long wall method and centre line method, deductions in masonry, plastering, white washing, painting etc., multiplying factor (paint coefficients) for painting of doors and windows (paneled/glazed), grills etc., detailed estimate of single storied flat roof building with shallow foundation and RCC roof slab with leak proof treatment over it including staircase and mumty room.

**Analysis of Rates and Valuation**

Analysis of rates for cement concrete, brick masonry in cement mortar, laterite stone masonry in Cement Mortar, cement plaster, white washing, artificial stone flooring, tile flooring, concrete flooring, R.C.C. with centering and shuttering, reinforcing steel, painting of doors and windows etc. as per O.P.W.D, calculation of lead, lift, conveyance charges, royalty of materials, etc. as per Odisha P.W.D. system (Concept of C.P.W.D./Railways provisions), abstract of cost of estimate.

Valuation- Value and cost, scrap value, salvage value, assessed value, sinking fund, depreciation and obsolesce, methods of valuation.

**Administrative Set-Up of Engineering Organisations:**

Administrative set-up and hierarchy of Engineering department in State Govt./Central Govt./PSUs/Private Sectors etc. duties and responsibilities of engineers at different positions /levels.

## ENVIRONMENTAL STUDIES

The Multidisciplinary nature of environmental studies, definition, scope and importance, need for public awareness.

**Natural Resources, Renewable and non renewable resources**

Natural resources and associated problems.

Forest resources: Use and over-exploitation, deforestation, case studies, timber extraction mining, dams and their effects on forests and tribal people.

Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dam's benefits and problems.

Mineral Resources: Use and exploitation, environmental effects of extracting and using mineral resources.

Food Resources: World food problems, changes caused by agriculture and over grazing, effects of modern agriculture, fertilizers- pesticides problems, water logging, salinity.

Energy Resources: Growing energy need, renewable and non- renewable energy sources, use of alternate energy sources, case studies.

Land Resources: Land as a resource, land degradation, man induces landslides, soil erosion, and desertification.

Role of individual in conservation of natural resources, equitable use of resources for sustainable life styles.

**Systems**

Concept of an eco system, structure and function of an eco system, producers, consumers, decomposers, energy flow in the eco systems, ecological succession, food chains, food webs and ecological pyramids, introduction, types, characteristic features, structure and function of the following eco system: forest ecosystem: aquatic eco systems (ponds, streams, lakes, rivers, oceans, estuaries).

**Biodiversity and it's Conservation**

Introduction-Definition: genetics, species and ecosystem diversity, biogeographically classification of India, value of biodiversity: consumptive use, productive use, social ethical, aesthetic and option values, Biodiversity at global, national and local level, threats to biodiversity: habitats loss, poaching of wild life, man wildlife conflicts.

**Environmental Pollution**

Definition, causes, 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, disaster management: floods, earthquake, cyclone and landslides.

**Social issues and the Environment**

Form unsustainable to sustainable development, urban problems related to energy, water conservation, rain water harvesting, water shed management, Resettlement and rehabilitation of people; its problems and concern, environmental ethics: issue and possible solutions, climate change, global warming, acid rain, ozone layer depletion,nuclear accidents and holocaust case studies, Air (prevention and control of pollution) Act., water (prevention and control of pollution) Act., public awareness.

**Human population and the environment**

Population growth and variation among nations, population explosion- family welfare program, Environment and human health, human rights, value education, role of information technology in environment and human health.

## STRUCTURAL DESIGN – I

**Working stress method (WSM)**

Objectives of design and detailing, state the different methods of design of concrete structures, introduction to reinforced concrete, R.C. sections their behavior, grades of concrete and steel, permissible stresses, assumption in W.S.M., flexural design and analysis of single reinforced sections from first principles, concept of under reinforced, over reinforced and balanced sections, advantages and disadvantages of W.S.M, reasons for its obsolescence.

**Philosophy Of Limit State Method (LSM)**

Definition, advantages of LSM over WSM, IS code suggestions regarding design philosophy, types of limit states, partial safety factors for materials strength, characteristic strength, characteristic load, design load, loading on structure as per I.S. 875, study of I.S specification regarding spacing of reinforcement in slab, cover to reinforcement in slab, beam column & footing, minimum reinforcement in slab,beam & column, lapping, anchorage, effective span for beam & slab.

**Analysis and Design of Single and Double Reinforced Sections (LSM)**

Limit state of collapse (flexure), assumptions, stress-strain relationship for concrete and steel, neutral axis, stress block diagram and strain diagram for singly reinforced section, concept of under- reinforced, over-reinforced and limiting section, neutral axis co-efficient, limiting value of moment of resistance and limiting percentage of steel required for limiting singly R.C. section, analysis and design: determination of design constants, moment of resistance and area of steel for rectangular sections, necessity of doubly reinforced section, design of doubly reinforced rectangular section.

**Shear, Bond and Development Length (LSM)**

Nominal shear stress in R.C. section, design shear strength of concrete,maximum shear stress, design of shear reinforcement, minimum shear reinforcement, forms of shear reinforcement, bond and types of bond, bond stress, check for bond stress, development length in tension and compression, anchorage value for hooks $90^0$ bend and $45^0$ bend standards lapping of bars, check for development length, numerical problems on deciding whether shear reinforcement is required or not, check for adequacy of the section in shear, design of shear reinforcement; minimum shear reinforcement in beams.

**Analysis and Design of T-Beam (LSM)**

General features, advantages, effective width of flange as per IS: 456-2000 code provisions. analysis of singly reinforced T-Beam, strain diagram & stress diagram, depthof neutral axis, moment of resistance of T-beam section with neutral axis lying within the flange.Simple numerical problems on deciding effective flange width.

**Analysis and Design of Slab and Stair case (LSM)**

Design of simply supported one-way slabs for flexure check for deflection control and shear, design of one-way cantilever slabs and cantilevers chajjas for flexure checkfor deflection control and check for development length and shear, design of two-way simply supported slabs for flexure with corner free to lift, design of dog-legged staircase, detailing of reinforcement in stairs spanning longitudinally.

**Design of Axially loaded columns and Footings (LSM)**

Assumptions in limit state of collapse- compression, definition and classification of columns, effective length of column, specification for minimum reinforcement; cover, maximum reinforcement, number of bars in rectangular, square and circular sections, diameter and spacing of lateral ties, analysis and design of axially loaded short square, rectangular and circular columns (with lateral ties only),types of footing,

design of isolated square column footing of uniform thickness for flexure and shear.

## HYDRAULICS AND IRRIGATION ENGINEERING

### HYDRAULICS

**Hydrostatics**

**Properties of fluid:** density, specific gravity, surface tension, capillarity, viscosity and their uses

**Pressure and its measurements:** Intensity of pressure, atmospheric pressure, gauge pressure, absolute pressure and vacuum pressure; relationship between atmospheric pressure, absolute pressure and gauge pressure; pressure head; pressure gauges.

**Pressure exerted on an immersed surface:** Total pressure, resultant pressure, expression for total pressure exerted on horizontal & vertical surface.

**Kinematics of fluid flow**

**Basic equation of fluid flow and their application:** Rate of discharge, equation of continuity of liquid flow, total energy of a liquid in motion- potential, kinetic & pressure, Bernoulli's theorem and its limitations. practical applications of Bernoulli's equation.

**Flow over Notches and Weirs:** Notches, weirs, types of notches and weirs, discharge through different types of notches and weirs-their application (no derivation).

**Types of flow through the pipes:** uniform and non uniform; laminar and turbulent; steady and unsteady; Reynold's number and its application

**Losses of head of a liquid flowing through pipes:** Different types of major and minor losses. simple numerical problems on losses due to friction using Darcy's equation, total energy lines & hydraulic gradient lines (concept only).

**Flow through the Open Channels:** Types of channel sections-rectangular, trapezoidal and circular, discharge formulae- Chezy's and Manning's equation, best economical section.

**Pumps**

**Type of pumps**

**Centrifugal pump:** Basic principles, operation, discharge, horse power & efficiency.

**Reciprocating pumps:** Types, operation, discharge, horse power & efficiency.

### IRRIGATION ENGINEERING

**Hydrology**

Hydrology cycle, rainfall: types, intensity, hyetograph, estimation of rainfall, rain gauges, Its types(concept only), concept of catchment area, types, run-off, estimation of flood discharge by Dicken's and Ryve's formulae.

**Water Requirement of Crops**

Definition of irrigation, necessity, benefits of irrigation, types of irrigation Crop season, duty,delta and base period their relationship, overlap allowance, kharif and rabi crops, Gross command area, culturable command area, Intensity of irrigation,irrigable area, time factor, crop ratio.

**Flow irrigation**

Canal irrigation, types of canals, loss of water in canals, perennial irrigation, different components of irrigation canals and their functions, sketches of different canal cross-sections, classification of canals according to their alignment, various types of canallining – advantages and disadvantages.

**Water logging and drainage**

Causes and effects of water logging, detection, prevention and remedies.

**Diversion head works and regulatory structures**

Necessity and objectives of diversion head works, weirs and barrages, general layout, functions of different parts of barrage, silting and scouring, functions of regulatory structures.

**Cross drainage works**

Functions and necessity of cross drainage works - aqueduct, siphon, super- passage, level crossing concept of each with help of neat sketch.

**Dams**

Necessity of storage reservoirs, types of dams, earthen dams: types, description, causes of failure and protection measures, gravity dam- types, description, causes of failure and protection measures, spillways - types (with sketch) and necessity.

## LAND SURVEY – I

**Introduction to surveying, linear measurements**

Surveying: Definition, aims and objectives, principles of survey-plane surveying- geodetic surveying-instrumental surveying, precision and accuracy of measurements, instruments used formeasurement of

distance, types of tapes and chains, errors and mistakes in linear measurement – classification, sources of errors and remedies, corrections to measured lengths due to-incorrect length, temperature variation, pull, sag, numerical problem applying corrections.

**Chaining and chain surveying**

Equipment and accessories for chaining, ranging – Purpose, signaling, direct and indirect ranging, line ranger –features and use, error due to incorrect ranging, methods of chaining –chaining on flat ground, chaining on sloping ground – stepping method, clinometer-features and use, slope correction, setting perpendicular with chain & tape, chaining across different types of obstacles –numerical problems on chaining across obstacles, purpose of chain surveying, its principles, concept of field book. selection of survey stations, base line, tie lines, check lines, offsets – necessity, perpendicular and oblique offsets, instruments forsetting offset – cross staff, optical square, errors in chain surveying – compensating and accumulative errors causes &remedies, precautions to be taken during chain surveying.

**Angular measurement and compas surveying**

Measurement of angles with chain, tape & compass, compass – types, features, parts, merits & demerits, testing & adjustmentof compass, designation of angles- concept of meridians – magnetic, true, arbitrary; concept of bearings – whole circle bearing, quadrantal bearing, reduced bearing, suitability of application, numerical problems on conversion of bearings,use of compasses – setting in field-centering, leveling, taking readings, concepts of fore bearing, back bearing, numerical problems on computationof interior & exterior angles from bearings, effects of earth's magnetism – dip of needle, magnetic declination, variation in declination, numerical problems on application of correction for declination, errors in angle measurement with compass – sources & remedies, principles of traversing – open & closed traverse, methods of traversing, local attraction – causes, detection, errors, corrections, numerical problems of application of correction due to local attraction, errors in compass surveying – sources & remedies, plotting of traverse – check of closing error in closed & open traverse, Bowditch'scorrection, Gales table.

**Map reading cadastral maps & nomenclature**

Study of direction, scale, grid reference and grid square study of signs and symbols, cadastral map preparation methodology, unique identification number of parcel, positions of existing control points and its types, adjacent boundaries and features, topology creation and verification.

**Plane table surveying**

Objectives, principles and use of plane table surveying, instruments & accessories used in plane table surveying, methods of plane table surveying – (1) radiation, (2) intersection, (3)traversing, (4) resection, statements of two point and three point problem, errors in plane table surveying and their corrections, precautions in plane table surveying.

**Theodolite surveying and traversing**

Purpose and definition of theodolite surveying, transit theodolite- description of features, component parts, fundamental axes of a theodolite, concept of vernier, reading a vernier, temporary adjustmentof theodolite, concept of transiting –measurement of horizontal and vertical angles, measurement of magnetic bearings, deflection angle, direct angle, setting out angles, prolonging a straight line with theodolite, errors in theodolite observations, methods of theodolite traversing with – inclined angle method, deflection angle method, bearing method, plotting the traverse by coordinate method, checks for open and closed traverse, traverse computation – consecutive coordinates, latitude and departure, Gale's traverse table, numerical problems on omitted measurement of lengths & bearings, closing error – adjustment of angular errors, adjustment of bearings, numerical problems, balancing of traverse – Bowditch's method, transit method, graphical method, axis method, calculation of area of closed traverse.

**Levelling and contouring**

Definition and Purpose and types of leveling– concepts of level surface, horizontal surface, vertical surface, datum, R.L., B.M., instruments used for leveling, concepts of line of collimation, axis of bubble tube, axis of telescope, vertical axis, levelling staff – temporary adjustments of level, taking reading with level, concept of bench mark, BS, IS, FS, CP, HI, field data entry – level book – height of collimation method and rise & fall method, comparison, numerical problems on reduction of levels applying both methods, arithmetic checks, effects of curvature and refraction, numerical problems on application of correction, reciprocal leveling – principles, methods, numerical problems, precise leveling, errors in leveling and precautions, permanent and temporary adjustments of different types of levels, definitions, concepts and characteristics of contours, methods of contouring, plotting contour maps, interpretation of

contour maps, toposheets, use of contour maps on civil engineering projects – drawing cross- sections from contour maps, locating proposal routes of roads / railway / canal on a contour map, computation of volume of earthwork from contour map for simple structure, map interpretation: interpret human and economic activities (i.e.: settlement, communication, land use etc.), interpret physical landform (i.e.: relief, drainage pattern etc.), problem solving and decision making.

**Computation of area & volume**

Determination of areas, computation of areas from plans, calculation of area by using ordinate rule, trapezoidal rule, Simpson's rule, calculation of volumes by prismoidal formula and trapezoidal formula, prismoidal corrections, curvature correction for volumes.

## HIGHWAY ENGINEERING

**Introduction**

Importance of highway transportation: Importance organizations like indianroads congress, ministry of surface transport, central road research institute, functions of Indian Roads congress, IRC classification of roads organisation of state highway department.

**Road Geometrics**

Glossary of terms used in geometric and their importance, right of way, formation width, road margin, road shoulder, carriage way, side slopes, kerbs,formation level, camber and gradient, design and average running speed, stopping and passing sight distance, necessity of curves, horizontal and vertical curves including transition curvesand super elevation, Methods of providing super – elevation.

**Road Materials**

Difference types of road materials in use: soil, aggregates, and binders, Function of soil as highway subgrade, California Bearing Ratio: methods of finding CBR value in the laboratoryand at site and their significance, testing aggregates: abrasion test, impact test, crushing strength test, water absorption test & soundness test.

**Road Pavements**

Road pavement: flexible and rigid pavement, their merits and demerits,typical cross-sections, functions of various components, flexible pavements: sub-grade preparation, setting out alignment of road, setting out bench marks, control pegs for embankment and cutting, borrow pits, making profile of embankment, construction of embankment, compaction, stabilization, preparation of subgrade, methods of checking camber, gradient and alignment as per recommendations of IRC, equipment used for subgrade preparation, sub base course:, necessity of sub base, stabilized sub base, purpose of stabilization (no designs) types of stabilization- mechanical stabilization, lime stabilization, cement stabilization, fly ash stabilization, base course: preparation of base course, brick soling, stone soling and metalling, water bound macadam and wet-mix macadam, bituminous constructions: different types surfacing: surface dressing (i) premix carpet and (ii) semi dense carpet, bituminous concrete grouting, rigid pavements: concept of concrete roads as per IRC specifications.

**Hill Roads**

Introduction: Typical cross-sections showing all details of a typical hill road incut, partly in cutting and partly in filling, breast walls, retaining walls, different types of bends.

**Road Drainage**

Necessity of road drainage work, cross drainage works, surface and sub-surface drains and storm water drains, location, spacing and typical details of side drains, side ditches for surface drainage, intercepting drains, pipe drains in hill roads, details of drains in cutting embankment, typical cross sections.

**Road Maintenance**

Common types of road failures – their causes and remedies, maintenance of bituminous road such as patch work and resurfacing, maintenance of concrete roads – filling cracks, repairing joints, maintenance of shoulders (berm), maintenance of traffic control devices, basic concept of traffic study, traffic safety and traffic control signal.

**Construction equipments**

Preliminary ideas of the following plant and equipment: hot mixing plant, tipper, tractors (wheel and crawler), scraper, bulldozer, dumpers, shovels,graders, roller dragline, asphalt mixer and tar boilers, road pavers, modern construction equipments for roads.

## ENTREPRENEURSHIP AND MANAGEMENT & SMART TECHNOLOGY

**Entrepreneurship**

Concept /Meaning of entrepreneurship, need of entrepreneurship, characteristics, qualities and types of entrepreneur, functions, barriers in entrepreneurship, entrepreneurs vrs. manager, forms of business

ownership: sole proprietorship, partnership forms and others, types of industries, concept of start-ups, entrepreneurial support agencies at national, state, district level(sources): DIC, NSIC,OSIC,SIDBI, NABARD,commercial banks,KVIC etc., technology business incubators (tbi) and science and technology entrepreneur parks.

**Market Survey and Opportunity Identification (Business Planning)**

Business planning, SSI, ancillary units, tiny units, service sector units, time schedule plan, agencies to be contacted for project implementation, assessment of demand and supply and potential areas of growth, identifying business opportunity, final product selection.

**Project Report Preparation**

Preliminary project report, detailed project report, techno economic feasibility, project viability

**Management Principles**

Definitions of management, principles of management, functions of management (planning, organising, staffing, directing and controlling etc.), level of management in an organisation

**Functional Areas of Management**

Production management- functions, activities, productivity, quality control, production planning and control, Inventory Management- Need for inventory management, models/techniques of inventory management, Financial Management- functions of financial management, management of working capital, costing (only concept),break even analysis, brief idea about accounting terminologies: book keeping, journal entry, petty cash book, p & l accounts, balance sheets(only concepts), Marketing management- concept of marketing and marketing management, marketing techniques (only concepts), concept of 4Ps (Price, Place, Product, Promotion), Human resource management- functions of personnel management, manpower planning, recruitment, sources of manpower, selection process, method of testing, methods of training & development, payment of wages.

**Leadership and Motivation**

Leadership- Definition and need/importance, qualities and functions of a leader, manager vs leader, style of leadership (autocratic, democratic, participative).

Motivation- Definition and characteristics, Importance of motivation, Factors affecting motivation, Theories of motivation (Maslow),Methods of Improving Motivation,Importance of Communication in Business, types and barriers of communication.

**Work Culture, TQM & Safety**

Human relationship and performance in organization, relations with peers, superiors and subordinates, TQM concepts: quality policy, quality management, quality system, accidents and safety, cause, preventive measures, general safety rules,personal protection Equipment(PPE).

**Legislation**

Intellectual property rights(IPR), patents, trademarks, copyrights, features of factories act 1948 with amendment (only salient points),features of payment of wages act 1936 (only salient points).

**Smart Technology**

Concept of IOT, how IOT works, components of IOT, characteristics of IOT, categories of IOT, applications of IOT- smart cities, smart transportation, smart home, smart health care, smart industry, smart agriculture, smart energy management etc.

## STRUCTURAL DESIGN-II

**Introduction**

Common steel structures, advantages & disadvantages of steel structures, types of steel, properties of structural steel, rolled steel sections, special considerations in steel design, loads and load combinations, structural analysis and design philosophy, brief review of principles of limit state design.

**Structural Steel Fasteners and Connections**

Bolted connections, classification of bolts, advantages and disadvantages of bolted connections, different terminology, spacing and edge distance of bolt holes, types of bolted connections, types of action of fasteners, assumptions and principles of design, strength of plates in a joint, strength of bearing type bolts (shear capacity & bearing capacity),reduction factors and shear capacity of HSFG bolts, analysis & design joints using bearing type and HSFG bolts (except eccentric load and prying forces), efficiency of a joint, welded connections, advantages and disadvantages of welded connection, types of welded joints and specifications for welding, design stresses in welds, strength of welded joints.

**Design of steel tension Members**

Common shapes of tension members, maximum values of effective slenderness ratio, analysis and design of tension members (considering strength only and concept of block shear failure).

**Design of steel compression members**

Common shapes of compression members, buckling class of cross sections, slenderness ratio, design compressive stress and strength of compression members, analysis and design of compression members (axial load only).

**Design of Steel beams**

Common cross sections and their classification, deflection limits, web buckling and web crippling, design of laterally supported beams against bending and shear.

**Design of Tubular Steel Structures**

Round tubular sections, Permissible stresses, tubular compression & tension members, joints in tubular trusses.

**Design of Masonry Structures**

Design considerations for masonry walls & columns, load bearing & non-load bearing walls, permissible stresses, slenderness ratio, effective length, height & thickness.

## RAILWAY & BRIDGE ENGINEERING

**RAILWAYS**

**Introduction**

Railway terminology, advantages of railways, classification of Indian railways.

**Permanent way**

Definition and components of a permanent way, concept of gauge, different gauges prevalent in India, suitability of these gauges under different conditions.

**Track materials**

Rails, functions and requirement of rails, types of rail sections, length of rails, rail joints-types, requirement of an ideal joint, purpose of welding of rails & its advantages, creep-definition, cause & prevention, Sleepers, definition, function & requirements of sleepers, classification of sleepers, advantages & disadvantages of different types of sleepers, ballast, function & requirements of ballast, materials for ballast, fixtures for broard gauge, connection of rails to rail - fish plate, fish bolts, connection of rails to sleepers.

**Geometric for broad gauge**

Typical cross-sections of single & double broad gauge railway track in cutting and embankment , permanent & temporary land width, gradients for drainage, super elevation- necessity & limiting valued.

**Points and Crossing**

Definition, necessity of points and crossing, types of points & crossing with tie diagrams.

**Laying & maintenance of track**

Methods of laying & maintenance of track , duties of a permanent way inspector.

**BRIDGES**

**Introduction to bridges**

Definitions, components of a bridge, classification of bridges, requirements of an ideal bridge.

**Bridge site investigation, hydrology & planning**

Selection of bridge site, alignment, determination of flood Discharge, waterway & economic span, afflux, clearance & free board.

**Bridge Foundation**

Scour depth, minimum depth of foundation, types of bridge foundations-spread foundation, pile foundation, well foundation, sinking of wells, caisson foundation, coffer dams.

**Bridge substructure and approaches**

Types of piers, types of abutments, types of wing walls, approaches.

**Culvert & Cause ways**

Types of culverts- brief description, types of causeways- brief description

## WATER SUPPLY AND WASTE WATER ENGINEERING

**WATER SUPPLY**

**Introduction to Water Supply, Quantity and Quality of Water**

Necessity of treated water supply, per capita demand, variation in demand and factors affecting demand, methods of forecasting population, numerical problems using different methods, Impurities in water- organic and inorganic, harmful effects of impurities, analysis of water- physical, chemical and bacteriological, water quality standards for different uses.

**Sources and Conveyance of Water**

**Surface sources-** Lake, stream, river and impounded reservoir, underground sources- aquifer type &

occurrence- infiltration gallery, infiltration well, springs, well , yield from well- methods of determination, numerical problems using yield formulae (deduction excluded), Intakes- types, description of river intake, reservoir intake, canal intake, pumps for conveyance & distribution- types, selection, installation, Pipe materials- necessity, suitability, merits & demerits of each type, pipe joints- necessity, types of joints, suitability, methods of jointing laying of pipes-method.

**Treatment of Water**

Flow diagram of conventional water treatment system, treatment process/units, aeration; necessity, Plain sedimentation: necessity, working principles, sedimentation tanks- types, essential features, operation & maintenance, sedimentation with coagulation: necessity, principles of coagulation, types of coagulants, flash mixer, flocculator, clarifier (definition and concept only), filtration: necessity, principles, types of filters, slow sand filter, rapid sand filter and pressure filter- essential features, disinfection: necessity, methods of disinfection, Chlorination- free and combined chlorine demand, available chlorine, residual chlorine, pre-chlorination, break point chlorination, super-chlorination, softening of water- necessity, methods of softening-lime soda process and ion exchange method (concept only).

**Distribution system and Appurtenance in distribution system**

General requirements, types of distribution system- gravity, direct and combined, methods of supply- intermittent and continuous, distribution system layout- types, comparison, suitability, valves- types, features, uses, purpose- sluice valves, check valves, air valves, scour valves, fire hydrants, water meters.

**W/s plumbing in building**

Method of connection from water mains to building supply, general layout of plumbing arrangement for water supply in single storied and multi-storied building as per I.S code.

**WASTE WATER ENGINEERING**

**Introduction**

Aims and objectives of sanitary engineering, definition of terms related to sanitary engineering, systems of collection of wastes-conservancy and water carriage system-features, comparison, suitability.

**Quantity and Quality of sewage**

Quantity of sanitary sewage-domestic & industrial sewage, variation in sewage flow, numerical problem on computation quantity of sanitary sewage, computation of size of sewer, application of Chazy's formula, limiting velocities of flow: self-cleaning and scouring, general Importance, strength of sewage, characteristics of sewage- physical, chemical & biological, concept of sewage- sampling, tests for- solids, PH, dissolved oxygen, BOD, COD.

**Sewerage system**

Types of system- separate, combined, partially separate, features, comparison between the types, suitability, Shapes of sewer- rectangular, circular, avoid- features, suitability, laying of sewer- setting out sewer alignment.

**Sewer Appurtenances and Sewage Disposal**

Manholes and Lamp holes- types, features, location, function, inlets, grease & oil trap- features, location, function, strom regulator, inverted siphon- features, location, function, disposal on land- sewage farming, sewage application and dosing, sewage sickness- causes and remedies, disposal by dilution- standards for disposal in different types of water bodies, self purification of stream.

**Sewage treatment**

Principles of treatment, flow diagram of conventional treatment, Primary treatment- necessity, principles, essential features, functions, Secondary treatment- necessity, principles, essential features, functions.

**Sanitary plumbing for building**

Requirements of building drainage, layout of lavatory blocks in residential buildings, layout of building drainage, Plumbing arrangement of single storied & multi storied building as per I.S. code practice, sanitary fixtures- features, function, and maintenance and fixing of the fixtures- water closets, flushing cisterns, urinals, inspection chambers, traps, anti- syphonage pipe.

## ESTIMATION & COST EVALUATION-II

**Detailed estimate of culverts and bridges**

Detailed estimate of a RCC slab culvert with right angled wing walls with bar bending schedule, RCC hume pipe culvert with splayed angled wing wall.

**Estimate of irrigation structures**

Detailed estimate of simple type of vertical fall to given specification, detailed estimate of drainage siphon to given specification.

**Detailed estimate of roads**

Detail estimate of a water bound macadam road, detailed estimate of a flexible pavement in cutting/filling, detailed estimate of septic tank and soak pit for 50 users.

**Miscellaneous estimates**

Tube well, piles and pile cap, Isolated and combined footing.

**PWD Accounts works**

Works, classification of work- original, major, petty, repair work, annual repair, special repair, quadrantal repair, concept of method of execution of works through the contractors and department, contract and agreement, work order, types of contract, piece work agreement, Accounts of works – explanation of various terms- administrative approval, technical sanction, tender, preparation of notice inviting tender, quotations, earnest money, E-tendering, security deposit, advance payment, Intermediate payment, final payment, running bill, final bill, regular and temporary establishment, cash, major & subhead of account, temporary advance (imprest money), supervision charges, suspense account, debit, credit, book transfer, voucher and related accounts, measurement book use & maintenance, procedure of marking entries of measurement of work and supply of materials, labour employed, standard measurement books and common irregularity, Muster roll: Its preparation & use for making payment of pay & wages, Acquaintance Roll: Its preparation & use for making payment of pay & wages, labour & labour report, method of labour payment, use of forms and necessity of submission, classification of stores, receipt/ issue statement on standard form, method of preparation of stock account, preparation and submission of returns, verification of stocks, shortage and excess, building BY LAWS and regulatory bodies, development authorities, types and their levels, RERA etc.

## LAND SURVEY– II

**Tacheometry**

Principles, stadia constants determination, Stadia tacheometry with staff held vertical and with line of collimation horizontal or inclined, numerical problems,Elevations and distances of staff stations – numerical problems.

**Curves**

Compound, reverse and transition curve, purpose & use of different types ofcurves in field, elements of circular curves, numerical problems, preparation of curve table for setting out, setting out of circular curve by chain and tape and by instrument angular methods (i) offsets from long chord, (ii) successive bisection of arc, (iii) offsets from tangents, (iv) offsets from chord produced, (v) Rankine's method of tangent angles (no derivation), obstacles in curve ranging – point of intersection inaccessible.

**Basics on scale and basics of map**

Fractional or ratio scale, linear Scale, graphical scale, what is map, map scale and map projections, how maps convey location and extent, how maps convey characteristics of features, how maps convey spatial relationship, classification of maps, physical map, topographic map, road map, political map, economic & resources map, thematic map, climate map.

**Survey of India map series**

Open series map, defense series map, map nomenclature, quadrangle name, latitude, longitude, UTM's, contour lines, magnetic declination, public land survey system, field notes.

**Basics of aerial photography, photogrammetry, dem and ortho image generation**

**Aerial Photography**

Film, focal length, scale,types of aerial photographs (oblique, straight).

**Photogrammetry**

Classification of photogrammetry, aerial photogrammetry,terrestrial photogrammetry.

**Photogrammetry Process**

Acquisition of imagery using aerial and satellite platform, control survey,geometric distortion in imagery, application of imagery and its support dataorientation and triangulation, stereoscopic measurement,19.9.1 X-parallax,19.2.2 Y-parallax.

**DTM/DEM Generation**

**Ortho Image Generation**

**Modern surveying methods**

Principles, features and use of (i) Micro-optic theodolite, digital theodolite, working principles of a total station (set up and use of total station to measure angles, distances of points under survey from total station and the co-ordinates (X,Y & Z or northing, easting, and elevation) of surveyed points relative to total station position using trigonometry and triangulation.

**Basics on GPS & DGPS and ETS**

**GPS:-** Global Positioning System, working principle of GPS,GPS signals, errors of GPS, positioning methods.

**DGPS:-** Differential Global Positioning System, base station setup, rover GPS set up, download, post-process and export GPS data, sequence to download GPS data from flashcards, sequence to post - process GPS data, sequence to export post process GPS data, sequence to export GPS time tags to file.

**ETS:-**

Electronic Total Station, distance measurement, angle measurement, leveling, determining position, reference networks, errors and accuracy.

**Basics of GIS and map preparation using GIS**

Components of GIS, integration of spatial and attribute information, three views of information system, database or table view, map view and model view, spatial data model, attribute data management and metadata concept, prepare data and adding to arc map, organizing data as layers, editing the layers, switching to layout view, change page orientation, removing borders, adding and editing map information, finalize the map.

## CONSTRUCTION MANAGEMENT

**Introduction To Construction Management**

Aims and objectives of construction management, functions of construction management, the construction team components- owner, engineer, architect, contractor-their functions and interrelationship and jurisdiction, Resources for construction management-men, machines, materials, money.

**Constructional Planning**

Importance of construction planning, developing work breakdown structure for construction work, construction planning stages-pre-tender stage, post-tender stage, construction scheduling by bar charts-preparation of bar charts for simple construction works, preparation of schedules for labour materials, machinery, finance for small works, limitation of bar charts,construction scheduling by network techniques-defination of terms ,PERT and CPM techniques, advantages and disadvantages of two techniques, network analysis, estimation of time and critical path, application of PERT and CPM techniques in sample construction works.

**Materials and Stores Management**

Classification of stores-storage of stock, Issue of materials-indent , invoice, bin card.

**Construction Site Management**

Job lay out- Objectives, review plans, specifications, lay out of equipments, location of equipment, organizing labour at site, job lay out for different construction sites, principle of storing material at site.

**Construction Organization**

Introduction – Characteristics, structure, importance, organization types-line and staff, functions and their characteristics, principles of organization- meaning and significance of terms- control, authority, responsibility, job & task, leadership-necessity, styles of leadership, role of leader,human relations-relations with subordinates, peers, supervisors, characteristics of group behavior, mob psychology, handling of grievances,absenteeism, labour welfare, conflicts in organization- genesis of conflicts, types-intrapersonal,interpersonal, intergroup, resolving conflicts.

**Construction Labour and Labour Management**

Preparing labour schedule, essential steps for optimum labour output, labour characteristics, wages & their payment, labour incentives, motivation- classification of motives, different approaches to motivation.

**Equipment Management**

Preparing the equipment schedule, identification of different alternative equipment, importance of owning & operating costs in making decisions for hiring & purchase of equipment, inspection and testing of equipment, equipment maintenance.

**Quality Control**

Concept of quality in construction, quality standards- during construction, afterconstruction, destructive & non destructive methods.

**Monitoring Progress**

Programme and progress of work, work study, analysis and control of physical and financial progress corrective measures.

**Safety Management in Construction**

Importance of safety, causes and effects of accidents in construction works, safety measures in work sites for excavation, scaffolding, formwork, fabrication and erection, demolition, development of safety

consciousness, safety legislation- workman's compensation act, contract labour act.

**Role of Vulnerability Atlas of India in construction projects**

Introduction to vulnerability atlas of India, concepts of natural hazards and disasters and vulnerability profile of India. definition of disaster related terms, earthquake hazard and vulnerability, magnitude and intensity scales of earthquake, seismic zones, earthquake hazard maps, types of structures and damage classification, effects in housing and resistant measures, wind / cyclone hazard and vulnerability, wind speed and pressures, wind hazard and cyclone occurrence maps, storm surveys and cyclone resistant measures, flood hazard and vulnerability, flood hazard and flood prone areas of the country, general protection of habitants and flood resistant construction, landslides, tsunamis and thunderstorm hazards and vulnerability, landslide & thunderstorm incidence maps, measures against tsunami hazards, housing vulnerability risk tables and usage of vulnerability atlas of India, inclusion of vulnerability atlas in tender documents.

## ADVANCED CONSTRUCTION TECHNIQUES & EQUIPMENT

**Advanced construction materials**

Fibers and Plastics-

Types of fibers- steel, carbon, glass fibers, use of fibers as construction material, properties of fibers, Types of plastics- PVC, RPVC, HDPE, FRP, GRP etc. colored plastic sheets.use of plastic as construction material, Artificial timbers- Properties and uses of artificial timber, types of artificial timber available in market, strength of artificial timber, Miscellaneous materials – Properties and uses of acoustics materials, wall claddings, plaster boards, micro-silica, artificial sand, bonding agents, adhesives etc.

**Prefabrication**

Introduction, necessity and scope of prefabrication of buildings, history of prefabrication, current uses of prefabrication , types of prefabricated systems, classification of prefabrication, advantages and disadvantages of prefabrication, the theory and process of prefabrication, design principle of prefabricated systems, types of prefabricated elements, modular coordination, Indian standard recommendation for modular planning, earthquake resistant construction, building configuration, lateral load resisting structures, building characteristics, effect of structural irregularities-vertical irregularities, plan configuration problems, safety consideration during additional construction and alteration of existing buildings, additional strengthening measures in masonry building-corner reinforcement, lintel band, sill band, plinth band, roof band, gable band etc., retrofitting of structures, seismic retrofitting of reinforced concrete buildings, sources of weakness in RC frame building, classification of retrofitting techniques and their uses, building services, cold water distribution in high rise building, lay out of installation, hot water supply – general principles for central plants-layout, sanitation-soil and waste water installation in high rise buildings, electrical services – i) Requirements in high rise buildings ii) Layout of wiring -types of wiring iii) Fuses and their types iv) Earthing and their uses, Lighting – requirement of lighting, measurement of light intensity, ventilation - methods of ventilation (natural and artificial systems of ventilation)problems on ventilation, mechanical services- lifts, escalator, elevators – types and uses.

**Construction and earth moving equipments**

Planning and selection of construction equipments, study on earth moving equipments like drag line, tractor, bulldozer, power shovel, study and uses of compacting equipments like tamping rollers, smooth wheel rollers, pneumatic tired rollers and vibrating compactors, owning and operating cost – problems, soil reinforcing techniques, necessity of soil reinforcing, use wire mesh and geo-synthetics, strengthening of embankments, slope stabilization in cutting and embankments by soil reinforcing techniques.

# Junior Engineer(Mechanical)

## Syllabus for main written examination:

The question of this paper will be of objection type from the Diploma course to conduct on CBRT mode. The question will be of objective type based on the 2nd and 3rd year of Diploma in Mechanical Engineering courses of SCTE & VT.

The gist of the syllabus of the written examination is a described below. The syllabus is indicative and not exhaustive. The question will be asked from both the theory and application part on each of the topic.

### a. Strength of Material

Stress and strain, Hooke 's law. Young's Modulus, bulk modulus, poison's ratio, Relation between elastic constants, Type of beams & loads, concept of shear force & bending moment , Shear Force & Bending Moment Diagrams & their salient features in cantilever beam under point load & UDL. Bending stress, section modulus & neutral axis. Axial Load & eccentric load in columns, buckling load in columns with various end connections.

### b. Engineering Materials

Material classification in to ferrous, non-ferrous category and alloys, physical and chemical properties. Classification, composition and application of low carbon steel, medium carbon steel and high carbon steel. Process of heat treatment, Annealing, normalizing, hardening, tempering, stress relieving measures. Surface hardening, carburizing, and nit riding. Effect of heat treatment on properties of steel. Reasons of corrosion and surface wear, purpose of painting and methods of industrial painting.

### c. Thermal Engineering/Applied thermodynamics.

Thermodynamic properties of a system (pressure, volume, temperature and units of measurement).Sensible heat. Latent heat, specific heat. Conceptual explanation of energy, work and heat. Introductory concept of conduction, convection and radiation of heat. Carnot cycle. Boyle'slaw. Charles Law, concept of I.C. engine. Otto Cycle. Diesel Cycle, Hydrocarbon fuel Quality of I.C. engine fuels: Octane number, Cetane number.

### d. Theory of Machines

Link, kinematic chain, mechanism, Command followers, friction between nut and screw for square thread. Screw jack. Description of roller and ball bearings. Flt colar bearings, working of simple frictional brakes. Concept of power transmission. Gear drives(Spur gear drives & worm gear drives).

### e. Manufacturing technology/ Production technology.

Physical properties and uses of cutting too materials. Coolants and lubricants in machining. Major components of lathe and their functions, different operations carried out in a lathe. Safety measures during machining. Shaper machine uses, major components and their functions. Types of milling machines and operations performed by them. Grinding machine and its operation. Working of cylindrical grinder, surface grinder and centre less grinder. Criteria for selection of grinding

wheels. Working of bench drilling machine. pillar drilling machining and radial drilling machine. Basic principle of boring. Difference between boring and drilling. Surface finishing and lapping. Welding processes and welding electrodes. TIG welding and MIG welding processes. Testing of welded joints. Jigs and fixtures, definitions and advantages of using them.

**f. Fluid Mechanics and Hydraulic machines**

Properties of fluids, definition and units of fluid pressure, pressure intensity and pressure head, concept of atmospheric pressure, gauge pressure and absolute pressure, manometers. Hydrostatic pressure, centre of pressure on immersed bodies. Archimedes principle, concept of buoyancy, types of fluid flow, Bernoulli's theorem, venturimetre, pitot tube, Orifice coefficient( Ce,Cv and Cd) and relation among them. Definition of pipe, laws of fluid friction, head loss due to friction. Hydraulic gradient. Definition and classification of pumps, centrifugal pumps.

**g. Machine Design.**

Types of loads, working stress, yield stress, ultimate stress and factor of safety. Mechanical properties of material. Design of screw thread (Nut & bolt), types of welded joints. Advantage of welded joints over other joints. Strength of welded joints. Design of solid & hollow shafts, function of keys for shafts, types of keys, Design of rectangular sunk key.

**h. Industrial Engineering & Quality Control**

Objectives of Inventory Control, Definition of Inspection and Quality Control. Typos of inspection, study of factors influencing the quality of manufacture.

**i. Automobile Engineering**

Working principle of petrol engine, carburetion and air fuel ratio, battery ignition and magnet ignition system. MPFI System. Working Principle of Diesel Engine, Feed Pump Injector. Working principle of fuel injection system of multi cylinder engine. Clutch system. Need, types and working principle. Gear box and its purpose, construction and working of four speed gear box. Differential:- need. type and working principle. Braking system in automobile: types and working principle. Description of conventional suspension system for rear and front axles. Description of independent suspension system used in cars. Necessary of cooling system in Automobile Engine. Defects in cooling and their remedial measures. Function of lubrication system in I.E. engines.

# Syllabus for Junior Engineer (Electrical)

## 1. ENGINEERING MATHEMATICS-III

Complex Numbers:-Real Imaginary numbers, Complex numbers, conjugate complex numbers, Modulus and Amplitude of a complex number, Geometrical Representation of Complex Numbers, Properties of Complex Numbers Determination of three cube roots of unity and their properties, De Moivre's theorem **Matrics:-**Define rank of a matrix, Perform elementary row transformations to determine the rank of matrix, State Rouche's theorem for consistency of a system of a linear equation п unknowns, Solve equation in three unknowns testing consistency **Linear Differential Equation:-**Define Homogeneous and Non-Homogeneous Linear Differential Equations with constant coefficients with examples, Find general solution of linear Differential Equations in terms of C.F and P.I, Derive rules for finding C.F AND P.I in terms of operator D, excluding ---- Define partial differential equation (P.D.E), Form partial differential equations by eliminating arbitrary constants and arbitrary functions, Solve partial differential equations of the form Pp+Qq=R, **Laplace Transforms**: Define Gramma function and find Γ( ½)= √ п, Define Laplace Transform of a function f(t) and Inverse Laplace Transform Derive L.T of standard functions and explain existence conditions of L.T, Explain linear, shifting property of L.T, Formulate L.T of derivatives, integrals, multiplication by t n and division by t, Derive formulae of inverse L.T and explain method of partial fractions, **Fourier Series**:- Define periodic functions, State Dirichlet's condition for the Fourier expansion of function an it's convergence, Express periodic function f(x) satisfying Dirichlet's conditions as a Fourier series, State Euler's formulae, Define Even and Odd functions and find Fourier series in (0 ≤ X ≤ 2 п and п≤ x≤ п), Obtains F.S of continuous functions and functions having points of discontinuity in (0≤ X ≤ 2 п and п≤ x≤ п) **Numerical Methods**:- Appraise limitation of analytical methods of solution of Algebraic Equations Derive Iterative formula for finding the solutions of Algebraic Equations by:Bisection method, Newton-Raphson method **Finite difference and interpolation**: Explain finite difference and form table of forward and backward difference, Define shift Operator(E) and establish relation between E & difference operator Derive Newton's forward and backward interpolation formula for equal intervals, State Lagrange's interpretation formula for unequal intervals, Explain numerical integration and state. Newton's Cote's formula, Trapezoidal rule. Simpson's $1/3^{rd}$ rule.

difference, Define shift Operator ($E$) and establish relation between E & difference operator($\Delta$), Derive Newton's forward and backward interpolation formula for equal intervals, State Lagrange's interpretation formula for unequal intervals. Explain numerical integration and state: Newton's Cote's formula, Trapezoidal rule, Simpson's 1/3rd rule

## 2. CIRCUIT AND NETWORK THEORY

**Magnetic Circuits:-** Introduction, Magnetizing force, Intensity, MMF, flux and their relations ,Permeability, reluctance and permeance, Analogy between electric and Magnetic Circuits,, B-H Curve, Series & parallel magnetic circuit, Hysteresis loop **Coupled Circuits:-** Self Inductance and Mutual Inductance, Conductively coupled circuit and mutual impedance ,Dot convention ,Coefficient of coupling, Series and parallel connection of coupled inductors, Solve numerical problems **Circuit Elements and Analysis:-** Active, Passive, Unilateral & bilateral, Linear & Nonlinear elements, Mesh Analysis, Mesh Equations by inspection, Super mesh Analysis, Nodal Analysis, Nodal Equations by inspection, Super node Analysis, Source Transformation Technique, Solve numerical problems (With Independent Sources Only) **Network Theorems:-** Star to delta and delta to star transformation, Super position Theorem, Thevenin's Theorem, Norton's Theorem, Maximum power Transfer Theorem, Solve numerical problems (With Independent Sources Only) **AC Circuit and Resonance:-** A.C. through R-L, R-C & R-L-C Circuit, Solution of problems of A.C. through R-L, R-C & R-L-C series Circuit by complex algebra method, Solution of problems of A.C. through R-L, R-C & R-L-C parallel & Composite Circuits, Power factor & power triangle, Deduce expression for active, reactive, apparent power, Derive the resonant frequency of series resonance and parallel resonance circuit, Define Bandwidth, Selectivity & Q-factor in series circuit **Polyphase Circuit:-** Concept of poly-phase system and phase sequence, Relation between phase and line quantities in star & delta connection, Power equation in 3-phase balanced circuit, Measurement of 3-phase power by two wattmeter method **Transients:-** Steady state & transient state response, Response to R-L, R-C & RLC circuit under DC condition **Two-Port Network:-** Open circuit impedance (z) parameters, Short circuit admittance (y) parameters, Transmission (ABCD) parameters, Hybrid (h) parameters, Inter relationships of different parameters, T and $\pi$ representation **Filters:-** Define filter, Classification of pass Band, stop Band and cut-off frequency, Classification of filters, Constant – K low pass filter, Constant – K high pass filter, Constant – K Band pass filter, Constant – K Band elimination filter.

## 3. ELEMENTS OF MECHANICAL ENGINEERING

**Thermodynamics:-** State Unit of Heat and work, 1st law of thermodynamics, State Laws of perfect gases, Determine relationship of specific heat of gases at constant volume and constant pressure **Properties of Steam:-** Use steam table for solution of simple problem, Explain total heat of wet, dry and super heated steam **Boilers:-** State types of Boilers, Describe Cochran, Babcock Wilcox boiler, Describe Mountings and accessories **Steam Engines:-** Explain the principle of Simple steam engine. Draw Indicator diagram, Calculate Mean effective pressure, IHP and BHP and mechanical efficiency **Steam Turbines:-** State Types, Differentiate between impulse and reaction Turbine **Condenser:-** Explain the function of condenser, State their types .**I.C. Engine:-** Explain working of two stroke and 4 stroke petrol and Diesel engines, Differentiate between them **Hydrostatics:-** Describe properties of fluid, Determine pressure at a point, pressure measuring Instruments **Hydrokinetics:-** Deduce equation of continuity of flow, Explain energy of flowing liquid, State and explain Bernoulli's theorem **Hydraulic Devices and Pneumatics:-** Intensifier, Hydraulic lift, Accumulator, Hydraulic ram

## 4. ELECTRICAL ENGINEERING MATERIAL

**Conducting Materials:-** Introduction, Resistivity, factors affecting resistivity, Classification of conducting materials into low-resistivity and high resistivity materials, Low Resistivity Materials and their Applications. (Copper, Silver, Gold, Aluminum, Steel, Stranded conductors, Bundled conductors, Low resistivity copper alloys, High Resistivity Materials and their Applications(Tungsten, Carbon, Platinum, Mercury), Superconductivity, Superconducting materials, Application of superconductor materials **Semiconducting Materials:-** Introduction, Semiconductors, Electron Energy and Energy Band Theory, Excitation of Atoms, Insulators, Semiconductors and Conductors, Semiconductor Materials, Covalent Bonds, Intrinsic Semiconductors, Extrinsic Semiconductors, N-Type Materials, P-Type Materials, Minority and Majority Carriers, Semi-Conductor Materials, Applications of Semiconductor materials, Rectifiers, Temperature-sensitive resisters or thermistors, Photoconductive cells, Photovoltaic cells, Varisters, Transistors, Hall effect generators, Solar power **Insulating Materials:-** Introduction, General properties of Insulating Materials, Electrical properties, Visual properties, Mechanical

properties, Thermal properties, Chemical properties, Ageing, Insulating Materials - Classification, properties, applications, Introduction, Classification of insulating materials on the basis physical and chemical structure, Insulating Gases, Introduction, Commonly used insulating gases **Dielectric Materials:-** Introduction, Dielectric Constant of Permittivity, Polarization, Dielectric Loss, Electric Conductivity of Dielectrics and their Break Down, Properties of Dielectrics, Applications of Dielectrics **Magnetic Materials:-** Introduction, Classification, Diamagnetism, Para magnetism, Ferromagnetism, Magnetization Curve, Hysteresis, Eddy Currents, Curie Point, Magneto-striction, Soft and Hard magnetic Materials, Soft magnetic materials, Hard magnetic materials **Materials for Special Purposes:-** Introduction, Structural Materials, Protective Materials, Lead, Steel tapes, wires and strips, Other Materials, Thermocouple materials, Bimetals, Soldering Materials, Fuse and Fuse materials, Dehydrating material

## 5. ENVIRONMENTAL STUDIES

**The Multidisciplinary nature of environmental studies:-** Definition, scope and importance, Need for public awareness **Natural Resources:- Renewable and nonrenewable resources,** Natural resources and associated problems, Forest resources: Use and over-exploitation, deforestation, case studies, Timber extraction mining, dams and their effects on forests and tribal people, Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dam's benefits and problems, Mineral Resources: Use and exploitation, environmental effects of extracting and using mineral resources, Food Resources: World food problems, changes caused by agriculture and over grazing, effects of modern agriculture, fertilizers- pesticides problems, water logging, salinity, Energy Resources: Growing energy need, renewable and non-renewable energy sources, use of alternate energy sources, case studies, Land Resources: Land as a resource, land degradation, man induces landslides, soil erosion, and desertification, Role of individual in conservation of natural resources, Equitable use of resources for sustainable life styles **Systems:-** Concept of an ecosystem, Structure and function of an ecosystem, Producers, consumers, decomposers, Energy flow in the eco systems, Ecological succession, Food chains, food webs and ecological pyramids, introduction, types, characteristic features, structure and function of the following, eco system, Forest ecosystem, Aquatic eco systems (ponds, streams, lakes, rivers, oceans, estuaries) **Biodiversity and it's Conservation:-** Introduction-Definition: genetics, species and ecosystem diversity, Biogeographically classification of India,

Value of biodiversity: consumptive use, productive use, social ethical, aesthetic and option values, Biodiversity at global, national and local level, Threats to biodiversity: Habitats loss, poaching of wild life, man wildlife conflicts **Environmental Pollution**:- Definition Causes, 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, Disaster management: Floods, earth quake, cyclone and landslides **Social issues and the Environment:-** Form unsustainable to sustainable development, Urban problems related to energy, Water conservation, rain water harvesting, water shed management, Resettlement and rehabilitation of people; its problems and concern Environmental ethics: issue and possible solutions, Climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust, case studies, Air (prevention and control of pollution) Act, Water (prevention and control of pollution) Act, Public awareness **Human population and the environment:-** Population growth and variation among nations, Population explosion- family welfare program, Environment and human health, Human rights, Value education, Role of information technology in environment and human health

## 6. ENERGY CONVERSION – I

**D.C Generator:** - Operating principle of generator, Constructional features of DC machine, Yoke, Pole & field winding, Armature, Commutator, Armature winding back pitch, Front pitch, Resultant pitch and commutator- pitch, Simple Lap and wave winding, Dummy coils, Different types of D.C. machines (Shunt, Series and Compound), Derivation of EMF equation of DC generators. (Solve problems). Losses and efficiency of DC generator. Condition for maximum efficiency and numerical problems, Armature reaction in D.C. machine, Commutation and methods of improving commutation, Role of inter poles and compensating winding in commutation, Characteristics of D.C. Generators, Application of different types of D.C. Generators, Concept of critical resistance and critical speed of DC shunt generator, Conditions of Build-up of emf of DC generator, Parallel operation of D.C. Generators, Uses of D.C generators **D.C Motors**:- Basic working principle of DC motor, Significance of back emf in D.C. Motor, Voltage equation of D.C. Motor and condition for maximum power output(simple problems), Derive torque equation (solve problems), Characteristics of shunt, series and compound motors and their application, Starting method of shunt, series and compound motors, Speed control

of D.C shunt motors by Flux control method. Armature voltage Control method Solve problems, Speed control of D.C. series motors by Field Flux control method, Tapped field method and series-parallel method, Determination of efficiency of D.C. Machine by Brake test method(solve numerical problems), Determination of efficiency of D.C. Machine by Swinburne's Test method(solve numerical problems), Losses, efficiency and power stages of D.C. motor(solve numerical problems) Uses of D.C. motors **Single Phase Transformor:-** Working principle of transformer Constructional feature of Transformer, Arrangement of core & winding in different types of transformer, Brief ideas about transformer accessories such as conservator, tank, breather, and explosion vent etc, Explain types of cooling methods, State the procedures for Care and maintenance, EMF equation of transformer, Ideal transformer voltage transformation ratio , Operation of Transformer at no load, on load with phasor diagrams, Equivalent Resistance, Leakage Reactance and Impedance of transformer, To draw phasor diagram of transformer on load, with winding Resistance and Magnetic leakage with using upf, leading pf and lagging pf load, To explain Equivalent circuit and solve numerical problems, Approximate & exact voltage drop calculation of a Transformer Regulation of transformer, Different types of losses in a Transformer. Explain Open circuit and Short Circuit test.(Solve numerical problems), Explain Efficiency, efficiency at different loads and power factors, condition for maximum efficiency (solve problems), Explain All Day Efficiency (solve problems), Determination of load corresponding to Maximum efficiency, Parallel operation of single phase transformer **Auto Transformer:-** Constructional features of Auto transformer, Working principle of single phase Auto Transformer, Comparison of Auto transformer with an two winding transformer (saving of Copper), Uses of Auto transformer, Explain Tap changer with transformer (on load and off load condition) **Instrument Transformers:-** Explain Current Transformer and Potential Transformer, Define Ratio error, Phase angle error, Burden, Uses of C.T. and P.T.

## 7. ANALOG ELECTRONICS AND OP-AMP

**P-N Junction Diode:-** P-N Junction Diode, Working of Diode, V-I characteristic of PN junction Diode, DC load line, Important terms such as Ideal Diode, Knee voltage, Junctions break down, Zener breakdown, Avalanche breakdown, P-N Diode clipping Circuit, P-N Diode clamping Circuit **Special Semiconductor Devices:-** Thermistors, Sensors & barretters, Zener Diode, Tunnel Diode, PIN

Diode **Rectifier Circuits & Filters:-** Classification of rectifiers, Analysis of half wave, full wave centre tapped and Bridge rectifiers and calculate DC output current and voltage, RMS output current and voltage, Rectifier efficiency, Ripple factor, Regulation, Transformer utilization factor, Peak inverse voltage, Filters Shunt capacitor filter, Choke input filter, π filter **Transistors:-** Principle of Bipolar junction transistor, Different modes of operation of transistor, Current components in a transistor, Transistor as an amplifier, Transistor circuit configuration & its characteristics, CB Configuration, CE Configuration, CC Configuration **Transistor Circuits:-** Transistor biasing, Stabilization, Stability factor, Different method of Transistors Biasing, Base resistor method, Collector to base bias, Self bias or voltage divider method **Transistor Amplifiers & Oscillators:-** Practical circuit of transistor amplifier, DC load line and DC equivalent circuit, AC load line and AC equivalent circuit, Calculation of gain, Phase reversal, H-parameters of transistors, Simplified H-parameters of transistors, Generalised approximate model, Analysis of CB, CE, CC amplifier using generalised approximate model, Multi stage transistor amplifier, R.C. coupled amplifier, Transformer coupled amplifier, Feed back in amplifier, General theory of feed back, Negative feedback circuit, Advantage of negative feed back, Power amplifier and its classification, Difference between voltage amplifier and power amplifier, Transformer coupled class A power amplifier, Class A push – pull amplifier, Class B push – pull amplifier, Oscillators, Types of oscillators, Essentials of transistor oscillator, Principle of operation of tuned collector, Hartley, colpitt, phase shift, wein-bridge oscillator (no mathematical derivations) **Field Effect Transistor:-** Classification of FET, Advantages of FET over BJT, Principle of operation of BJT, FET parameters (no mathematical derivation), DC drain resistance, AC drain resistance, Trans-conductance, Biasing of FET **Operational Amplifiers:-** General circuit simple of OP-AMP and IC – CA – 741 OP AMP, Operational amplifier stages, Equivalent circuit of operational amplifier, Open loop OP-AMP configuration, OPAMP with fed back, Inverting OP-AMP, Non inverting OP-AMP, Voltage follower & buffer, Differential amplifier, Adder or summing amplifier, Sub tractor, Integrator, Differentiator, Comparator

## 8. ELECTRICAL MEASUREMENT & INSTRUMENTATION

**Measuring Instruments:-** Define Accuracy, precision, Errors, Resolutions Sensitivity and tolerance, Classification of measuring instruments, Explain Deflecting,

controlling and damping arrangements in indicating type of instruments, Calibration of instruments **Analog Ammeters and Voltmeters:-** Describ Construction, principle of operation, errors, ranges merits and demerits of, Moving iron type instruments, Permanent Magnet Moving coil type instruments, Dynamometer type instruments, Rectifier type instruments, Induction type instruments, Extend the range of instruments by use of shunts and Multipliers, Solve Numerical **Wattmeters and Measurement of Power:-** Describe Construction, principle of working of Dynamometer type wattmeter. (LPF and UPF type), The Errors in Dynamometer type wattmeter and methods of their correction, Discuss Induction type watt meters **Energymeters and Measurement of Energy:-** Introduction, Single Phase Induction type Energy meters – construction, working principle and their compensation & adjustments, Testing of Energy Meters **Measurement of Speed, Frequency and Power Factor:-** Tachometers, types and working principles, Principle of operation and construction of Mechanical and Electrical resonance Type frequency meters, Principle of operation and working of Dynamometer type single phase and three phase power factor meters **Measurement of Resistance, Inductance& Capacitance:-** Classification of resistance, Measurement of low resistance by potentiometer method, Measurement of medium resistance by wheat Stone bridge method, Measurement of high resistance by loss of charge method, Construction, principle of operations of Megger & Earth tester for insulation resistance and earth resistance measurement respectively, Construction and principles of Multimeter. (Analog and Digital), Measurement of inductance by Maxewell's Bridge method, Measurement of capacitance by Schering Bridge method **Sensors and Transducer:-** Define Transducer, sensing element or detector element and transduction elements, Classify transducer. Give examples of various class of transducer, Resistive transducer, Linear and angular motion potentiometer, Thermistor and Resistance thermometers, Wire Resistance Strain Gauges, Inductive Transducer, Principle of linear variable differential Transformer (LVDT), Uses of LVDT, Capacitive Transducer, General principle of capacitive transducer, Variable area capacitive transducer, Change in distance between plate capacitive transducer, Piezo electric Transducer and Hall Effect Transducer with their applications **Oscilloscope:-** Principle of operation of Cathode Ray Tube, Principle of operation of Oscilloscope (with help of block diagram), Measurement of DC Voltage & current, Measurement of AC Voltage, current, phase & frequency

## 9. GENERATION TRANSMISSION & DISTRIBUTION

**Generation of Electricity:-** Elementary idea on generation of electricity from Thermal, Hydel, Nuclear, Power station, Introduction to Solar Power Plant (Photovoltaic cells), Layout diagram of generating stations **Transmission of Electric Power:-** Layout of transmission and distribution scheme, Voltage Regulation & efficiency of transmission, State and explain Kelvin's law for economical size of conductor, Corona and corona loss on transmission lines **Over Head Lines:-** Types of supports, size and spacing of conductor, Types of conductor materials, State types of insulator and cross arms, Sag in overhead line with support at same level and different level, (approximate formula effect of wind, ice and temperature on sag), Simple problem on sag **Performance of Short & Medium Lines:-** Calculation of regulation and efficiency **EHV Transmission:-** EHV AC transmission, Reasons for adoption of EHV AC transmission, Problems involved in EHV transmission, HV DC transmission, Advantages and Limitations of HVDC transmission system **Distribution Systems:-** Introduction to Distribution System, Connection Schemes of Distribution System: (Radial, Ring Main and Inter connected system), DC distributions, Distributor fed at one End, Distributor fed at both the ends, Ring distributors, AC distribution system, Method of solving AC distribution problem, Three phase four wire star connected system arrangement **Underground Cables:-** Cable insulation and classification of cables, Types of L. T. & H.T. cables with constructional features, Methods of cable lying, Localization of cable faults: Murray and Varley loop test for short circuit fault / Earth fault **Economic Aspects:-** Causes of low power factor and methods of improvement of power factor in power system, Factors affecting the economics of generation: (Define and explain) Load curves, Demand factor, Maximum demand, Load factor, Diversity factor, Plant capacity factor, Peak load and Base load on power station **Types of Tariff:-** Desirable characteristic of a tariff, Explain flat rate, block rate, two part and maximum demand tariff. (Solve Problems) **Substation:-** Layout of LT, HT and EHT substation, Earthing of Substation, transmission and distribution lines.

## 10. ENTREPRENEURSHIP AND MANAGEMENT & SMART TECHNOLOGY

**Entrepreneurship:-** Concept /Meaning of Entrepreneurship, Need of Entrepreneurship, Characteristics, Qualities and Types of entrepreneur, Functions, Barriers in

entrepreneurship, Entrepreneurs vrs. Manager, Forms of Business Ownership: Sole proprietorship, partnership forms and others, Types of Industries, Concept of Start-up, Entrepreneurial support agencies at National, State, District Level (Sources): DIC, NSIC, OSIC, SIDBI, NABARD, Commercial Banks, KVIC etc., Technology Business Incubators (TBI) and Science and Technology Entrepreneur Parks. **Market Survey and Opportunity Identification (Business Planning):-** Business Planning, SSI, Ancillary Units, Tiny Units, Service sector Units, Time schedule Plan, Agencies to be contacted for Project Implementation, Assessment of Demand and supply and Potential areas of Growth, Identifying Business Opportunity, Final Product selection, **Project Report Preparation:-** Preliminary project report, Detailed project report, Techno economic Feasibility, Project Viability, **Management Principles:-** Definitions of management, Principles of management, Functions of management (planning, organising, staffing, directing and controlling etc.), Level of Management in an Organisation. **Functional Areas of Management:** Production management, Functions, Activities, Productivity, Quality control, Production Planning and control, Inventory Management, Need for Inventory management, Models/Techniques of Inventory management, Financial Management, Functions of Financial management, Management of Working capital, Costing (only concept), Break even Analysis, Brief idea about Accounting Terminologies: Book Keeping, Journal entry, Petty Cash book, P&L Accounts, Balance Sheets(only Concepts, Marketing Management, Concept of Marketing and Marketing Management, Marketing Techniques (only concepts), Concept of 4P s (Price, Place, Product, Promotion), Human Resource Management, Functions of Personnel Management, Manpower Planning, Recruitment, Sources of manpower, Selection process, Method of Testing, Methods of Training & Development, Payment of Wages, **Leadership and Motivation:-** Leadership, Definition and Need/Importance, Qualities and functions of a leader, Manager Vs Leader, Style of Leadership (Autocratic, Democratic, Participative). Motivation, Definition and characteristics, Importance of motivation, Factors affecting motivation, Theories of motivation (Maslow), Methods of Improving Motivation, Importance of Communication in Business, Types and Barriers of Communication, **Work Culture, TQM & Safety**:- Human relationship and Performance in Organization, Relations with Peers, Superiors and Subordinates, TQM concepts: Quality Policy, Quality Management, Quality system, Accidents and Safety, Cause, preventive measures, General Safety Rules , Personal Protection Equipment(PPE), **Legislation:-** Intellectual Property Rights(IPR), Patents, Trademarks, Copyrights, Features of Factories Act 1948 with Amendment (only salient points), Features of Payment of Wages Act 1936 (only salient points), **Smart Technology:-** Concept of IOT, How IOT works, Components of IOT, Characteristics of IOT, Categories of IOT, Applications of IOT- Smart Cities, Smart Transportation, Smart Home, SmartHealthcare, Smart Industry, Smart Agriculture, Smart Energy Management etc.

## 11. ENERGY CONVERSION-II

**Alternator:-** Types of alternator and their constructional features, Basic working principle of alternator and the relation between speed and frequency, Terminology in armature winding and expressions for winding factors (Pitch factor, Distribution factor), Explain harmonics, its causes and impact on winding factor, E.M.F equation of alternator. (Solve numerical problems), Explain Armature reaction and its effect on emf at different power factor of load, The vector diagram of loaded alternator. (Solve numerical problems). Testing of alternator (Solve numerical problems), Open circuit test, Short circuit test. Determination of voltage regulation of Alternator by direct loading and synchronous, impedance method. (Solve numerical problems), Parallel operation of alternator using synchro-scope and dark & bright lamp method, Explain distribution of load by parallel connected alternators. **Synchronous Motor:** Constructional feature of Synchronous Motor, Principles of operation, concept of load angle, Derive torque, power developed, Effect of varying load with constant excitation, Effect of varying excitation with constant load, Power angle characteristics of cylindrical rotor motor, Explain effect of excitation on Armature current and power factor, Hunting in Synchronous Motor, Function of Damper Bars in synchronous motor and generator, Describe method of starting of Synchronous motor, State application of synchronous motor. **Three Phase Induction Motor:-** Production of rotating magnetic field, Constructional feature of Squirrel cage and Slip ring induction motors, Working principles of operation of 3-phase Induction motor, Define slip speed, slip and establish the relation of slip with rotor quantities, Derive expression for torque during starting and running conditions and derive conditions for maximum torque. (solve numerical problems), Torque-slip characteristics, Derive relation between full load torque and starting torque etc. (solve numerical problems), Establish the relations between Rotor Copper loss, Rotor output and Gross, Torque and relationship of slip with rotor copper loss. (solve numerical problems), Methods of starting and different types of starters used for three phase Induction motor, Explain speed control by Voltage Control, Rotor resistance control, Pole changing, frequency control methods, Plugging as applicable to three phase induction motor, Describe different types of motor enclosures, Explain principle of Induction Generator and state its applications. **Single Phase Induction Motor:** Explain Ferrari's principle, Explain double revolving field theory and Cross-field theory to analyze, starting torque of 1-phase induction motor, Explain Working principle, Torque speed characteristics, performance characteristics and application of following single phase motors, Split phase motor, Capacitor Start motor, Capacitor start, capacitor run motor, Permanent capacitor type motor, Shaded pole motor, Explain the method to change the direction of rotation of above motors, **Commutator**

**Motors:** Construction, working principle, running characteristic and application of single phase series motor, Construction, working principle and application of Universal motors, Working principle of Repulsion start Motor, Repulsion start Induction run motor, Repulsion Induction motor, **Special Electrical Machine:-** Principle of Stepper motor, Classification of Stepper motor, Principle of variable reluctant stepper motor, Principle of Permanent magnet stepper motor, Principle of hybrid stepper motor, Applications of Stepper motor, **Three Phase Transformers:-** Explain Grouping of winding, Advantages, Explain parallel operation of the three phase transformers, Explain tap changer (On/Off load tap changing), Maintenance Schedule of Power Transformers.

## 12. DIGITAL ELECTRONICS & MICROPROCESSOR

**Basics of Digital Electronics:-** Binary, Octal, Hexadecimal number systems and compare with Decimal system, Binary addition, subtraction, Multiplication and Division, 1's complement and 2's complement numbers for a binary number, Subtraction of binary numbers in 2's complement method, Use of weighted and Un-weighted codes & write Binary equivalent number for a number in 8421, Excess-3 and Gray Code and vice-versa, Importance of parity Bit, Logic Gates: AND, OR, NOT, NAND, NOR and EX-OR gates with truth table, Realize AND, OR, NOT operations using NAND, NOR gates, Different postulates and De-Morgan's theorems in Boolean algebra, Use Of Boolean Algebra For Simplification of Logic Expression, Karnaugh Map For 2,3,4 Variable, Simplification Of SOP And POS Logic Expression Using K-Map, **Combinational Logic Circuits**:- Give the concept of combinational logic circuits, Half adder circuit and verify its functionality using truth table, Realize a Half-adder using NAND gates only and NOR gates only, Full adder circuit and explain its operation with truth table, Realize full-adder using two Half-adders and an OR – gate and write truth table, Full subtractor circuit and explain its operation with truth table, Operation of 4 X 1 Multiplexers and 1 X 4 demultiplexer, Working of Binary-Decimal Encoder & 3 X 8 Decoder, Working of Two bit magnitude comparator, **Sequential Logic Circuits**: Give the idea of Sequential logic circuits, State the necessity of clock and give the concept of level clocking and edge triggering, Clocked SR flip flop with preset and clear inputs, Construct level clocked JK flip flop using S-R flip-flop and explain with truth table, Concept of race around condition and study of master slave JK flip flop, Give the truth tables of edge triggered D and T flip flops and draw their symbols, Applications of flip flops, Define modulus of a counter, 4-bit asynchronous counter and its timing diagram, Asynchronous decade counter, 4-bit synchronous counter, Distinguish between synchronous and asynchronous counters, State the need for a Register and list the four types of registers, Working of SISO, SIPO, PISO, PIPO Register with truth table

using flip flop. **8085 Microprocessor**: Introduction to Microprocessors, Microcomputers, Architecture of Intel 8085A Microprocessor and description of each block, Pin diagram and description, Stack, Stack pointer & stack top, Interrupts. Opcode & Operand, Differentiate between one byte, two byte & three byte instruction with example, Instruction set of 8085 example, Addressing mode, Fetch Cycle, Machine Cycle, Instruction Cycle, T-State, Timing Diagram for memory read, memory write, I/O read, I/O write, Timing Diagram for 8085 instruction, Counter and time delay. Simple assembly language programming of 8085. **Interfacing and Support Chips:** - Basic Interfacing Concepts, Memory mapping & I/O mapping, Functional block diagram and description of each block of Programmable peripheral interface Intel 8255, Application using 8255: Seven segment LED display, Square wave generator, Traffic light Controller.

## 13. UTILIZATION OF ELECTRICAL ENERGY & TRACTION

**Electrolytic Process:** Definition and Basic principle of Electro Deposition, Important terms regarding electrolysis, Faradays Laws of Electrolysis, Definitions of current efficiency, Energy efficiency, Principle of Electro Deposition, Factors affecting the amount of Electro Deposition, Factors governing the electro deposition, State simple example of extraction of metals. Application of Electrolysis. **Electrical Heating:** - Advantages of electrical heating, Mode of heat transfer and Stephen's Law, Principle of Resistance heating. (Direct resistance and indirect resistance heating.), Discuss working principle of direct arc furnace and indirect arc furnace, Principle of Induction heating, Working principle of direct core type, vertical core type and indirect core type Induction furnace, Principle of coreless induction furnace and skin effect, Principle of dielectric heating and its application, Principle of Microwave heating and its application. **Principles of ARC Welding:** - Explain principle of arc welding, Discuss D. C. & A. C. Arc phenomena, D.C. & A. C. arc welding plants of single and multi-operation type, Types of arc welding, Explain principles of resistance welding, Descriptive study of different resistance welding methods. **Illumination:** - Nature of Radiation and its spectrum, Terms used in Illuminations. [Lumen, Luminous intensity, Intensity of illumination, MHCP, MSCP, MHSCP, Solid angle, Brightness, Luminous efficiency]. Explain the inverse square law and the cosine law, Explain polar curves, Describe light distribution and control. Explain related definitions like maintenance factor and depreciation factors, Design simple lighting schemes and depreciation factor, Constructional feature and working of Filament lamps, effect of variation of voltage on working of filament lamps, Explain Discharge lamps, State Basic idea about excitation in gas discharge lamps, State constructional factures and operation of fluorescent lamp. (PL and PLL Lamps), Sodium vapor lamps, High pressure mercury vapor lamps, Neon sign lamps, High lumen output & low consumption fluorescent

lamps. **Industrial Drives:** - State group and individual drive, Method of choice of electric drives, Explain starting and running characteristics of DC and AC motor, State Applicatio:1 of DC motor, 3-phase induction motor, 3 phase synchronous motors, Single phase induction, series motor, universal motor and repulsion moto. **Electric Traction:** - Explain system of traction, System of Track electrification, Running Characteristics of DC and AC traction motor, explain control of motor, tapped field control, Rheostatic control, Series parallel control, multi-unit control, Metadyne control, Explain Braking of the following types, Regenerative Braking, Braking with 1-phase series motor, Magnetic Braking.

## 14. POWER ELECTRONICS AND PLC

**Understand the Construction and Working of Power Electronic Devices:** Construction, Operation, V-I characteristics & application of power diode, SCR, DIAC,TRIAC, Power MOSFET,GTO & IGBT, Two transistor analogy of SCR, Gate characteristics of SCR, Switching characteristic of SCR during turn on and turn off. Turn on methods of SCR, Turn off methods of SCR (Line commutation and Forced commutation), Load Commutation, Resonant pulse commutation, Voltage and Current ratings of SCR, Protection of SCR, Over voltage protection, Over current protection.

Gate protection, Firing Circuits, General layout diagram of firing circuit. R firing circuits R-C firing circuit

UJT pulse trigger circuit, Synchronous triggering (Ramp Triggering ), Design of Snubber Circuits. **Understand the Working of Converters, AC Regulators and Choppers:-** Controlled rectifiers Techniques(Phase Angle, Extinction Angle control), Single quadrant semi converter, two quadrant full converter and dual Converter, Working of single-phase half wave controlled converter with Resistive and R-L loads, Understand need of freewheeling diode, Working of single phase fully controlled converter with resistive and R- L loads, Working of three-phase half wave controlled converter with Resistive load, Working of three phase fully controlled converter with resistive load, Working of single phase AC regulator, Working principle of step up & step down chopper, Control modes of chopper, Operation of chopper in all four quadrants. **Understand the Inverters and Cyclo-Converters:-** Classify inverters, Explain the working of series inverter, Explain the working of parallel inverter, Explain the working of single-phase bridge inverter, Explain the basic principle of Cyclo-converter, Explain the working of single-phase step up & step down Cyclo-converter. Applications of Cyclo-converter, **Understand Applications of Power Electronic Circuits:-** List applications of power electronic circuits, List the factors affecting the speed of DC Motors, Speed control for DC Shunt motor using converter, Speed control for DC Shunt motor using chopper, List the factors affecting speed of the AC Motors, Speed control of Induction Motor by using AC voltage regulator,

Speed control of induction motor by using converters and inverters (V/F control), Working of UPS with block diagram, Battery charger circuit using SCR with the help of a diagram, Basic Switched mode power supply (SMPS) - explain its working & applications. **PLC and Its Applications:-** Introduction of Programmable Logic Controller(PLC), Advantages of PLC, Different parts of PLC by drawing the Block diagram and purpose of each part of PLC, Applications of PLC, Ladder diagram, Description of contacts and coils in the following states, i)Normally open ii) Normally closed iii) Energized output iv)latched Output)) v)branching, Ladder diagrams for i) AND gate ii) OR gate and iii) NOT gate, Ladder diagrams for combination circuits using NAND,NOR, AND, OR and NOT , Timers-i)T ON ii) T OFF and iii)Retentive timer, Counters-CTU, CTD, Ladder diagrams using Timers and counters, PLC Instruction set, Ladder diagrams for following (i) DOL starter and STAR-DELTA starter (ii) Stair case lighting (iii) Traffic light Control (iv) Temperature Controller, Special control systems- Basics DCS & SCADA systems. Computer Control–Data Acquisition, Direct Digital Control System (Basics only).

## 15. ELECTRICAL INSTALLATION AND ESTIMATING

**Indian Electricity Rules:-** Definitions, Ampere, Apparatus, Accessible, Bare, cable, circuit, circuit breaker, conductor voltage (low, medium, high, EH), live, dead, cut-out, conduit, system, danger, Installation, earthing system, span, volt, switch gear, etc., General safety precautions, rule 29, 30, 31, 32, 33, 34, 35, 36, 40, 41, 43, 44, 45, 46, General conditions relating to supply and use of energy : rule 47, 48, 49, 50, 51, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 70, OH lines : Rule 74, 75, 76, 77, 78, 79, 80, 86, 87, 88, 89, 90, 91, **Electrical Installations:** Electrical installations, domestics, industrial, Wiring System, Internal distribution of Electrical Energy. Methods of wiring, systems of wiring, wire and cable, conductor materials used in cables, insulating materials mechanical protection. Types of cables used in internal wiring, multi-stranded cables, voltage grinding of cables, general specifications of cables, ACCESSORIES: Main switch and distribution boards, conduits, conduit accessories and fittings, lighting accessories and fittings, fuses, important definitions, determination of size of fuse – wire, fuse units. Earthing conductor, earthing, IS specifications regarding earthing of electrical installations, points to be earthed. Determination of size of earth wire and earth plate for domestic and industrial installations. Material required for GI pipe earthing, LIGHTING SCHEME: Aspects of good lighting services. Types of lighting schemes, design of lighting schemes, factory lighting, public lighting installations, street lighting, general rules for wiring, determination of number of points (light, fan, socket, outlets), determination of total load, determination of Number of sub-circuits. **Internal Wiring:** - Type of internal wiring, cleat wiring, CTS wiring, wooden casing capping, metal sheathed wiring, conduit wiring, their advantage and

disadvantages comparison and applications, Prepare one estimate of materials required for CTS wiring for small domestic installation of one room and one verandah within 25 $m^2$ with given light, fan & plug points, Prepare one estimate of materials required for conduit wiring for small domestic installation of one room and one verandah within 25 $m^2$ with given light, fan & plug points, Prepare one estimate of materials required for concealed wiring for domestic installation of two rooms and one latrine, bath, kitchen & verandah within 80$m^2$ with given light, fan & plug points. Prepare one estimate of materials required for erection of conduct wiring to a small workshop installation about 30$m^2$ and load within 10 KW. **Over Head Installation: -** Main components of overhead lines, line supports, factors Governing Height of pole, conductor materials, determination of size of conductor for overhead transmission line, cross arms, pole brackets and clamps, guys and stays, conductors configurations, spacing and clearances, span lengths, overhead line insulators, types of insulators, lighting arresters, danger plates, anti-climbing devices, bird guards, beads of jumpers, jumpers, tee-offs, guarding of overhead lines, Prepare an estimate of materials required for LT distribution line within load of 100 KW maximum and standard spans involving calculation of the size of conductor (from conductor chart), current carrying capacity and voltage regulation consideration using ACSR, Prepare an estimate of materials required for LT distribution line within load of 100 KW maximum and standard spans involving calculation of the size of conductor (from conductor chart), current carrying capacity and voltage regulation consideration using ACSR, Prepare an estimate of materials required for HT distribution line (11 KV) within 2 km and load of 2000 KVA maximum and standard spans involving calculation of the size of conductor (from conductor chart), current carrying capacity and voltage regulation of the size of conductor (from conductor chart), current carrying capacity and voltage regulation consider action using ACSR, **Over Head Service Lines**:- Components of service lines, service line (cables and conductors), bearer wire, lacing rod, Ariel fuse, service support, energy box and meters etc., Prepare and estimate for providing single phase supply of load of 5 KW (light, fan, socket) to a single stored residential building. Prepare and estimate for providing single phase supply load of 3KW to each floor of a double stored building having separate energy meter, Prepare one estimate of materials required for service connection to a factory building with load within 15 KW using insulated wire, Prepare one estimate of materials required for service connection to a factory building with load within 15 KW using bare conductor and insulated wire combined. **Estimating For Distribution Substations**: - Prepare one material estimate for following types of transformer substations, Pole mounted substation, Plinth Mounted substation

## 16. SWITCH GEAR AND PROTECTIVE DEVICES

**Introduction to Switchgear**:- Essential Features of switchgear Switchgear Equipment, Bus-Bar Arrangement, Switchgear Accommodation. Short Circuit. Short circuit, Faults in a power system. **Fault Calculation**:- Symmetrical faults on 3-phase system, Limitation of fault current, Percentage Reactance, Percentage Reactance and Base KVA, Short – circuit KVA, Reactor control of short circuit currents. Location of reactors, Steps for symmetrical Fault calculations. Solve numerical problems on symmetrical fault. **Fuses**:- Desirable characteristics of fuse element. Fuse Element materials, Types of Fuses and important terms used for fuses, Low and High voltage fuses, Current carrying capacity of fuse element, Difference Between a Fuse and Circuit Breaker. **Circuit Breakers**:- Definition and principle of Circuit Breaker. Arc phenomenon and principle of Arc Extinction. Methods of Arc Extinction. Definitions of Arc voltage, Re-striking voltage and Recovery voltage. Classification of circuit Breakers, Oil circuit Breaker and its classification. Plain brake oil circuit breaker. Arc control oil circuit breaker, Low oil circuit breaker. Maintenance of oil circuit breaker. Air-Blast circuit breaker and its classification. Sulphur Hexa-fluoride (SF6) circuit breaker, Vacuum circuit breakers. Switchgear component. Problems of circuit interruption, Resistance switching. Circuit Breaker Rating. **Protective Relays**:- Definition of Protective Relay, Fundamental requirement of protective relay. Basic Relay operation, Electromagnetic Attraction type. Induction type. Definition of following important terms, Definition of following important terms, Pick-up current. Current setting, Plug setting Multiplier, Time setting Multiplier, Classification of functional relays, Induction type over current relay (Non-directional). Induction type directional power relay, Induction type directional over current relay, Differential relay Current differential relay, Voltage balance differential relay, Types of protection. **Protection of Electrical Power Equipment and Lines**: Protection of alternator. Differential protection of alternators. Balanced earth fault protection. Protection systems for transformer, Buchholz relay. Protection of Bus bar. Protection of Transmission line, Different pilot wire protection (Merz-price voltage Balance system). Explain protection of feeder by over current and earth fault relay. **Protection Against over Voltage and Lighting**:- Voltage surge and causes of over voltage. Internal cause of over voltage, External cause of over voltage (lighting), Mechanism of lightning discharge, Types of lightning strokes. Harmful effect of lightning. Lightning arresters and Type of lightning Arresters. Rod-gap lightning arrester. Horn-gap arrester, Valve type arrester, Surge Absorber. **Static Relay**:- Advantage of static relay, Instantaneous over current relay, Principle of IDMT relay.

## 17. CONTROL SYSTEM ENGINEERING

**Fundamental of Control System**: - Classification of Control system, Open loop system & Closed loop system and its comparison, Effects of Feed back, Standard test Signals(Step, Ramp, Parabolic, Impulse Functions), Servomechanism. **Mathematical Model of a System**:- Transfer Function & Impulse response, Properties, Advantages & Disadvantages of Transfer Function, Poles & Zeroes of transfer Function, Simple problems of transfer function of network, Mathematical modeling of Electrical Systems(R, L, C, Analogous systems). **Control System Components**:- Components of Control System. Gyroscope, Synchro's, Tachometer, DC servomotors, AC Servomotors. **Block Diagram Algebra & Signal Flow Graphs:-** Definition: Basic Elements of Block Diagram, Canonical Form of Closed loop Systems, Rules for Block diagram reduction, Procedure for of Reduction of Block Diagram, Simple Problem for equivalent transfer function, Basic Definition in Signal Flow Graph & properties, Construction of Signal Flow graph from Block diagram, Mason's Gain formula, Simple problems in Signal flow graph for network. **Time Response Analysis**:- Time response of control system, Standard Test signal, Step signal, Ramp Signal, Parabolic Signal, Impulse Signal, Time Response of first order system with, Unit step response, Unit impulse response, Time response of second order system to the unit step input, Time response specification, Derivation of expression for rise time, peak time, peak overshoot, setting time and steady state error, Steady state error and error constants, Types of control system.[ Steady state errors in Type-0, Type-1, Type-2 system], Effect of adding poles and zero to transfer function. 5 . 7., Response with P, PI, PD and PID controller. **Analysis of Stability by Root Locus Technique:-** Root locus concept, Construction of root loci, Rules for construction of the root locus, Effect of adding poles and zeros to G(s) and H(s). **Frequency Response Analysis:-** Correlation between time response and frequency response, Polar plots, Bode plots, All pass and minimum phase system, Computation of Gain margin and phase margin, Log magnitude versus phase plot, Closed loop frequency response.

**Nyquist Plot:-** Principle of argument, Nyquist stability criterion, Nyquist stability criterion applied to inverse polar plot, Effect of addition of poles and zeros to G(S) H(S) on the shape of Nyquist plot, Assessment of relative stability, Constant M and N circle, Nicholas chart.

## 18. TESTING AND MAINTENANCE OF ELECTRICAL MACHINE

**Installation, Commissioning and Testing of Machine:-** Inspection of arrival of machine and inspection procedure before its installation, Generalized procedure of

installation of Electrical machines, Electric wiring for motors and switch gears, General requirement for Electric Installation according to Indian Electricity rules, Necessity of starters and relays for both DC and AC machines, Testing before giving supply and testing report. **Installation, Commissioning and Testing of Transformer**:- Basic idea on dispatch, inspection, storage and handling of transformer, Civil construction feature regarding connection like ventilation, noise level, space for free movement, Foundation and drainage of oil, Cabling and cable box for transformer, Provision for fire protection, Provision for bushing support location of switch gear, Steps for commissioning fitting of all accessories, Filling of oil, drying out, Charging the breather with fresh silica gel, Cleaning of bushing, fixing of conductor & cables, earthing of tank and cover, neutral earthing, Fixing of protection circuits and setting of relays. **Installation, Commissioning & Testing of Sub-station:-** Design and planning of indoor substation, General requirement of layout of indoor substation with key diagram, Consideration of safe operation of substation, Installation of Outdoor Substation: Selection of site, transport & receipt of transformer, checking of insulation resistance of the winding, testing of transformer oil, protection fittings, construction of mounting, earthing arrangement and final commissioning. Testing and commissioning of substation, Installation of control and relay panels, Preliminary preparation, Sequence card for erection of switch gear equipments, Location of place, Unpacking, Foundation, Erection, Relays, Bus-bar earthing connection, Earthing, Connection to main cable, Safety precaution. Installation of outdoor circuit breaker, Receipt and storage, Civil works, Various steps for installation, Pre-commissioning tests. **Maintenance**:- Fundamental of maintenance, Preventive maintenance and planning [Daily, Weekly, Monthly, Half-yearly and Yearly maintenance.], Advantages of Preventive maintenance, Breakdown maintenance: List of tools / instruments and materials used for maintenance, Making or Preparing Maintenance schedule of DC machines, Induction machines, Synchronous machines, Transformer, Transmission line, Distribution lines, Underground cables, Circuit breakers, Switch gear and protective relays and substations, SF-6 circuit breakers, Batteries in substation.

## 19. RENEWABLE ENERGY SYSTEMS

**Introduction to Renewable Energy**: Environmental consequences of fossil fuel use, Importance of renewable sources of energy, Sustainable Design and development, Types of RE sources, Limitations of RE sources, Present Indian and international energy scenario of conventional and RE sources. **Solar Energy**: Solar photovoltaic system-Operating principle, Photovoltaic cell concepts, Cell, module, array, series and parallel connections, Maximum power point tracking (MPPT),

Classification of energy Sources, Extra-terrestrial and terrestrial Radiation, Azimuth angle, Zenith angle, Hour angle, Irradiance, Solar constant, Solar collectors, Types and performance characteristics, Applications: Photovoltaic - battery charger, domestic lighting, street lighting, water pumping, solar cooker, Solar Pond. **Wind Energy: -** Introduction to Wind energy, Wind energy conversion, Types of wind turbines, Aerodynamics of wind rotors, Wind turbine control systems; conversion to electrical power, Induction and synchronous generators, Grid connected and self excited induction generator operation, Constant voltage and constant frequency generation with power electronic control, Single and double output systems, Characteristics of wind power plant. **Biomass Power:-** Energy from Biomass, Biomass as Renewable Energy Source, Types of Biomass Fuels - Solid, Liquid and Gas, Combustion and fermentation, Anaerobic digestion, Types of biogas digester, Wood gassifier, Pyrolysis, Application: Bio gas, Bio diesel. **Other Energy Sources:-** Tidal Energy: Energy from the tides, Barrage and Non Barrage Tidal power systems, Ocean Thermal Energy Conversion (OTEC), Geothermal Energy – Classification, Hybrid Energy Systems, Need for Hybrid Systems, Diesel-PV, Wind-PV, Microhydel-PV, Electric and hybrid electric vehicles.

## 20. ELECTRIC VEHICLES

**Introduction to Hybrid Electric Vehicles:** Evolution of Electric vehicles, Advanced Electric drive vehicle technology Vehicles- Electric vehicles (EV), Hybrid Electric drive (HEV), Plug in Electric vehicle (PIEV), Components used Hybrid Electric Vehicle, Economic and environmental impacts of Electric hybrid vehicle Parameters affecting Environmental and economic analysis. Comparative study of vehicles for economic, environmental aspects. **Dynamics of hybrid and Electric vehicles:-** General description of vehicle movement, Factors affecting vehicle motion- Vehicle resistance, tyre ground adhesion, rolling resistance, aerodynamic drag, equation of grading resistance, dynamic equation. Drive train configuration, Automobile power train, classification of vehicle power plant. Performance characteristics of IC engine, electric motor, need of gear box. Classification of motors used in Electric vehicles. Basic architecture of hybrid drive trains, types of HEVs Energy saving potential of hybrid drive trains ,HEV Configurations-Series, parallel, Series-parallel, complex. **DC-DC Converters for EV and HEV Applications:-** EV and HEV configuration based on power converters, Classification of converters — unidirectional and bidirectional, Principle of

step down operation, Boost and Buck- Boost converters, Principle of Step-Up operation, Two quadrant converters; multi quadrant converters, Electrical Engineering Curriculum Structure 210. **DC-AC Inverter & Motors for EV and HEVs:-** DC-AC Converters, Principle of operation of half bridge DC-AC inverter (R load, R-L load), Single phase Bridge DC-AC inverter with R load, R-L load, Electric Machines used in EVs and HEVs, principle of operation, working & control , Permanent magnet motors, their drives, switched reluctance motor, Characteristics and applications of above motors. **Batteries:-** Overview of batteries, Battery Parameters, types of batteries, Battery Charging, alternative novel energy sources-solar photovoltaic cells, fuel cells, super capacitors, flywheels, Control system for EVs and HEVs, overview, Electronic control unit ECU, Schematics of hybrid drive train, control architecture Regenerative braking in EVs.

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