SYLLABUS FOR THE POSTS AGAINST ADVT NO-08/2025 & ADVT NO-09/2025

SL NO.	NAME OF THE POST	SYLLABUS
1.	Assistant Manager- Civil in E-3 Grade	Click here
2.	Assistant Manager- Electrical in E-3 Grade	Click here
3.	Assistant Manager- Mechanical in E-3 Grade	Click here
4.	Mine Surveyor in S-2 Grade	Click here
5.	Mine Junior Overman in S-2 Grade	Click here

SYLLABUS FOR THE POST OF ASSISTANT MANAGER- CIVIL IN E-3 GRADE

1. Fluid Mechanics:

- Introduction: Fluid and continuum, physical properties of fluids, rheology of fluids.
  Fluid Statics: Pressure-density-height relationship, manometers, pressure on plane and curved surfaces, centre of pressure, buoyancy, stability of immersed and floating bodies, fluid masses subjected to linear acceleration and uniform rotation about an axis.
- Kinematics of Fluid Flow: Continuum and free molecular flows, steady and unsteady, uniform and non- uniform, laminar and turbulent flows, rotational and irrotational flows, compressible and incompressible flows, subsonic, sonic and supersonic flows, sub-critical, critical and supercritical flows, one, two and three dimensional flows, ideal and real flow.
  System versus control volume approach, fundamentals of flow visualization, streamlines, streak lines and path lines, continuity equation in Cartesian and polar co-ordinate system, rotation and circulation, stream function and potential function, flow nets.
- Laminar Flow: Relation between shear and pressure gradient in laminar flow, introduction toNavier-Stokes equations, Reynolds experiment, equation of motion for laminar flow through pipes, flow between parallel plates, Kinetic energy and Momentum correction factors.
  Turbulent Flow: Types of turbulent flow, isotropic, homogenous turbulence, scale and intensity of turbulence, measurement of turbulence, eddy viscosity, Prandtl's mixing length concept and velocity distribution in turbulent flow over smooth and rough surfaces.
  Flow through Pipes: Major and minor losses, energy and hydraulic grade lines, combination of pipes, flow through siphon pipes, pipe network, power transmission through pipes, surge tanks, water hammer.
- Theory of Boundary Layer: Boundary layer thickness, boundary layer over a flat plate, application of Von- Karman integral momentum equation, laminar sub-layer, boundary layer separation and its control.
  Forces on Submerged Bodies: Drag and lift, drag on a sphere and on a cylinder, development of lift on a circular cylinder and an aerofoil, Magnus effect.
  Compressible Flow: Thermodynamic relations, basic equations of compressible flow, expression for velocity of sound wave in a fluid.

2. Strength of materials:

- Stresses in Beams: Review of pure Bending. Direct and shear stresses in beams due to transverse and axial loads, composite beams.

  Curved Beams: Bending of beams with large initial curvature, position of neutral axis for rectangular, trapezoidal and circular cross sections, stress in crane hooks, stress in circular rings subjected to tension or compression.
- Unsymmetrical Bending: Properties of beam cross-section, slope of neutral axis, stress and deflection in unsymmetrical bending, determination of shear center and flexural axis (for symmetry about both axis and about one axis) for I-section and channel section.

  Deflection of Beams: Equation of elastic curve, cantilever and simply supported beams, Macaulay's method, area moment method fixed beams.
- Helical and Leaf Springs: deflection of springs by energy method, helical springs under axial load and under axial twist (respectively for circular and square cross sections) axial load and twisting moment acting simultaneously both for open and closed coiled springs, laminated springs.
- Columns and Struts: Combined bending and direct stress, middle third and middle quarter rules. Struts with different end conditions, Euler's theory and experimental results, Ranking Gardon Formulae, Examples of columns in mechanical equipments and machines.
- Thin cylinders & spheres: Hoop and axial stresses and strain. Volumetric strain. Thick cylinders: Radial, axial and circumferential stresses in thick cylinders subjected to internal or external pressures, Compound cylinders Stresses due to interference fits.

3. Building Materials & Construction :

- Scope of Study of Building Materials: Building materials and their performance, economics of the building materials. Stones: Requirement of good building stones, characteristics of building stones and their testing. Common building stones. Method of preservation of stones. Bricks: Manufacturing process of clay bricks, classification of clay bricks. Properties of clay bricks, testing methods for clay bricks. Problems of efflorescence & lime bursting in bricks & tiles. Gypsum: properties of gypsum

plaster, building products made of gypsum and their uses. Lime: Manufacture of limes, classification of limes, properties of limes. Cement: raw materials used, Process of manufacturing, Chemical composition, compounds formed and their effect on strength, Types of cement, Testing of cement properties, Uses of cement. Cement Concrete: Constituent materials and their properties, Grades of concrete, Factors affecting strength, Properties of concrete at fresh and hardened stage, Testing of concrete, Method of Curing of concrete. Pozzolona: Chemical composition and requirements for uses, Natural and Artificial flyash, Surkhi (burnt clay pozzolona), rice husk and ash pozzolona, properties and specifications for use in construction, Timber: Classification and identification of timber, fundamental Engineering Properties of timber, Defects in timber, factors affecting strength of timber, Methods of seasoning and preservation of timber. Wood based products. Asphalt: Bitumen and tar: Terminology, specifications and uses, Bituminous materials.

- Plastics: classification, advantages of plastics, Mechanical properties and use of plastic in construction. Paints, Varnishes and Distemper: Common constituents, types and desirable properties, Cement paints. Ferrous Metals: Desirable characteristics of reinforcing steel. Principles of cold working. Reinforcing telemechanical & physical properties and chemical composition. Brief discussion on properties and uses of Aluminum and Lead. Glass: Ingredients, properties, types and use in construction. Insulating Materials: Thermal and sound insulating material, desirable properties and types.
- Buildings: Components of building, area considerations, Construction Principle and Methods for layout, Damp proofing, anti-termite treatment in buildings, Vertical circulation: stair cases and their types, design and construction. Different types of floors, and flooring materials (Ground floor and upper floors). Bricks and stone masonary construction. Cavity wall & hollow block construction.
- Doors and Windows: Construction details, types of doors and windows and their relative advantages & disadvantages. Types of roof and roof treatments, Lintel and Chhajja, Principles of building Planning.
- Natural Ventilation, Water supply and Sanitary fittings (Plumbing), Electric Fittings. Heating Ventilation & Air conditioning (HVAC), Mechanical Lifts and Escalators, Fire Fighting and Fire Protection of Buildings. Acoustics. Plastering and its types,

pointing, distempering, colour washing, painting etc. Principles & Methods of building maintenance.

4. Surveying:

- Introduction, Classification of Survey, Principles of Surveying, Plans and Maps, Scale Accuracy and Errors.
- Horizontal Distance Measurement: Chain Surveying, Chains, Tapes, Accuracy of Chaining, Running Survey lines, Linear measurements with chains, Errors in chaining
- Compass Surveying: Bearing and Angles, Theory of Magnetic Compass , The Prismatic Compass, The Surveyor's Compass, Magnetic Declination, Local Attraction, Error in Compass Surveying
- Theodolite Surveying: Classification of Theodolite, Temporary adjustments, Permanent adjustments, measurement of horizontal angles, measurement of vertical angles, Electronic theodolite
- Traversing: Methods of Traversing, Plotting Traverse Survey, Checks, Closing Errors, Balancing Traverse, Adjustment of Bearings, Omitted measurements
- Levelling: Mehods of Levelling, Temporary adjustment of a level, Theory of direct leveling, Differential leveling, Balancing Back sight and Fore sight, Curvature and Refraction, Reciprocal Levelling, Cross Sectioning
- Contouring: Contour Interval, Characteristics of Contours, Methods of Locating contours, Interpolation of contours, Contour gradient, Uses of Contour Maps
- Trigonometric Levelling, Methods of Trigonometric Levelling
- Plane Table Surveying: Description of Plane Table, Methods of Plane Table Surveying, Radiation, Traversing, Intersection, Resection, The three-point problem, Two point problem, Advantages and disadvantages of Plane Tabling
- Tachaeometric Surveying: Methods of Tachaeometry, Fixed hair methods, Anallactic Lens, Subtense Method, Tangential Method, Range Finding
- Curves: Classification, Simple Circular Curves, Compound Curves, Reverse Curves, Transition Curves, Vertical Curves
- Triangulation: Geodetic Surveying, Classification of Triangulation System, Reconnaissance, Signals and Towers, Base Line Measurements, Measurement of Horizontal Angles, Sattelite Station, Extension of Base.

5. Hydraulics & Hydraulic Machines:

- Introduction: Difference between open channel flow and pipe flow, channel geometry, hydraulic parameters of various shapes of channels, types of open channel flow, velocity and pressure distribution, mass, energy and momentum conservation principles for prismatic and non-prismatic channels, continuity equation for steady and unsteady flow.

  Energy-Depth Relations: Concept of specific energy, specific force, critical flow and its computation, flow in vertical and horizontal channel transitions.
- Uniform Flow: Characteristics of uniform flow, Manning‟s and Chezy‟s formula, normal depth, normal, critical and limit slopes, equivalent roughness coefficient, flow in compound sections, hydraulically efficient channel sections, flow in circular channels.
- Gradually Varied Flow: Dynamic equation of gradually varied flow and its limitations, classification and analysis of flow profiles, control sections, transitional depth.

  Computation of GVF Profile: Integration of varied flow equation by analytical, graphical and advanced numerical methods, flow profiles in dividing and combining channels, role of end conditions.

  Spatially Varied Flow: Differential SVF equations for increasing and decreasing discharge conditions
- Rapidly Varied Flow: Types of RVFs, hydraulic jump, types of jump, characteristics of jump in rectangular and non-rectangular channels on horizontal and sloping beds, length and location of jump, jump as an energy dissipator.

  RVF Measurement: Flow in sharp crested, narrow crested and broad crested weirs, critical depth flumes, sluice gates, end depth in a free overfall.

  Centrifugal Pumps: Difference between centrifugal and reciprocating pumps, classification of centrifugal pumps on the basis of various parameters, priming of a centrifugal pump, fundamental equation of a centrifugal pump, types of heads and efficiencies, cavitation in pumps, characteristic curves.
- Turbines: Layout of a hydroelectric plant, classification of turbines on the basis of various parameters, important terms used, Surge Tanks.

Power produced by an impulse turbine and efficiencies. Velocity triangle and work done for pelton wheel.

Reaction turbines classification and expression for work done. Propeller and Kaplan turbines.

Rapidly Varied Unsteady Flow: Celerity of wave, types of surges, analysis of positive and negative surges in a rectangular channel.

6. Engineering Geology:

- Introduction, Importance of Geology in Civil Engineering.

  Minerals: Their physical properties and detailed study of certain rock forming & common economic minerals.

  Rocks: Their origin, structure, texture and classification & properties of igneous, sedimentary and metamorphic rocks.

  Engineering classification of Rocks: Deere & miller classification, Rock mass, Rock quality designation, Rock mass rating, Rock mass quality.
- Rock deformation: Folds, Faults, joints, unconformity and their classification, causes and relation to Civil engineering.
- Landslides, its causes, classification and preventive measures. Settlement & subsidence.

  Underground water, sources, Aquifers, Aquiclude, Artesian Wells, Underground water provinces of India and its role as geological hazard.

  Building Stones, Engineering. properties of rocks, Alkali aggregate reaction, Grouting, Puzzolonic materials, Fly ash.
- Geological investigations for site selection of Dams and reservoirs, tunnels, bridges and roads in hilly areas.

  Principles of Geophysical explorations methods for subsurface Investigation.

7. Geo-informatics:

- Photogrammetric Survey, basic principles, elevation of a point, determination of focal length of lens, aerial camera, scale of a vertical photograph.Photogrammetry – analog, analytical and digital photogrammetry.

- Remote Sensing, Introduction, concepts and physical basis of Remote Sensing, Electromagnetic spectrum, radiation laws, atmospheric effects, image characteristics. Remote sensing systems; sources of remote sensing information, spectral quantities spectral signatures and characteristics spectral reflectance curves for rocks, soil, vegetation and water.
- Digital image processing: introduction, image rectification and restoration, image enhancement, image transformation, manipulation, image classification, fusion. Applications of remote sensing to civil engineering.
- GIS system: Definition terminology and data types, basic components of GIS software, data models, data acquisition, both raster based and vector based data input and data processing and management including topology, overlaying and integration and finally data product and report generation. GIS applications in civil engineering.

8. Structural Analysis:

- Classification of Structures, Types of structural frameworks and Load transfer Mechanisms, stress resultants, degrees of freedom, Static and Kinematic Indeterminacy for beams, trusses and building frames. Analysis of cables with concentrated and continuous loadings, Effect of Temperature upon length of cable.
- Classification of Pin Jointed determinate trusses, Analysis of determinate plane trusses (compound and complex). Method of Substitution, Method of tension coefficient for analysis of plane trusses.
- Strain Energy of deformable systems, Maxwell‟s reciprocal & Betti‟s theorem, Castigliano‟s theorems, Calculations of deflections: Strain Energy Method, Unit load method & for statically determinate beams, frames and trusses. Deflection of determinate beams by Conjugate beam method.
- Rolling loads and influence line diagrams for determinate beams and trusses, Absolute maximum bending moment and shear force. Muller-Breslau‟s principal & its applications for determinate structures.
- Arches, Types of Arches, Analysis of three hinged parabolic and circular Arches. Linear arch, Eddy‟s theorem, spandrel braced arch, moving load & influence lines for three hinged parabolic arch.

- Analysis of fixed beams, Continuous beams and simple frames with and without translation of joint, Method of Consistent Deformation, Slope-Deflection method, Moment Distribution method, Strain Energy method.
- Muller-Breslau's Principle and its applications for drawing influence lines for indeterminate beams, Analysis of two hinged arches, Influence line diagrams for maximum bending moment, Shear force and thrust.
- Suspension Bridges, Analysis of cables with concentrated and continuous loadings, Basics of two and three hinged stiffening girders, Influence line diagrams for maximum bending moment and shear force for stiffening girders.
- Basics of Force and Displacement Matrix methods for beams, frames and trusses.'
- Basics of Plastic Analysis, Applications of Static and Kinematic theorem for Plastic Analysis of Beams and Frames.

9. Design of Concrete Structure:

- Concrete Making materials , Properties of concrete and reinforcements , Testing of concrete, Introduction to Various Design Philosophies, Design of Rectangular Singly and Doubly Reinforced Sections by Working Stress Method.
- Assumptions in Limit State Design Method, Design of Rectangular Singly and Doubly Reinforced beams, T-beams, L-beams by Limit State Design Method.
- Behaviour of RC beam in Shear, Shear Strength of beams with and without shear reinforcement, Minimum and Maximum shear reinforcement, Design of beam in shear, Introduction to development length, Anchorage bond, flexural bond. (Detailed Examples by Limit State Design Method), Failure of beam under shear, Concept of Equivalent Shear and Moments.
- Design of one way and two way solid slabs by Limit State Design Method, Serviceability Limit States, Control of deflection, cracking and vibrations.
- Design of Columns by Limit State Design Method- Effective height of columns, Assumptions, Minimum eccentricity, Short column under axial compression, Requirements for reinforcement, Column with helical reinforcement, Short column under axial load and uni-axial bending, Design of columns under bi-axial loading by Design Charts.

- Nature of Stresses in flat slabs with and without drops, coefficient for design of flat slabs, reinforcement in flat slabs. (IS Code Method).
- Analysis and design of beam curved in plan. Structural behaviour of footings, design of footing for a wall and a single column, combined rectangular and trapezoidal footings, and design of strap footing.
- Structural behaviour of retaining wall, stability of retaining wall against overturning and sliding, design of T-shaped retaining wall, Concept of Counter fort retaining wall. Loads, forces and I.R.C. bridge loadings and design of R.C. slab culvert.
- Design criteria, material specifications and permissible stresses for tanks, design concept of circular and rectangular tanks situated on the ground / underground, design of overhead tanks.
- Advantages of prestressing, methods of prestressing, losses in prestress, analysis of simple pre-stressed rectangular and T-section.

10. Environmental Engineering:

- Public Water supply: Hydrosphere, Hydrological cycle and Natural water. Beneficial uses of water,basic needs and factors affecting consumption.
- Sources of water: Surface and underground sources, relation and development of source in r/o quality and quantity of water, Development of wells, Storage reservoir-balancing and service storage, capacity determination by mass curve method. Intake systems.
- Quality and Examination of Water: Necessity for examination of impurities in water, sampling of water, physical, chemical and bacteriological quality for domestic water supply. Drinking water quality standards and criteria.
- Transmission of water: Various types of conduits, capacity and sizes including economical sizes of rising main, structural requirements; laying and testing of water supply pipelines; pipe materials, joints, appurtenances and valves; leakages and control; water hammer and its control measures.
- Storage and distribution of water: Methods of distribution, pressure and gravity distribution systems, general design guidelines for distribution systems, Hardy - Cross, Newton – Raphsonand equivalent pipe methods of pipe network analysis.
- Water supply and plumbing systems in buildings and houses

- Wastewater collection: Systems of sanitation and wastewater collection; choice of sewerage system and suitability to Indian conditions.
- Estimation of wastewater flows and variations in wastewater flows. Storm water: Collection and estimation of storm water by different methods.
- Wastewater Transmission: Flow in full and partially full sewers and design of sewers; types of sewers, materials and construction of sewers, joints and sewer appurtenances, layout and construction of sewer lines; small bore sewer systems. Planning of sewerage systems.
- Filtration: Theory of filtration; Hydraulics of filtration; Carmen - Kozeny and other equations; slow sand, rapid sand and pressure filters, backwashing; brief introduction to other filters; design of filters. Disinfection: Requirements of an ideal disinfectant; kinetics of disinfection, various disinfectants, chlorination and practices of chlorination. Water softening and ion exchange: calculation of dose of chemicals. Adsorption.
- Waste water Treatment: Preliminary, primary, secondary and tertiary treatment processes. Primary Treatment: Screens, grit chamber and their design, sedimentation and chemical treatment to be given. Secondary Treatment: Theory of organic matter removal; activated sludge process, design of different units and modifications, extended aeration systems; trickling filters, R.B.C. Community and Low Cost Treatment Systems: aerated lagoons, waste stabilization ponds, oxidation ditches.
- Anaerobic digestion of sludge: Design of low and high rate anaerobic digesters and septic tanks.

  Basic concept of anaerobic contact process, anaerobic filter, anaerobic fixed film reactor, fluidized bed and expanded bed reactors and up flow anaerobic sludge blanket (UASB) reactor.

11. Transportation Engineering:

- Introduction: Role of Transportation, Modes of Transportation,.Geometric Design: Cross sectional elements, camber, shoulder, sight distance, horizontal curves, super elevation, extra widening, transition curves and gradient, vertical curves, summit and valley curves

- Road Construction Methods: WBM, Surface dressing, Bituminous carpeting, Bituminous Bound Macadam and Asphaltic Concrete, Cement Concrete road construction.
- Indian railways: Development and organization of Indian Railways. Permanent way : Sub-grade, formation, embankment and cutting, track drainage.
  Ballast: Ballast materials, size of ballast, screeming of ballast, specification of ballast, tests on ballast.
- Airport Engineering: Air craft characteristics affecting airport design; Runway operation; Runway pavement design, design of overlay; Runway lighting and marking heliport.
- Water Transport - Harbors: Layout and port facilities; Inland waterways; Inland water operation

12. Advanced Foundation Engineering:

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- Vertical pressures under surface loads, elastic solution, Bousisinesq and New Mark charts, Westergaard's equation and approximate solution.
- Bearing capacity and settlement analysis of shallow foundations: Meyerhof and Hansen's bearing capacity equations, BIS bearing capacity equation, immediate and consolidation settlements in cohesive soil, De-Beer and schmmertman's methods of settlement prediction in non-cohesive soil.
- Classification of piles, load carrying capacity of single pile in clay, silt and sand by dynamic and static methods, pile load test, pile group, negative skin friction and settlement of pile group.
- Foundation on expansive soil, construction on expansive soil, alteration of soil condition, under-reamed piles. Elements of well foundation, shape, depth of scour, well sinking, tilt, shift and their prevention.
- Stability of slopes, limit equilibrium method, method of slices, simplified Bishop method, Stability charts.

  Machine foundation: Classification, definitions, design principle in brief, Barken's method.

13. Design of Steel Structures:

- Introduction to steel and steel structures: Advantages and Disadvantages of Steel as a Structural Material, Properties of Steel, Stress strain curve for Mild Steel and High Strength Steel Rolled steel section. Introduction to design: Design loads and load combinations, design philosophies. Introduction to Limit State Design: Limit States of Strength, Limit States of Serviceability, Actions (Loads), Probabilistic Basis for Design.
- Design of Riveted, Bolted and Pinned Connections: Riveted Connections, Patterns of Riveted Joints, Bolted Connections, Types of Bolts, Types of Bolted Joints, Load Transfer Mechanism, Failure of Bolted Joints, Specification for Bolted Joints, Bearing-Type Connections, Prying Action, Tensile Strength of Plate, Efficiency of the Joint, Combined Shear and Tension, Slip-Critical Connections, Combined Shear and Tension for Slip-Critical Connections, Design of eccentric bolted connections. Simple Welded Connections: Types of Welds, Assumptions in the Analysis of Welded Joints, Design of Groove Welds, Design of Fillet Welds, Fillet Weld Applied to the Edge of A Plate Or Section, Fillet Weld for Truss Members, Design of Intermittent Fillet Welds, Plug and Slot Welds, Stresses Due To Individual Forces, Combination of Stresses, Failure of Welds, Distortion of Welded Parts, Fillet Weld Vs Butt Weld, Welded Jointed Vs Bolted and Riveted Joints, Design of eccentric welded connections
- Design of Tension Members: Introduction, Types of Tension Members, Net Sectional Area, Effective Net Area, Types of Failure, Design Strength of Tension Members, Slenderness Ratio (λ), Displacement, Design of Tension Member, Lug Angles, Splices, Gusset Plate.
- Design of Compression Members: Introduction, Effective Length, Slenderness Ratio , Types of Sections, Types of Buckling, Classification of Cross Sections, Column Formula, Design Strength, Design of Axially Loaded Compression Members, Built-Up Columns (Latticed Columns), Lacing, Batten, Compression Member Composed of Two Components Back-to-Back, Splices, Design of Column Bases.
- Design of Beams: Introduction, Types of Sections, Behaviour of Beam in Flexure, Section Classification, Lateral Stability of Beams, Lateral-Torsional Buckling, Bending Strength of Beams, Laterally Supported Beams, Laterally Unsupported Beams, Shear Strength of Beams, Web Buckling, Bearing Strength, Web Crippling, Deflection, Design Procedure of Rolled Beams, Built-Up Beams (Plated Beams), Purlins, Beam

Bearing Plates, Effect of Holes in Beam, Introduction to Plate Girder , Introduction to Gantry Girder.

14. Engineering Hydrology:

- Introduction: hydrologic cycle, water budget equation, world water balance, application in engineering. Precipitation: Forms of precipitation, weather systems for precipitation, measurement, raingauge network preparation of data, presentation of rainfall data, mean precipitation over an area, depth-area-duration relationships & maximum intensity-duration- frequency relationships, probable maximum precipitation (PMP).
- Abstraction from Precipitation: Evaporation and consumptive use – process and affecting factors, estimation and measurement techniques, Reservoir Evaporation and methods for its reduction, transpiration, Evapotranspiration - measurement and estimation; Actual Evapotranspiration (AET), Potential Evapotranspiration (PET), Initial Losses- Interception & Depression storage; Infiltration- process, capacities, Infiltration indices, measurement & estimation
- Runoff: Components, methods of estimation of runoff volume and peak runoff, runoff characteristics and types of streams, Rainfall-runoff relationship, empirical equations, Soil Conservation System (SCS-CN) method, flow duration curve, Flow-Mass curve, rating curve, runoff characteristics of stream, droughts: definition and its classification
- Hydrographs: Classification of hydrographs, components of a flood hydrograph, Factors affecting flood hydrographs, base flow separation, effective rainfall, hyetograph, Direct Runoff Hydrograph,Unit Hydrograph: Definition, application and limitations of unit hydrographs, derivation of unit hydrograph, method of superposition and S-curve, distribution graph, derivation of synthetic unit hydrograph, and introduction to instantaneous unit hydrographs, SCS dimensionless unit Hydrograph.
- Flood: Rational method, empirical formulae, unit hydrograph method, flood frequency studies, Gumbel's Method, Long-Pearson type-III distribution, design flood, risk/reliability and safety factor;

  Flood Routing: Basic equation, hydrologic storage routing & attenuation, hydrologic channel routing, hydraulic method of flood routing, Clark's method for IUH, Nash's conceptual model, flood forecasting & control.

15. Water Resource Engineering:

- Canal Irrigation system: alluvial and non-alluvial canals.
  Sediment transport and design of irrigation channels: Importance of sediment transport, sediment load, bed formation, mechanics of sediment transport.
- Irrigation channels: Types: lined and unlined, silt theories: Lining of Irrigation Canals: Advantages and types, factors for selection of a particular type, design of lined channels, cross section of lined channels, Economics of canal lining
- Water Logging: Definition, effects, causes and anti-water logging measures, Drainage of water-logged land, Types of drains open and closed, spacing of closed drains.
- Ground Water Hydrology: Zones of underground water, forms of subsurface water, Aquifers and their types, important terms, Determination of discharge through unconfined and confined aquifers with steady flow conditions.

16. Construction Technology & Management:

- Project cycle, organizing, planning, scheduling, monitoring, updating and management, work break down structure, Bar charts, milestone charts, network techniques, fundamentals of network, network rules and errors, Fulkerson's rule, types of networks viz A-O-A & A-O-N.
- Introduction to network techniques, types, comparison of PERT and CPM, central limit theory, critical path, slack& its type, network analysis by PERT, activity times, float& its type, network analysis by CPM, Updating and resource allocation.
- Cost model analysis, Direct Cost, Indirect cost, Total Cost Curve, Cost Slope, Time Value of money, Cash flow diagram, economic comparison, Present Worth method, Annual Equivalent Method, Rate of Return Method, break even cost -analysis.
- Depreciation, Book value, Salvage Value, Scrap Value, methods of depreciation calculation, Construction Equipments: various excavation equipments, compaction equipments, hoisting equipments, Owning Cost, Operational cost.

- Agreement, contract, essential requirements of a valid contract, various types of contracts and their relative advantages and disadvantages, tender, process of tendering, security deposit, mobilisation advance, BOQ, PPP, BOT, EPC, EIA, DLP.

SYLLABUS FOR THE POST OF ASSISTANT MANAGER -ELECTRICAL IN E-3 GRADE

1. Basic Electrical Engineering

- Electrical Circuit Analysis: Introduction, Circuit Concepts: Concepts of network. Active and passive elements. Voltage and current sources. Concept of linearity and linear network. Unilateral and bilateral elements. Source transformation, Kirchhoff's laws, Loop and nodal methods of analysis. Star-delta transformation, AC fundamentals: Sinusoidal, square and triangular waveforms - Average and effective values. Form and peak factors, Concept of phasors, phasor representation of sinusoidally varying voltage and current.

- Steady- State Analysis of Single Phase AC Circuits: Analysis of series and parallel RLC Circuits, Concept of Resonance in series & parallel circuits, bandwidth and quality factor; Apparent, active & reactive powers. Power factor, Concept of power factor improvement and its improvement (Simple numerical problems)

  Network theorems (AC & DC with independent sources): Superposition theorem, Thevenin's theorem, Norto's theorem, Maximum Power Transfer theorem (Simple numerical problems)

- Three Phase AC Circuits: Three phase system-its necessity and advantages, Star and delta connections, Balanced supply and balanced load, Line and phase voltage/current relations. Three-phase power and its measurement (simple numerical problems).

  Measuring Instruments: Types of instruments, Construction and working principles of PMMC and moving iron type voltmeters & ammeters, Single phase dynamometer wattmeter, Use of shunts and multipliers (Simple numerical problems on shunts and multipliers), Single phase energy meter.

  Power system: basic concept, power line diagram, concept of grid.

- Magnetic Circuits: Magnetic circuit concepts, analogy between electric & magnetic circuits, B-H curve, Hysteresis and eddy current losses, Magnetic circuit calculations (Series & Parallel).

  Single Phase Transformer: Principle of operation, Construction, EMF equation, Phaser diagram Equivalent circuit. Power losses, Efficiency (Simple numerical problems), Introduction to auto transformer.

- Electrical Machines: DC machines: Principle & Construction, Types, EMF equation of generator and torque equation of motor, applications of DC motors (simple numerical problems)

  Three Phase Induction Motor: Principle & Construction, Types, Slip-torque characteristics. Applications (Numerical problems related to slip only) Single Phase

  Induction motor: Principle of operation and introduction to methods of starting, applications.

  Three Phase Synchronous Machines: Principle of operation of alternator and synchronous motor and their applications.

2. ***Electrical Measurement and Measuring Instruments***

- Philosophy Of Measurement: Methods of Measurement, Measurement System, Classification of instrument system, Characteristics of instruments & measurement system, Errors in measurement & its analysis, Standards. Analog Measurement of Electrical Quantities: Analog Instruments-Classification, Principle of operation of Permanent Magnet Moving Coil (PMMC) and Moving Iron Instruments, Voltmeters & ammeters, Errors in Voltmeter and Ammeters, Range extension, Advantages and disadvantages, Electrodynamometer Instruments, Power & Energy measurement.

- Instrument Transformers: Principle of operation and applications, Current transformer and its error analysis, Potential transformer and its error analysis, Miscellaneous Measurement (speed, Frequency & power factor).

- Measurement of Parameters: Different methods of measuring low, medium and high resistances, measurement of inductance & capacitance with the help of AC Bridges, Quality factor (Q) Meter.

- AC Potentiometer: Polar type & Co-ordinate type AC potentiometers, application of AC Potentiometers in electrical measurement.

  Magnetic Measurement: Ballistic Galvanometer, flux meter, determination of hysteresis loop, measurement of iron losses.

- Digital Measurement of Electrical Quantities: Concept of digital measurement, block diagram Study of digital voltmeter, frequency meter Power Analyzer and Harmonics Analyzer; Electronic Multimeter.

  Cathode Ray Oscilloscope: Basic CRO circuit (Block Diagram), Cathode ray tube (CRT) & its components, application of CRO in measurement, Lissajous Pattern, Dual Trace & Dual Beam Oscilloscopes.

3. ***Electrical Machines***

- *Principles of Electro-mechanical Energy Conversion* - Introduction, Flow of Energy in Electromechanical Devices, Energy in magnetic systems (defining energy & Co-energy), singly Excited Systems; determination of mechanical force, mechanical energy, torque equation, Doubly excited Systems; Energy stored in magnetic field, electromagnetic torque.

- D.C. Machines: Construction of DC Machines, operation, Armature winding, Types according to excitation (with circuit representation and equations), emf and torque equation, Armature Reaction, Commutation process, Interpoles and Compensating Windings, Performance Characteristics of DC generators. Performance Characteristics of D.C. motors, Starting of D. C. motors; 3 point and 4 point starters, Speed control of D.C. motors: Field Control, armature control and Voltage Control (Ward Lenonard method); Efficiency and Testing of D.C. machines (Hopkinson's and Swinburne's Test).

- Single Phase Transformer: Construction, working principle, equivalent circuit, Phasor diagram, efficiency and voltage regulation, Losses in Transformer, Separation of hysteresis and eddy current losses, all day efficiency. Testing of Transformers: O.C. and S.C. tests, Sumpner's test, polarity test. Auto Transformer: Single phase and three phase auto transformers, volt-amp relation, efficiency, merits & demerits and applications.

- Three Phase Transformers: Construction, three phase transformer phasor groups and their connections, open delta connection, three phase to 2 phase, 6 phase or 12 phase connections, and their applications, parallel operation and load sharing of single phase and three phase transformers, excitation phenomenon and harmonics in transformers, three winding transformers.

- Synchronous Machine-I: Constructional features, Armature winding, EMF Equation, Winding coefficients, equivalent circuit and phasor diagram, Armature reaction, O. C. &

S. C. tests, Voltage Regulation using Synchronous Impedance Method, MMF Method, Potier's Triangle Method, Parallel Operation of synchronous generators, operation on infinite bus, synchronizing power and torque co efficient.

- Synchronous Machine-II: Two Reaction Theory, Power flow equations of cylindrical and salient pole machines, operating characteristics Synchronous Motor: Starting methods, Effect of varying field current at different loads, V- Curves, Hunting & damping, synchronous condenser.
- Three phase Induction Machine-I: Constructional features, Rotating magnetic field, Principle of operation Phasor diagram, equivalent circuit, torque and power equations, Torque- slip characteristics, no load & blocked rotor tests, efficiency, Induction generator & its applications.
- Three phase Induction Machine-II: Starting, Deep bar and double cage rotors, Cogging & Crawling, Speed Control (with and without emf injection in rotor circuit.)
- Single phase Induction Motor: Double revolving field theory, Equivalent circuit, No load and blocked rotor tests, Starting methods, repulsion motors.

  AC Commutator Motors: Universal motors, Single phase A.C. series compensated motors, stepper motors.

4. Analog and Digital Electronics

- Special Diodes: LED, Varactor diode, Photo diode, Schottky diode, Tunnel diode and their characteristics and applications, Transistors as a switch.
- Frequency Response: Amplifier transfer function, low and high frequency response of common emitter and common source amplifiers.

  Feedback: General feedback structure, properties of negative feedback: series-series, series-shunt, shunt-series and shunt-shunt feedback amplifiers.
- Oscillator: Basic principle of sinusoidal oscillator, R-C Phase Shift and Wein Bridge oscillators, tuned oscillators-Collpits, Hartley and Crystal oscillators.
- Combinational Logic Circuits: Multiplexers/Demultiplexers, Encoders/Decoders.

  Sequential Logic Circuits: latches, flip-flops- S-R, T, D and J-K.

Shift Registers: Basic principle, serial and parallel data transfer, shift left/right registers, universal shift registers.

Counters: Mode N Counters, ripple counters, synchronous counters and ring/Johnson counters.

- OP-AMP applications: Astable, Monostable and Bistable multivibrators, Schmitt trigger, IC-555 Timer, A/D and D/A converters.

  Voltage Regulators: Series, shunt and switching regulators, op-amp based configurations.

  Memories: Introduction to ROM, RAM; Sequential Memory and Memory organization.

5. ***Basic System Analysis***

- Introduction to continuous time signals and systems: Basic continuous time signals, unit step, unit ramp, unit impulse and periodic signals with their mathematical representation and characteristics. Introduction to various types of systems.

  Analogous System: Linear mechanical elements, force-voltage and force-current analogy, modelling of mechanical and electro-mechanical systems: Analysis of first and second order linear systems by classical method.

- Fourier Transform Analysis: Exponential form and Trigonometric form of Fourier series, Fourier symmetry, Fourier Integral and Fourier Transform. Transform of common functions and periodic wave forms: Applications of Fourier Transform to network analysis.

- Laplace Transform Analysis: Review of Laplace Transform, Laplace Transform of periodic functions, Initial and Final Value Theorems, Inverse Laplace Transform, Convolution Theorem, Superposition Integral, Application of Laplace Transform to analysis of networks, waveform synthesis and Laplace Transform of complex waveforms.

- State – Variable analysis: Introduction, State Space representation of linear systems, Transfer Function and state Variables, State Transition Matrix, Solution of state equations for homogeneous and non-homogeneous systems, Applications of State-Variable technique to the analysis of linear systems.

- Z-Transform Analysis: Concept of Z-Transform, Z-Transform of common functions, Inverse Z-Transform, Initial and Final Value theorems, Applications to solution of difference equations, Pulse Transfer Function.

6. ***Power System***

- Power System Components: Single line diagram of power system; Brief description of power system elements: Synchronous machines. Transformers, transmission lines, busbar, circuit breaker and isolator etc.

  Supply System: Different kinds of supply system and their comparison, choice of transmission voltage.

  Transmission Lines: Conductor materials, types of conductors, resistance of line, Kelvin's law, current distortion effects: skin effect, proximity effect.

- Over Head Transmission Lines: Calculation of inductance and capacitance of single phase, three phase, single circuit and double circuit transmission lines; Interference with communication lines, Reduction methods; Representation and performance of short, medium and long transmission lines, Ferranti effect, surge impedance loading.

- Mechanical Design of Transmission Lines: Catenary curve, calculation of sag & tension, stringing chart, effects of wind and ice loading, sag template, vibration dampers

  Overhead Line Insulators: Type of insulators and their applications, potential distribution over a string of insulators, methods of equalizing the potential, string efficiency.

- Corona and Interference: Phenomenon of corona, corona formation, calculation of potential gradient, corona loss, factors affecting corona, methods of reducing corona.

  Insulated Cables: Type of cables, construction and their applications; dielectric stress, grading of cables, insulation resistance, capacitance of single phase and three phase cables, dielectric loss, heating of cables.

- Neutral Grounding: Necessity of neutral grounding, various methods of neutral grounding, earthing transformer, grounding practices.

  Electrical Design of Transmission Line: Design consideration of EHV transmission lines, choice of voltage, number of circuits, conductor configuration, insulation design, selection of ground wires.

EHV AC and HVDC Transmission: Introduction to EHV AC and HVDC transmission and their comparison, use of bundle conductors, kinds of DC links and incorporation of HVDC into AC system.

- Representation of Power System Components: Synchronous machines, transformers, transmission lines, one-line diagram, impedance and reactance diagram, per unit system

  Symmetrical components: Symmetrical components of unbalanced phasors, power in terms of symmetrical components, sequence impedances and sequence networks.

  Symmetrical fault analysis: Transient in R-L series circuit, calculation of 3-phase short circuit current and reactance of synchronous machine, internal voltage of loaded machines under transient conditions.

- Unsymmetrical faults: Analysis of single line-to-ground fault, line-to-line fault and double line-to ground fault on an unloaded generators and power system network with and without fault impedance, formation of Z-bus using singular transformation.

- Load Flows: Introduction, bus classifications, nodal admittance matrix (Y-bus), development of load flow equations, load flow solution using Gauss-Seidel and Newton-Raphson methods, approximation to N-R method, line flow equations and fast decoupled method.

- Power System Stability: Stability and Stability limit, Steady state stability study, Swing equation, transient stability studies by equal area criterion and step-by-step method. Factors affecting steady state and transient stability and methods of improvement.

- Traveling Waves: Wave equation for uniform transmission lines, velocity of propagation, surge impedance, reflection and transmission of traveling waves under different line loadings, standing wave ratio, Bewlay's lattice diagram, protection of equipment's and line against traveling waves

7. ***Control Systems***

- The Control System: Open loop & close loop control, servomechanism, physical examples. Modelling of mechanical, electrical and electro-mechanical systems by differential equations, analogy between electrical and mechanical systems.

Transfer functions and its properties, block diagram algebra, signal flow graph, basic characteristics of feedback systems, modes of feedback control, the performance of feedback systems, Mason's gain formula, Reduction of parameter variation and effects of disturbance by using negative feedback.

- Time Response Analysis: Standard test signals, time response of first and second order systems, time response specifications, steady state errors and error constants.

  Design Specifications of Second Order Systems: Derivative error, derivative output, integral error and PID compensations, design considerations for higher order systems, performance indices.

- Control System Components: Constructional and working concept of ac servomotor, synchros and stepper motor.

  Stability and Algebraic Criteria: concept of stability and necessary conditions, Routh-Hurwitz criteria and limitations.

  Root Locus Technique: Concepts of root locus, construction of root loci, effect of transportation lag and Root locus of non-minimal phase system and effect of pole-zero cancellation.

- Frequency Response Analysis: Frequency response analysis from transfer function model, correlation between time and frequency responses, polar and inverse polar plots, Bode plots.

  Stability in Frequency Domain: Nyquist stability criterion, assessment of relative stability: gain margin and phase margin; Close loop frequency response: Constant M&N circles.

- Introduction to Design: The design problem and preliminary considerations; Realization of basic compensators: lead, lag and lead- lag, design of closed loop systems using compensation techniques in time domain and frequency domain.

  Review of State Variable Technique: The concept of state & space, state-space model of physical system, conversion of state variable model to transfer function model and vice-versa, diagonalization, controllability and observability and their testing.

8. ***Advanced Electrical Machines***

- Poly-phase AC Machines: Construction and performance of double cage and deep bar three phase induction motors; e.m.f. injection in rotor circuit of slip ring induction motor, concept of constant torque and constant power controls, static slip power recovery control schemes (constant torque and constant power).

- Induction Generator: Self-excited Induction Generator (SEIG), Doubly-fed Induction Generator (DFIG): Operating Principle, Equivalent Circuit, Characteristics, Applications.

  Two Phase AC Servomotors: Construction, torque-speed characteristics, performance and applications.

- Stepper Motors: Principle of operation, variable reluctance, permanent magnet and hybrid stepper motors, characteristics, drive circuits and applications.

  Switched Reluctance Motors: Construction; principle of operation; torque production, modes of operation, drive circuits.

- Permanent Magnet Machines: Types of permanent magnets and their magnetization characteristics, demagnetizing effect, permanent magnet dc motors, sinusoidal PM AC motors, brushless dc motors and their important features and applications, PCB motors. Single phase synchronous motor; construction, operating principle and characteristics of reluctance and hysteresis motors; introduction to permanent magnet generators and applications.

- Single Phase Commutator Motors: Construction, principle of operation, characteristics of universal and repulsion motors.

  Linear Induction Motors: Construction, principle of operation, linear force, and applications.

9. ***Power Electronics***

- Power semiconductor Devices: Power semiconductor devices, their symbols and static characteristics; Characteristics and specifications of switches, types of power electronic circuits.

  Power Diodes: General purpose diode, Fast recovery diode, Schottky diode and its applications.

Power Bipolar Junction Transistors: Physical structure and device operation, static V-I and switching characteristics, switching limits of power transistor.

Power MOSFETS: Physical structure and device operation, Static V-I characteristics and switching characteristics, safe operating area.

Insulated Gated Bipolar Transistors: Physical structure and device operation, static V-I characteristics, safe operating area. Thyristor: Physical structure and device operation, static V-I characteristics, two transistor model, methods of turn-on.

GTO (Gate Turn Off) Thyristors: Physical structure and device operation, static V-I and switching characteristics.

TRIAC: Physical structure and device operation, static V-I characteristics and applications.

Special Power Devices: Physical structure, device operation and static V-I characteristics of Reverse Conducting Thyristor (RCT), FET controlled thyristor, Static Induction Thyristors (SITH), MOS Controlled Thyristor (MCT), LASCR.

- Power Semiconductor Devices: Protection of devices, series and parallel operation of thyristors, commutation techniques of thyristor.

  DC-DC Converters: Introduction, Principle of chopper operation, Control strategies, Principles of step-down chopper, step-down chopper with R-L load, Principle of step-up chopper, and operation with R-L load, classification of choppers.

- Phase Controlled Converters: Single-phase half wave-controlled rectifier with resistive and inductive loads, effect of freewheeling diode. Single-phase fully controlled and half controlled bridge converters, performance parameters, Three-phase half wave converters, Three-phase fully controlled and half controlled bridge converters, effect of source impedance single-phase and three phase dual converters.

- AC Voltage Controllers: Principle of On-Off and phase controls, Single-phase ac voltage controller with resistive and inductive loads, Three-phase ac voltage controllers (various configurations and comparison only) Single-phase transformer taps changer.

  Cyclo-converters: Introduction, The basic principle of operation, single-phase to single-phase, three-phase to single-phase and three-phase to three-phase cyclo-converters, output voltage equation.

- Inverters: Introduction, Single-phase series resonant inverter, Single-phase bridge inverters, Three phase bridge inverters, voltage control of inverters, harmonics reduction techniques, Single-phase and three-phase current source inverters.

10. ***Switchgear and Protection***

- Introduction to Protection System: Introduction to protection system and its elements, functions of protective relaying, protective zones, primary and backup protection, desirable qualities of protective relaying, basic terminology; Introduction to numerical relays.

  Relays: Electromagnetic: attraction and induction type relays; thermal relay, gas actuated relay, design considerations of electromagnetic relay.

- Relay Application and Characteristics: Amplitude and phase comparators, over current relays, directional relays, distance relays, differential relay

  Static Relays: Comparison with electromagnetic relay, classification and their description, over current relays, directional relay, distance relays, differential relay.

- Transmission Line Protection: Overcurrent, differential, directional-overcurrent and distance relays, back-up protection, carrier relaying; Busbar protection.

  Transformer Protection: internal faults such as short circuit and turn-to-turn fault protection using differential and overcurrent relays, protection for other abnormal conditions.

- Generator Protection: short circuit and turn-to-turn fault, stator to ground fault, field to ground fault, loss of excitation, loss of synchronism protection using different types of relays.

  Circuit Breaking: Properties of arc, arc extinction theories, re-striking voltage transient, current chopping, resistance switching, capacitive current interruption, short line interruption, circuit breaker ratings.

- Circuit Breakers: Operating modes, selection of circuit breakers, constructional features and operation of Bulk Oil, Minimum Oil, Air Blast, SF6, Vacuum and DC circuit breakers, auto-reclosing - definitions & features, Three-Phase versus Single-Phase auto-reclosing.

Testing Of Circuit Breakers: Classification, testing station and equipments, testing procedure, direct and indirect testing.

SYLLABUS FOR THE POST OF ASSISTANT MANAGER-MECHANICAL IN E-3 GRADE

1. *Elements of Mechanical Engineering*

- Force System: Law of Parallelogram of forces, Lami's theorem. Principle of Transmissibility of forces. Moment of a force. Couple, Varignon's theorem. Resolution of a force into a force and a couple. Resultant and equilibrium of coplanar force system. Determination of reactions. Free body diagrams. Concept of Centre of Gravity, Centroid and Area Moment of Inertia, Perpendicular axis theorem and Parallel axis theorem.

- Plane Truss: Perfect Deficient and Redundant Truss. Assumptions and Analysis of Plane Truss by Method of joints and Method of section.
  Beams: Types of beams., Shear force and bending moment in Statically Determinate Beams. Shear force and bending moment diagrams. Relationships between load, shear and bending moment.

- Simple stress and strain**:** Normal and shear stresses. One Dimensional Loading; members of varying cross section, bars in series. Tensile Test diagram for ductile and brittle materials. Elastic Constants. Strain energy.
  Bending (Flexural) Stresses: theory of pure bending, neutral surface and neutral axis, stresses in beams.

  Engineering Materials: Importance of engineering materials, classification, mechanical properties and applications of Ferrous, Nonferrous and composite materials.

- Basic Concepts and Definitions of Thermodynamics: Introduction and definition of thermodynamics. Microscopic and Macroscopic approaches. System, surrounding and universe. Concept of continuum. Thermodynamic equilibrium. Thermodynamic properties, path, process and cycle. Quasi static process. Energy and its forms. Work and heat.
  Zeroth law of thermodynamics: Temperature and it's measurement.
  First law of thermodynamics: First law of thermodynamics. Internal energy and enthalpy. First law
  analysis for non-flow processes. Steady flow energy equation; Boilers, Condensers, Turbine, Throttling process. Pumps etc.

- Second law: Thermal reservoir, Kelvin Planck statement. Heat engines. Efficiency; Clausius' statement Heat pump, Refrigerator. Coefficient of Performance. Carnot cycle, Carnot theorem and it's corollaries. Clausius inequality. Concept of Entropy.

  Properties of Pure Substances: P-v, T-s and h-s diagram, dryness fraction and steam tables. Rankine Cycle.

  Internal Combustion Engines: Classification of I.C. Engines, working principle and comparison between 2 Stroke and 4 stroke engine, difference between SI and Cl engines. P- V and T-s diagrams of Otto and Diesel cycles, comparison of efficiency.

2. ***Fluid Mechanics***

- Introduction: Fluid and continuum, physical properties of fluids, rheology of fluids.

  Fluid Statics: Pressure-density-height relationship, manometers, pressure on plane and curved surfaces, centre of pressure, buoyancy, stability of immersed and floating bodies, fluid masses subjected to linear acceleration and uniform rotation about an axis.

- Kinematics of Fluid Flow: Continuum and free molecular flows, steady and unsteady, uniform and non-uniform, laminar and turbulent flows, rotational and irrotational flows, compressible and incompressible flows, subsonic, sonic and supersonic flows, sub-critical, critical and supercritical flows, one, two and three dimensional flows, ideal and real flow.

  System versus control volume approach, fundamentals of flow visualization, streamlines, streak lines and path lines, continuity equation in Cartesian and polar co-ordinate system, rotation and circulation, stream function and potential function, flow nets.

  Dimensional Analysis and Hydraulic Similitude: Rayleigh's method, Buckingham's Pi theorem, important dimensionless numbers and their significance, geometric, kinematics and dynamic similarity, model studies, distorted and undistorted models.

- Potential flow: source, sink, doublet and half-body, free and forced vortex flow.

  Dynamics of Fluid Flow: Euler's Equation of motion along a streamline and its integration, Bernoulli's equation and its applications- Pitot tube, orifice meter, venturi meter and bend meter, Hot-wire anemometer and LDA, flow through orifices,

mouthpieces, notches and weirs, aeration of nappe, momentum equation and its application to pipe –bends, flow through nozzles.

- Laminar Flow**:** Relation between shear and pressure gradient in laminar flow, introduction to Navier-Stokes equations, Reynolds experiment, equation of motion for laminar flow through pipes, flow between parallel plates, Kinetic energy and Momentum correction factors.

  Turbulent Flow: Types of turbulent flow, isotropic, homogenous turbulence, scale and intensity of turbulence, measurement of turbulence, eddy viscosity, Prandtl's mixing length concept and velocity distribution in turbulent flow over smooth and rough surfaces.

  Flow through Pipes: Major and minor losses, energy and hydraulic grade lines, combination of pipes, flow through siphon pipes, pipe network, power transmission through pipes, surge tanks, water hammer.

- Theory of Boundary Layer: Boundary layer thickness, boundary layer over a flat plate, application of Von-Karman integral momentum equation, laminar sub-layer, boundary layer separation and its control.

  Forces on Submerged Bodies: Drag and lift, drag on a sphere and on a cylinder, development of lift on a circular cylinder and an aerofoil, Magnus effect.

  Compressible Flow: Thermodynamic relations, basic equations of compressible flow, expression for velocity of sound wave in a fluid.

3. ***Strength Of Materials***

- Stresses in Beams: Review of pure Bending. Direct and shear stresses in beams due to transverse and axial loads, composite beams.

  Curved Beams: Bending of beams with large initial curvature, position of neutral axis for rectangular, trapezoidal and circular cross sections, stress in crane hooks, stress in circular rings subjected to tension or compression.

- Unsymmetrical Bending: Properties of beam cross-section, slope of neutral axis, stress and deflection in unsymmetrical bending, determination of shear center and flexural

axis (for symmetry about both axis and about one axis) for I-section and channel section. Deflection of Beams: Equation of elastic curve, cantilever and simply supported beams, Macaulay's method, area moment method Fixed beams. Castigliano's Theorem.

- Helical and Leaf Springs: deflection of springs by energy method, helical springs under axial load and under axial twist (respectively for circular and square cross sections) axial load and twisting moment acting simultaneously both for open and closed coiled springs, laminated springs.

- Columns and Struts: Combined bending and direct stress, middle third and middle quarter rules. Struts with different end conditions, Euler's theory and experimental results, Ranking Gardon Formulae, Examples of columns in mechanical equipments and machines.

- Thin cylinders & spheres: Hoop and axial stresses and strain. Volumetric strain. Thick cylinders: Radial, axial and circumferential stresses in thick cylinders subjected to internal or external pressures, Compound cylinders Stresses due to interference fits.

4. Materials Science

- Introduction: Importance of materials, historical perspective, Future aspects of engineering materials.
  Crystal Structure: Brief description of BCC, FCC and HCP Structures, coordination number and atomic packing factors. Bravais lattices, Miller indices, crystal imperfections-point line and surface imperfections. Atomic Diffusion: Phenomenon, Ficks laws of diffusion, factors affecting diffusion.
  Ferrous and non- ferrous materials: Properties, Composition and uses of Grey cast iron, malleable iron, SG iron and steel, copper alloys-brasses and bronzes, Aluminium alloys.

- Mechanical Behaviour: Stress-strain diagram showing ductile and brittle behaviour of materials, mechanical properties in plastic range, yield strength off set yield strength, ductility, ultimate tensile strength, toughness, Plastic deformation of single crystal by slip and twinning, Hardness Tests.

Fracture, Creep and Fatigue: Fracture: Type I, Type II and Type III. Creep: Description of the phenomenon with examples. Three stages of creep, creep properties, stress relaxation. Fatigue: Types of fatigue loading with examples, Mechanism of fatigue, fatigue properties, fatigue testing and S-N diagram.

- Solidification: Mechanism of solidification, Homogenous and Heterogeneous nucleation, crystal growth, cast metal structures. Phase Diagram I: Solid solutions Hume Rothery rule, substitutional and interstitial solid solutions, intermediate phases, Gibbs phase rule.

  Phase Diagram: Construction of equilibrium diagrams involving complete and partial solubility, lever rule. Iron carbon equilibrium diagram description of phases, solidification of steels and cast irons, invariant reactions.

- Heat Treating of Metals: TTT curves, continuous cooling curves, annealing and its types. Normalizing, hardening, tempering, mastempering, austempering, hardenability, surface hardening methods like carburizing, cyaniding, nitriding, flame hardening and induction hardening, age hardening of aluminium- copper alloys. Comparative study of microstructure of various Ferrous, nonferrous metals and alloys.

- Composite materials**:** Definition, classification, types of matrix materials & reinforcements, fundamentals of production of FRP's and MMC's advantages and application of composites.

  Ceramics: Structure types and properties and applications of ceramics. Mechanical/ Electrical behavior and processing of Ceramics.

  Plastics: Various types of polymers/plastics and its applications. Mechanical behaviour and processing of plastics, Future of plastics. Introduction to Smart materials & Nano-materials and their potential applications.

5. <u>Engineering Thermodynamics</u>

- Fundamental Concepts and Definitions: Introduction and definition of thermodynamics, Dimensions and units, Microscopic and Macroscopic approaches, Systems, surroundings and universe, Concept of continuum, Control system boundary,

control volume and control surface, Properties and states, Thermodynamic properties, Pressure and its measurement, Thermodynamic path, process and cycle, Thermodynamic equilibrium, Reversibility and irreversibility, Quasi static process, Energy and its forms, Work and heat, Gas laws, Ideal gas

Zeroth law of thermodynamics: Zeroth law of thermodynamics, Temperature and its measurement, Temperature scales.

- Properties of steam and thermodynamics cycles: Pure substance, Property of steam, Triple point, Critical point, Sub-cooled liquid, Saturation states, Superheated states, Phase transformation process of water, Graphical representation of pressure, volume and temperature, P-T & P-V diagrams, T-s and h-s diagrams, use of property diagram, Steam-Tables & Mollier charts, Dryness fraction and its measurement, processes involving steam in closed and open systems. Simple Rankine cycle.

- Availability and Irreversibility: Available and unavailable energy, Availability and Irreversibility, Second law efficiency, Helmholtz and Gibb's function.

  Thermodynamic relations**:** Mathematical conditions for exact differentials. Maxwell Relations, Clapeyron Equation, Joule-Thompson coefficient and Inversion curve. Coefficient of volume expansion, Adiabatic and Isothermal compressibility. Real gas, Law of corresponding states, Dalton's law, Amagat's law, Property of mixture of gases.

- Fuels and Combustion: Combustion analysis, Heating Values and its measurement, Air requirement, Air/Fuel ratio, Standard heat of reaction and effect of temperature on standard heat of reaction, heat of formation, Chemical Equilibrium, adiabatic flame temperature.

6. Manufacturing Science and Engineering

- Importance of manufacturing towards technological and social economic development. Classification of manufacturing processes. Survey of manufacturing processes. Manufacturing processes for common items, Concepts of Manufacturing Systems.

- Casting: Basic principle & survey of casting processes. Types of patterns and allowances. Types and properties of moulding sand. Elements of mould and design

considerations, Gating, Riser, Runner, Core. Solidification of casting, Sand casting, defects & remedies and inspection. Cupola furnace. Die Casting, Centrifugal casting. Investment casting, CO2 casting and Stir casting etc.

- Metal Forming Processes: Elastic & plastic deformation, yield criteria. Hot working vs cold working. Analysis (equilibrium equation method) of Forging process for load estimation with sliding friction sticking friction and mixed condition for slab and disc. Work required for forging, Hand, Power, Drop Forging. Analysis of Wire/strip drawing and maximum-reduction, Tube drawing, Extrusion and its application. Condition for Rolling force and power in rolling. Rolling mills & rolled-sections. Design, lubrication and defects in metal forming processes.

- Sheet Metal working: Presses and their classification, Die & punch assembly and press work methods and processes. Cutting/Punching mechanism, Blanking vs Piercing. Compound vs Progressive die. Flat-face vs Inclined-face punch and Load (capacity) needed. Analysis of forming process like cup/deep drawing. Bending & spring-back.

- Powder Metallurgy: Powder metallurgy manufacturing process. The need, process, advantage and applications. Introduction to rapid prototyping and tooling. Manufacturing of Plastic components: Review of plastics, and its past, present & future uses. Injection moulding. Extrusion of plastic section. Welding of plastics. Future of plastic & its applications.

- Metal Cutting : Mechanics of metal cutting. Geometry of tool and nomenclature. ASA system Orthogonal vs. oblique cutting. Mechanics of chip formation, types of chips. Shear angle relationship. Merchant's force circle diagram. Cutting forces, power required. Cutting fluids/lubricants. Tool materials. Tool wear and tool life. Machinability. Dynamometer. Brief introduction to machine tool vibration and surface finish. Economics of metal cutting.

- Metal Joining (Welding) : Survey of welding and allied processes. Gas welding and cutting, process and equipment. Arc welding : Power sources and consumables. TIG & MIG processes and their parameters. Resistance welding - spot, seam projection etc.

Other welding processes such as atomic hydrogen, submerged arc, electroslag, friction welding. Soldering & Brazing. Thermodynamic and Metallurgical aspects in welding and weld, Shrinkage/residual stress in welds. Distortions & Defects in welds and remedies. Weld decay in HAZ.

- Introduction to Un-conventional Machining and Welding : Need & benefits, application and working principle of EDM, ECM, LBM, EBM, USM. AJM, WJM. Similarly, non-conventional welding applications such as LBW, USW, EBW, Plasma-arc welding, Diffusion welding, Explosive welding/cladding.

7. Applied Thermodynamics

- Gas power cycles: Air Standard cycles: Carnot, Otto, Diesel, Dual and Stirling cycles, P-V and T-s diagrams, description, efficiencies and mean effective pressures, Comparison of Otto, Diesel and dual cycles.
  I.C. Engines: Testing of two stroke and four stroke SI and CI engines for performance related numerical problems, heat balance, Willian's line method, Morse test.

- Vapour Power cycles and compressors: Simple steam power cycle, Rankine cycle, actual vapour cycle processes, mean temperature of heat addition, effect of pressure and temperature on Rankine cycle, Reheat cycle, Regenerative cycle, Feed water heaters, Binary vapour cycle, Combined cycles,
  Process heat and by-product power: Cogeneration plant, single stage reciprocating air compressor, volumetric efficiency and multistage compression

- Boilers**:** Classification and working of boilers, boiler mountings and accessories, draught and its calculations, air preheater, feed water heater, superheater, boiler efficiency, equivalent evaporation boiler trial and heat balance.
  Condenser: Classification of condensers, air leakage, condenser performance parameters.

- Steam and Gas Nozzles: Flow through convergent and convergent-divergent nozzles, variation of velocity, area and specific volume, choked flow, throat area, nozzle

efficiency, effect of back pressure, shock waves, Rayleigh line and Fanno lines, effect of friction on nozzle, super saturated flow.

Steam Turbines: Classification of steam turbines, Impulse and Reaction turbines, Staging, Stage and Overall efficiency, Reheat factor, Bleeding, Velocity diagram of simple and compound multistage impulse and reaction turbines and related calculations, work done, efficiencies of reaction, Impulse reaction turbines, state point locus, Losses in steam turbines, Governing of turbines, Comparison with steam engine.

- Gas Turbine: Gas turbine classification, Brayton cycle, Principles of gas turbine, Gas turbine cycles with intercooling, reheat and regeneration and their combinations, Stage efficiency, Polytropic efficiency. Deviation of actual cycles from ideal cycles

  Jet Propulsion: Introduction to the principles of jet propulsion, Turbojet and turboprop engines and their processes, Principle of rocket propulsion, Introduction to Rocket Engine.

8. Kinematics Of Machines

- Introduction: Aims & scope of the course & basic concepts of Mechanisms. Basic definitions, Difference between structure & Machine, Links & their types, Types of constrained motion, Kinematic pair & their classification, Grubler's mobility criteria, Inversion of a kinematic chain and applications, Hooks joint, Devis and Ackermann steering mechanism. An introduction to approximate and exact straight line mechanism.

- Graphical (vector) method for velocity and acceleration of various mechanisms e.g. slider crank and four bar, Coriolis acceleration. Instantaneous centre method, Kennedy's theorem and Klien's construction.

- Transmission drives: Belt, Rope and Chain drives: Types and materials, Fundamentals of Power transmission Phenomena of slip & creep, centrifugal and initial tensions, Tight side and slack side tensions, Conditions of max. Power transmission.

- Brakes and Clutches: Types of braking systems, force and torque analysis for block, band and brake and block brake, disc brakes. Friction clutches: types, uniform pressure and uniform wear theory.

- Theory of gearing: Classification of gears and terminology, Law of gearing, systems of gear teeth, gear profiles, Interference, and efficiency of gears, epicyclical gear train, Compound gear train, Torque analysis and various applications of complex gear trains.

9. Machine Design

- Introduction: Definition, Design requirements of machine elements, Design procedure, Standards in design, Selection of preferred sizes, Indian Standards designation of carbon & alloy steels, Selection of materials for static and fatigue loads.
  Design against Static Load: Modes of failure, Factor of safety, Principal stresses, Stresses due to bending and torsion, Theory of failure.

- Design against Fluctuating Loads**:** Cyclic stresses, Fatigue and endurance limit, Stress concentration factor, Stress concentration factor for various machine parts, Notch sensitivity, Design for finite and infinite life, Soderberg, Goodman & Gerber criteria
  Riveted Joints **:** Riveting methods, materials, Types of rivet heads, Types of riveted joints, Caulking and Fullering, Failure of riveted joint, Efficiency of riveted joint, Design of boiler joints, Eccentric loaded riveted joint.

- Shafts: Cause of failure in shafts, Materials for shaft, Stresses in shafts, Design of shafts subjected to twisting moment, bending moment and combined twisting and bending moments, Shafts subjected to fatigue loads, Design for rigidity.

- Keys and Couplings **:** Types of keys, splines, Selection of square & flat keys, Strength of sunk key, Couplings- Design of rigid and flexible couplings
  Mechanical Springs**:** Types, Material for helical springs, End connections for compression and tension helical springs, Stresses and deflection of helical springs of circular wire, Design of helical springs subjected to static and fatigue loading.

- Power Screws**:** Forms of threads, multiple threads, Efficiency of square threads, Trapezoidal threads, Stresses in screws, Design of screw jack.
- Spur Gears : Tooth forms, System of gear teeth, contact ratio, Standard proportions of gear systems, Interference in involute gears, Backlash, Selection of gear materials, Gear

manufacturing methods, Design considerations, Beam strength of gear tooth, Dynamic tooth load, Wear strength of gear tooth, Failure of gear tooth, Design of spur gears, AGMA and Indian standards.

- Helical Gears: Terminology, Proportions for helical gears, Beam strength and wear strength of helical gears, herringbone gears, crossed helical gears, Design of helical gears.

  Worm Gears: Types of worms, Terminology, Gear tooth proportions, Efficiency of worm gears, Heat dissipation in worm gearing, Strength and wear tooth load for worm gears, Design of worm gearing.

- Sliding Contact Bearing: Types, Selection of bearing, Plain journal bearing, Hydrodynamic lubrication, Properties and materials, Lubricants and lubrication, Hydrodynamic journal bearing, Heat generation, Design of journal bearing, Thrust bearing-pivot and collar bearing, Hydrodynamic thrust bearing.

- Rolling Contact Bearing: Advantages and disadvantages, Types of ball bearing, Thrust ball bearing, Types of roller bearing, Selection of radial ball bearing, Bearing life, Selection of roller bearings, Dynamic equivalent load for roller contact bearing under constant and variable loading, Reliability of Bearing, Selection of rolling contact bearing, Lubrication of ball and roller bearing, Mounting of bearing.

- I.C Engine Parts: Selection of type of I.C engine, General design considerations, Design of Cylinder and cylinder head; Design of piston, piston ring and gudgeon pin; Design of connecting rod; Design of centre crankshaft.

10. <u>Heat & Mass Transfer</u>

- Introduction to Heat Transfer**:** Concepts of the mechanisms of heat flows; Conduction, convection and radiation; Effect of temperature on thermal conductivity of materials; Introduction to combined heat transfer mechanism.

  Conduction: One-dimensional general differential heat conduction equation in the rectangular, cylindrical and spherical coordinate systems; Initial and boundary conditions.

Steady State one-dimensional Heat conduction: Composite Systems in rectangular, cylindrical and spherical coordinates with and without energy generation; Thermal resistance concept; Analogy between heat and electricity flow; Thermal contact resistance; Critical thickness of insulation.

- Forced Convection: Basic concepts; Hydrodynamic boundary layer; Thermal boundary layer.

  Natural Convection: Physical mechanism of natural convection; Buoyant force; Empirical heat transfer relations for natural convection over vertical planes and cylinders, horizontal plates and cylinders, and sphere; Combined free and forced convection.

- Thermal Radiation**:** Basic radiation concepts; Radiation properties of surfaces; Black body radiation Planck's law, Wein's displacement law, Stefan Boltzmann law, Kirchoff's law; Gray body; Shape factor; Black-body radiation; Radiation shields; Radiation combined with conduction and convection; Absorption and emission in gaseous medium; Solar radiation; Green house effect.

- Heat Exchanger: Types of heat exchangers; Fouling factors; Overall heat transfer coefficient; Logarithmic mean temperature difference (LMTD) method; Effectiveness-NTU method; Compact heat exchangers.

  Condensation and Boiling: Introduction to condensation phenomena; Heat transfer relations for laminar film condensation on vertical surfaces and on outside & inside of a horizontal tube; Effect of non-condensable gases; Dropwise condensation; Heat pipes; Boiling modes, pool boiling; Hysteresis in boiling curve; Forced convective boiling.

11. Fluid Machinery

- Introduction: Classification of Fluid Machines & Devices, Application of momentum and momentum equation to flow through hydraulic machinery, Euler's fundamental equation.

  Impact of jet: Introduction to hydrodynamic thrust of jet on a fixed and moving surface (flat & curve), Effect of inclination of jet with the surface.

Hydraulic Turbines : Classification of turbines, Impulse turbines, Constructional details, Velocity triangles, Power and efficiency calculations, Governing of Pelton wheel.

- Reaction Turbines: Francis and Kaplan turbines, Constructional details, Velocity triangles, Power and efficiency calculations, Degree of reaction, Draft tube, Cavitation in turbines, Principles of similarity, Unit and specific speed, Performance characteristics, Selection of water turbines.

- Centrifugal Pumps: Classifications of centrifugal pumps, Vector diagram, Work done by impellor, Efficiencies of centrifugal pumps, Specific speed, Model testing, Cavitation & separation and their control, Performance characteristics.

- Positive Displacement Pumps: Reciprocating pump theory, Slip and coefficient of discharges, Indicator diagram, Effect and acceleration, Work saved by fitting air vessels, Comparison of centrifugal and reciprocating pumps, Positive rotary pumps, Gear and Vane-pumps, Performance characteristics.

- Other Machines: Hydraulic accumulator, Special duty pumps, Intensifier, Hydraulic press, Lift and cranes, Theory of hydraulic coupling and torque converters, Performance characteristics.
  Water Lifting Devices: Hydraulic ram, Jet pumps, Air lift pumps.

12. Industrial Engineering

- Introduction, engineering economy and costing, cost analysis, methods of depreciation, productivity concepts and measurements, job evaluation, methods of job evaluation, merit rating, wage incentive plan, types of wage incentive plans.

- Work measurement, time study, pre-determined motion and time study (PMTS), work sampling, method study, micro motion study, principles of motion economy.

- Plant location, Types of Layout, Principles of Facility Layout, Objective Functions, Steps in PPC, Planning, Routing, Scheduling, Loading, Despatching, Effectiveness of PPC.

- High Volume Production Systems- Transfer Devices, Feeder classification, Construction and Applications, Automated Flow lines, Analysis of Automated Flow lines for Reliability and Efficiency, Assembly Systems, Robot Technology, Flexible Manufacturing Systems (FMS).

13. <u>Power Plant Engineering</u>

- Introduction: Power and energy, sources of energy, review of thermodynamic cycles related to power plants, fuels and combustion calculations. Load estimation, load curves, various terms and factors involved in power plant calculations. Effect of variable load on power plant operation, Selection of power plant units.
  Power plant economics and selection : Effect of plant type on costs, rates, fixed elements, energy elements, customer elements and investor's profit; depreciation and replacement, theory of rates. Economics of plant selection, other considerations in plant selection.

- Steam power plant **:** General layout of steam power plant, Power plant boilers including critical and super critical boilers. Fluidized bed boilers, boilers mountings and accessories, Different systems such as coal handling system, pulverizers and coal burners, combustion system, draft, ash handling system, Dust collection system, Feed water treatment and condenser and cooling towers and cooling ponds, Turbine auxiliary systems such as governing, feed heating, reheating, flange heating and gland leakage. Operation and maintenance of steam power plant, heat balance and efficiency, Site selection of a steam power plant

- Hydro electric station **:** Hydrology, Principles of working, applications, site selection, classification and arrangements, hydroelectric plants, run off size of plant and choice of units, operation and aintenance, hydro systems, interconnected systems.

- Electrical system **:** Generators and generator cooling, transformers and their cooling, bus bar, etc. Instrumentation Purpose, classification, selection and application, recorders and their use, listing of various control rooms.

  Non Conventional Power Plants **:** Introduction to non-conventional power plants (Solar, wind, geothermal, tidal, Fuel cell based power plants etc.

  Pollution : Pollution due to power generation.

14. Refrigeration & Air Conditioning

- Refrigeration**:** Introduction to refrigeration system, Methods of refrigeration, Carnot refrigeration cycle, Unit of refrigeration, Refrigeration effect & C.O.P. Air Refrigeration cycle: Open and closed air refrigeration cycles, Reversed Carnot cycle, Bell Colemanor Reversed Joule air refrigeration cycle, Boot strap refrigeration, Regenerative, Reduced ambient, Dry air rated temperature (DART).

- Vapour Compression System: Single stage system, Analysis of vapour compression cycle, Use of T-Sand P-H charts.

- Vapour Absorption system: Working Principal of vapour absorption refrigeration system, Comparison between absorption & compression systems, Elementary idea of refrigerant absorbent mixtures.

  Refrigerants: Classification of refrigerants, Nomenclature, Desirable properties of refrigerants, Common refrigerants, Secondary refrigerants and CFC free refrigerants.

- Air Conditioning: Introduction to air conditioning, Psychometric properties and their definitions, Psychometric chart, Different Psychometric processes, Thermal analysis of human body, Effective temperature and comfort chart, Cooling and heating load calculations, Selection of inside & outside design conditions, Heat transfer through walls & roofs, Infiltration & ventilation, Internal heat gain, Sensible heat factor (SHF), By pass factor, Grand Sensible heat factor (GSHF), Apparatus dew point(ADP).

- Refrigeration Equipment & Application: Elementary knowledge of refrigeration & air conditioning equipment, Elementary knowledge of transmission and distribution of air through ducts and fans.

SYLLABUS OF MINE SURVEYOR IN S-2 GRADE

1. ***Statutory provisions of surveyor, surveying, plans & section, duties & responsibilities of surveyors under Coal Mine Regulation 2017.***

2. ***Linear measurement:***
   - Instruments for measuring distance ranging, chain surveying
   - Errors in chaining and plotting
   - Optical square.

   - ***EDM:***Principles of measurements
   - Types
   - Correction
   - Selection of instrument.

3. ***Angular measurement:***
   - Prismatic compass
   - Bearing of lines
   - Local attraction
   - Magnetic declination.

4. ***Plan Table Surveying:***
   - Methods contouring using plane table and micro-optic alidade
   - Miners' dials and other compass instruments Dialling
   - Loose and fast needle surveying.

5. ***Theodolite:***
   - Modern micro-optic theodolite
   - Measurement of horizontal and vertical angles
   - Theodolite traversing; traverse calculation
   - Computation of coordinates; adjustment of traverse
   - Temporary and permanent adjustment.

6. ***Total Stations:***

- Surveying by Total stations, Downloading the co-ordinates.
- Procedures of use, care, calibration and servicing, errors, adjustments and applications.

7. Levelling:

- Levelling instrument types of levelling
- Booking and reduction methods
- Temporary and permanent adjustment of levels
- Geometrical, trigonometric and physical levelling
- Characteristics and uses of contours
- Methods of contouring
- Traverse
- Co-ordinates and levelling problems.

8. Tachometry & Controlled surveys:

- Tachometry Triangulation
- Trilateration
- Application of GPS and Total Station in mine surveying
- Use, care, testing, and adjustments of instruments.

9. Field astronomy:

- Astronomical terms
- Determination of true bearing by equal altitude method
- Gyro theodolite-Pprinciple and determination of Gyro north, astronomical triangle
- Conversion of time systems and precise determination of azimuth by astronomical methods.

10. National grid:

- Map projection Cassini Lambert's polyconic and universal transfers Mercator
- Transformation of coordinates, vertical projections; mine models.

11. Geodesy:

- Geod, spheroid and ellipsoid, geocentric, geodetic and astronomical coordinates, orthometric and dynamic heights.

12. Photogrammetry:

- Introduction; scale of a vertical photograph
- Photographs versus map
- Application of photogrammetry and remote sensing in mining.

13. Theory of errors and adjustments:

- Causes and classification of errors, Inclines of precision, Laws of weight propagation and adjustment of errors, Adjustment of triangulation figures.

14. Area and volume calculation

- Different earth work and building estimation
- Laying out of rail and haul road curves

15. Determination of azimuth latitude and longitude

16. Borehole surveying and calculations, dip, strike, outcrop and fault problems.

17. Geological map reading

18. Application of computers in mine surveying and preparation of mine plan.

19. Use of Modern Surveying instruments like 3D, TLS, ETS, Precise Levels etc in OC & UG mines.

20. Use of Survey and Mapping Software

SYLLABUS FOR MINE JUNIOR OVERMAN IN S-2 GRADE

1. General Safety and Legislation:

- Duties and responsibilities of workmen, competent persons and officials (excluding managers, assistant managers), discipline amongst workers and control of staff.
- Provisions of the Coal Mines Regulations, 2017, relating to Coal mine working, explosives and shotfiring, loading, transportation and dumping, precautions against danger from fire, dust, gas and water and of other provisions and Rules, enforcement of and compliance of provisions under the regulations to which overman is responsible
- Writing of reports required to be made by overman under the regulations.
- Hazard Identification, risk assessment and risk management, safety management plan
- Mine Gases: Generation, Properties and Effects, Detection of Mine Gases, Methanometers and Multi Gas Detectors, Gas Chromotograph, Flame Safety Lamps
- Dangerous occurrences in mines and dealing with the same, accidents, their causes and preventions, accident reports, not disturbing the place of accident.
- Mine rescue physiological effect of mine gases; rescue equipment and First Aid.
- Sanitation and health, miners' diseases, their symptoms and preventions.

2. Methods of working:

- Nature of occurrence of coal seams, geological disturbances and their effects on working conditions, dangers and precautionary measures while approaching geological disturbances areas.
- The purpose and utility of boreholes in mines; shaft sinking, safety devices; temporary and permanent supports in sinking and working shafts, examination of shafts and outlets.
- Opencast methods of mining, mechanized and manual methods, deep hole drilling and blasting, shovel and dumpers, dragline, bucket wheel excavators, surface miner, benching, maintenance of haul roads, precautions while extracting developed pillars by opencast method and other safety precautions, methods of reclamation, dump management, high wall mining.
- General principles of bord and pillar and longwall method, multi-section workings, methods of depillaring under different conditions, mechanized pillar extraction, precautions to be taken while working near/beneath waterlogged areas, roof convergence and convergence measuring devices etc., stone drifting.
- Elements of roof control Rock Mass Rating (RMR) of roof strata, mechanism of roof bolting, support of roadways, face supports and their types, setting, testing and withdrawal, systematic

support rules, packing and stowing, protection of surface structures, working beneath statutorily restricted areas and surface structures.

- Safe handling and use of explosives in coal and stone, simultaneous short firing, blasting in fire areas in opencast mines, safety precautions. Inspection of workings, inspection and maintenance of haulage and travelling roadways, man riding system and return airways, gates and fences etc.
- Suppression and treatment, sampling and analysis of mine dust. Sources of danger from surface water and underground inundation, precaution to prevent inundation and irruption of water, water dams, water danger plans.
- Gates and fencing, different kind of fences. Reading of statutory plans.

3. ***Ventilation, Precautions against Explosions, Fires and Inundation:***

- Natural and mechanical ventilation, ventilation of headings and sinking shafts, siting of auxiliary and booster fans, distribution, measurement and control of air in mines, estimation of air quantity requirements, methods of coursing of air, anemometer, hygrometer, maintenance of ventilation appliances.
- Pollution of air, irruption/occurrence of gases in mines, properties of gases, detection and measurement of firedamp and noxious gases, sampling of air, determination of environmental condition, standards of ventilation.
- Design and construction of flame and electric safety lamps, their use, examination and maintenance.
- Suppression and treatment of coal dust, suitability of stone dust, sampling and analysis of mine dust.
- Elementary knowledge of causes and prevention of firedamp and coal dust explosion, limits of inflammability of firedamp.
- Prevention, detection and control of spontaneous heating / fire, sealing off fire areas, fire stopping and their examination, precautions against outbreak of surface fires, fire fighting on surface and belowground.
- Inspection of old workings.
- Sources of danger from surface and underground water, precaution to prevent inundation and irruption of water, precautionary measures while approaching abandoned and water logged areas, boring machines for exploratory work, water dams, water danger plan.
- Recovery of mines after explosions, fires and inundation, precautionary measures during re-opening and dewatering of mines.

4. Elements of Mining Machinery:

- Safety aspects and safe use of different kinds of machinery used in underground and opencast mines e.g. SDLs, LHDs, Continuous Miners, Shuttle Cars, Crushers, Conveyors, blast hole drills, rippers, scrappers, shovels, draglines, dumpers, road graders, dozers, wheel loaders, bucket wheel excavators, spreaders, surface miners, Brakes (including service and parking brakes)
- Use of steam and internal combustion engines in mines.
- Application of electricity in mines, safety precautions.
- Winding equipments, ropes and guides, signaling and decking arrangements, safety devices, examination of winding equipments and shaft fittings.
- Haulage and transport, types of haulage, rope haulage and locomotives, self-acting inclines, haulage roads in underground and opencast working, rails and tracks, their maintenance and inspection, tubs, signaling, safety devices, codes of practices, traffic rules, unsafe practices, derailments.
- Different types of pumps, principles and use of siphons, drainage and water lodgments.
- Code of practice for transport, installation, erection, use and shifting of underground and opencast machinery.
- Belt conveyors and safety appliances.