Syllabus for ISM JRF Entrance Exam

ISM-JRF Admission 2013-14

Phase-2

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CONTENT

1. Engineering Streams

1.1 Chemical Engineering (Code: CHE)

Fluid Mechanics: Fundamental concepts of fluid flow, mechanism of compressible and non compressible fluid flow. Transportation of fluids, reciprocating and centrifugal pumps, pump characteristics. Fluidization, aggregate and particulate fluidization, incipient fluidization, minimum fluidization velocity, entrainment in fluidization, operating characteristics of gas – solid, liquid – solid and liquid – gas and gas – solid – liquid (three phase) fluidized beds.

Chemical Process Calculation: Steady-state and dynamic processes; lumped and distributed processes; single and multi-phase systems; intensive and extensive variables; equilibrium relations; rate laws; correlations for physical and transport properties; behavior of ideal gases and gaseous mixtures; vapor pressure; humidity and saturation; phase equilibrium; non-reacting single-phase systems; systems with recycle, bypass and purge; processes involving vaporization and condensation; enthalpy; heat of reaction; thermochemistry; fuel calculations;

Heat transfer: Basic modes of heat transfer and its application.

Mechanical Operation: Types of Mechanical Operations, Characteristics of particulate solids: sampling techniques, specification and screen analysis, particle size distribution.

Principles of size reduction: Specific properties of solids for size reduction. Energy required for size reduction. Crushing and grinding efficiency. Laws of crushing, pulverization and ultrafine grinding.

. Filtration: classification of filters, theory of filtration.

Material Science and Technology: Classification of engineering materials, Elastic deformation, Plastic deformation, Creep, Visco-elastic deformation, Different types of fracture.

Annealing, Normalizing, Hardening, Martempering, Austempering, Hardenability, Quenching, Tempering, Carburising, Cyaniding, Nitriding, Flame hardening.

Ferrous metals, Non ferrous metals and alloys, Ceramic materials, Polymorphism, Smart materials, biomaterials, nanomaterials, polymers and composites.

Thermodynamics: Basic concepts: work, energy, heat, internal energy, extensive and intensive properties, state and path functions, First law of thermodynamics, energy balance for closed systems, equilibrium, the reversible process, constant-v and constant-p processes, enthalpy, heat capacity, energy balances for steady-state flow processes. Thermodynamic Properties of Fluids.

Energy: Coal analysis, Coal classification, Coal preparation, Coal washing and coal blending, Coal carbonization, Coal gasification, liquid fuel synthesis from coal, coke oven gas, blast Furnace gas, CBM. Petroleum crude, Types of crude, emergence of petroleum products as energy, Gaseous Fuels: Natural gas, Water gas, producer gas, L.P.G., LNG, CNG, GTL Technology (gas to liquid).

Fuel cell , Bio energy etc.

Mass Transfer: Fundamentals of Mass Transfer: Molecular diffusion, mass transfer coefficient and interface mass transfer, steady and unsteady state theories of mass transfer. Single Stage Distillation, Differential distillation, Flash vaporization, Vacuum, molecular and

steam distillation, Multistage contact operations, Absorption and Stripping, Humidification and Dehumidification, Drying, Crystallization, Membrane separation process.

Chemical Reaction Engineering: Chemical equilibria - Free energy and chemical reactions, feasibility of chemical reaction, calculation of free energy of homogeneous reactions, equilibrium constants and evaluation from thermodynamic data, effect of different variables on reaction equilibria, calculation of equilibrium composition for single and multiple reactions, equilibria of heterogeneous reactions. Kinetics of homogeneous reactions, Design of single homogeneous reactors, Multiple reactor systems, Multiple reaction systems.

Transport Phenomena: Development of mass, momentum and energy balance equations Application of momentum, heat and mass transfer in transport systems.

1.2 Computer Science and Engineering (Code: CSE)

Programming Skill: Programming proficiency in C/C++/Java

Discrete Mathematics: Counting Techniques, Generating Functions, Recurrence Relations, Formal Logic, Propositional and Predicate Calculus, Boolean Algebra.

Computer Organization and Architecture: Logic Functions, Minimization, Design and Synthesis of Combinational and Sequential Circuits, Data Representation, Machine Instructions, Addressing Modes, ALU, CPU, Control Unit Design, Cache and Main Memory, I/O Interface, Pipelining Multiprocessors.

Data Structures and Algorithms: Arrays, Stacks, Queues, Linked Lists, Binary Trees, Height Balanced Trees, Graphs, Sorting, Searching, Algorithm Analysis, Space and Time Complexity, Algorithm Design: Divide and Conquer, Greedy Approach, Dynamic Programming, Back Tracking, Complexity Classes: P, NP-hard and NP-complete.

Operating Systems: Processes, Threads, Inter-Process Communication, Synchronization, Deadlocks, CPU Scheduling, Memory Management, File Systems, I/O Systems.

Database: ER-Model, Relational Algebra, Tuple Calculus, Database Design, Query Languages, Transactions and concurrency Control.

Compiler Design: Lexical Analysis, Parsing, Syntax Directed Translation, Runtime Environments, Intermediate Code Generation, Code Optimization, Code Generation.

Computer Networks and Security: OSI and TCP/IP Architectures, Flow and Error Control, MAC Algorithms, Routing Algorithms, TCP and UDP, Sockets, Application Layer Protocols: SMTP, HTTP, DNS, WWW; Security: Symmetric and Asymmetric-Key Cryptography, Authentication, Hash Functions, SSL / TLS.

Software Engineering: Software Development Life Cycle, Software Requirement Specifications, System Design, Coding, Testing, Software Project Management.

1.3 Civil Engineering (Code: CVE)

Structural Engineering: Bending moment and shear force in statically determinate beams. Simple stress and strain relationship: Stress and strain in two dimensions, principal stresses, stress transformation, Mohr's circle. Simple bending theory, flexural and shear stresses, shear centre. Analysis of statically determinate trusses, arches, beams, cables and frames, displacements in statically determinate structures and analysis of statically indeterminate structures by force/ energy methods, analysis by displacement methods (slope deflection and moment distribution methods), influence lines for determinate and indeterminate structures.

Concrete Structures: Concrete Technology- properties of concrete, basics of mix design. Concrete design- basic working stress and limit state design concepts, analysis of ultimate load capacity and design of members subjected to flexure, shear, compression and torsion by limit state methods. Basic elements of prestressed concrete.

Steel Structures: Analysis and design of tension and compression members, beams and beam- columns, column bases. Connections- simple and eccentric, beam-column connections, plate girders and trusses.

Geotechnical Engineering: Origin of soils, soil classification, three-phase system, fundamental definitions, relationship and interrelationships, permeability & seepage, effective stress principle, consolidation, compaction, shear strength. Sub-surface investigations- scope, drilling bore holes, sampling, penetration tests, plate load test. Earth pressure theories, effect of water table, layered soils. Stability of slopes. Foundation types- foundation design requirements. Shallow foundations-bearing capacity, effect of shape, water table and other factors.

Water Resources Engineering: Properties of fluids, principle of conservation of mass, momentum, energy and corresponding equations, potential flow, applications of momentum and Bernoulli's equation, laminar and turbulent flow, flow in pipes, pipe networks. Concept of boundary layer and its growth. Uniform flow, critical flow and gradually varied flow in channels, specific energy concept, hydraulic jump. Forces on immersed bodies, flow measurements in channels, tanks and pipes. Dimensional analysis and hydraulic modeling. Hydrologic cycle, rainfall, evaporation, infiltration, stage discharge relationships, unit hydrographs, reservoir capacity**.** Duty, delta, estimation of evapo-transpiration. Crop water requirements. Types of irrigation system, irrigation methods. Water logging and drainage, sodic soils.

Environmental Engineering: Quality standards, basic unit processes and operations for water treatment. Drinking water standards, water requirements, basic unit operations and unit processes for surface water treatment, distribution of water. Sewage and sewerage treatment, quantity and characteristics of wastewater. Primary, secondary and tertiary treatment of wastewater, sludge disposal, effluent discharge standards. Domestic wastewater treatment, quantity of characteristics of domestic wastewater, primary and secondary treatment Unit operations and unit processes of domestic wastewater, sludge disposal. Types of air pollutants, their sources and impacts, air pollution meteorology, air pollution control, air quality standards and limits. Characteristics, generation, collection and transportation of solid wastes, engineered systems for solid waste management (reuse/ recycle, energy recovery, treatment and disposal). Impacts of noise, permissible limits of noise pollution, measurement of noise and control of noise pollution.

Transportation Engineering: Geometric design of highways, testing and specifications of paving materials, design of flexible and rigid pavements. Traffic characteristics, theory of traffic flow, intersection design, traffic signs and signal design, highway capacity.

Surveying: Importance of surveying, principles and classifications, mapping concepts, coordinate system, map projections, measurements of distance and directions, leveling, theodolite traversing, Total Station, errors and adjustments, curves.

1.4 Electronics Engineering (Code: ECE)

Networks: Network graphs: matrices associated with graphs; incidence, fundamental cut set and fundamental circuit matrices. Solution methods: nodal and mesh analysis. Network theorems: superposition, Thevenin and Nortons maximum power transfer, Wye-Delta transformation. Steady state sinusoidal analysis using phasors. Linear constant coefficient differential equations; time domain analysis of simple RLC circuits, Solution of network equations using Laplace transform: frequency domain analysis of RLC circuits. 2-port network parameters: driving point and transfer functions. State equations for networks.

Electronic Devices: Energy bands in silicon, intrinsic and extrinsic silicon. Carrier transport in silicon: diffusion current, drift current, mobility, and resistivity. Generation and recombination of carriers. p-n junction diode, Zener diode, tunnel diode, BJT, JFET, MOS capacitor, MOSFET, LED, p-I-n and avalanche photo diode, Basics of LASERs. Device technology: integrated circuits fabrication process, oxidation, diffusion, ion implantation, photolithography, n-tub, p-tub and twin-tub CMOS process.

Analog Circuits: Small Signal Equivalent circuits of diodes, BJTs, MOSFETs and analog CMOS. Simple diode circuits, clipping, clamping, rectifier. Biasing and bias stability of transistor and FET amplifiers. Amplifiers: single-and multi-stage, differential and operational, feedback, and power. Frequency response of amplifiers. Simple op-amp circuits. Filters. Sinusoidal oscillators; criterion for oscillation; single-transistor and op-amp configurations. Function generators and wave-shaping circuits, 555 Timers. Power supplies.

Digital circuits: Boolean algebra, minimization of Boolean functions; logic gates; digital IC families (DTL, TTL, ECL, MOS, CMOS). Combinatorial circuits: arithmetic circuits, code converters, multiplexers, decoders, PROMs and PLAs. Sequential circuits: latches and flip-flops, counters and shift-registers. Sample and hold circuits, ADCs, DACs. Semiconductor memories. Microprocessor(8085): architecture, programming, memory and I/O interfacing.

Signals and Systems: Definitions and properties of Laplace transform, continuous-time and discrete-time Fourier series, continuous-time and discrete-time Fourier Transform, DFT and FFT, z-transform. Sampling theorem. Linear Time-Invariant (LTI) Systems: definitions and properties; causality, stability, impulse response, convolution, poles and zeros, parallel and cascade structure, frequency response, group delay, phase delay. Signal transmission through LTI systems.

Control Systems: Basic control system components; block diagrammatic description, reduction of block diagrams. Open loop and closed loop (feedback) systems and stability analysis of these systems. Signal flow graphs and their use in determining transfer functions of systems; transient and steady state analysis of LTI control systems and frequency response. Tools and techniques for LTI control system analysis: root loci, Routh-Hurwitz criterion, Bode and Nyquist plots. Control system compensators: elements of lead and lag compensation, elements of Proportional-Integral-Derivative (PID) control. State variable representation and solution of state equation of LTI control systems.

Communications: Random signals and noise: probability, random variables, probability density function, autocorrelation, power spectral density. Analog communication systems: amplitude and angle modulation and demodulation systems, spectral analysis of these operations, superheterodyne receivers; elements of hardware, realizations of analog communication systems; signal-to-noise ratio (SNR) calculations for amplitude modulation (AM) and frequency modulation (FM) for low noise conditions. Fundamentals of information theory and channel capacity theorem. Digital communication systems: pulse code modulation (PCM), differential pulse code modulation (DPCM), digital modulation schemes: amplitude, phase and frequency shift keying schemes (ASK, PSK, FSK), matched filter receivers, bandwidth consideration and probability of error calculations for these schemes.

Basics of TDMA, FDMA and CDMA and GSM.

Electromagnetics: Elements of vector calculus: divergence and curl; Gauss and Stokes theorems, Maxwells equations: differential and integral forms. Wave equation, Poynting vector. Plane waves: propagation through various media; reflection and refraction; phase and group velocity; skin depth. Transmission lines: characteristic impedance; impedance transformation; Smith chart; impedance matching; S parameters, pulse excitation. Waveguides: modes in rectangular waveguides; boundary conditions; cut-off frequencies; dispersion relations. Basics of propagation in dielectric waveguide and optical fibers. Basics of Antennas: Dipole antennas; radiation pattern; antenna gain.

Instrumentation and Measurements: Principle of measurements and error analysis. Instruments: DC & AC voltage and current meters, power and energy meters, meter for measuring speed, potentiometer and bridges; estimation of instrument ranges. Amplifiers in instrumentation, Digital display in instruments. Principle of oscilloscope and recorders, Passive (resistive, inductive, capacitive) and active (thermoelectric, piezoelectric, photoelectric etc.) transducers.

1.5 Electrical Engineering (Code: ELE)

Electric Circuits and Fields: Network graph, KCL, KVL, node and mesh analysis, transient response of DC and AC networks; sinusoidal Steady-state analysis, resonance, basic filter concepts; ideal current and voltage sources, Thevenin's, Norton's and Superposition and Maximum Power Transfer theorems, two-port networks, three phase circuits; Gauss Theorem, electric field and potential due to point, plane and spherical charge distributions; Ampere's and Biot-Savart's laws; inductance; dielectrics; capacitance.

Signals and Systems: Representation of continuous and discrete-time signals; shifting and scaling operation; liner, time-invariant and casual system; Fourier series representation of continuous periodic signals; sampling theorem; Fourier, Laplace and Z transforms.

Electrical Machines: Single phase transformer- equivalent circuit, phasor diagram, tests, regulation and efficiency; three phase transformers – connections, parallel operation; auto-transformer; energy conversion principles; DC machines – type, winding, generator characteristics, armature reaction and commutation, stating and speed control of motors; three phase induction motor – principles, types, performance characteristics, starting and speed control; single phase induction motors; synchronous machines – performance, regulation and parallel operation of generators, motor starting, characteristics and applications; servo and stepper motors.

Power Systems: Basic power generation concepts; transmission line models and performance; cable performance, insulation; corona and radio interference; distribution systems; per-unit quantities; bus impedance and admittance matrices; load flow; voltage control; power factor correction; economic operation; symmetrical components; fault analysis; principles of over-current. Differential and distance protection; solid state relay and digital protection; circuit breakers; systems stability concepts, swing curves and equal area criterion; HVDC transmission and FACTS concepts.

Control Systems: Principles of feedback; transfer function; block diagrams; steady-state errors; Routh and Nyquist techniques; Bode plots; root loci; lag, lead-lag compensation; state space model; state transition matrix, controllability and observability.

Electrical and Electronic Measurements: Bridges and potentiometers; PMMC, moving iron, dynamometer and induction type instruments; measurements of voltage, current, power, energy and power factor; instrument transformers; digital voltmeters and multimeters; phase, time and frequency measurement; Q-meters; oscilloscopes; potentiometric recorders; error analysis.

Analog and Digital Electronics: Characteristics of diodes, BJT, FET; amplifier-biasing, equivalent circuit and frequency response; oscillators and feedback amplifiers; operational amplifier characteristics and application; simple active filter; VCOs and timers; combinational and sequential logic circuits; multiplexer; Schmitt trigger; multi-vibrators; sample and hold circuits; A/D and D/A converters; 8-bit microprocessor basics, architecture, programming and interfacing.

Power Electronics and Drives: Semiconductor power diodes, transistors, thyristors, triacs, GTOs, MOSFETs and IGBTs – static characteristics and principles of operation; triggering circuits; phase control rectifiers; bridge converters – fully controlled and half controlled; principles of choppers and inverters; basic concepts of adjustable speed dc and ac drives.

1.6 Environmental Science and Engineering (Code: ESE)

Global Environmental issues: Green House Effect, Global Warming, Acid Rain, Carbon Taxation, Carbon Sequestration

Air: Air Pollution-Sources & Effects, Air pollution control design such as Electrostatic Precipitator, Bag house, Scrubber, Settling Chamber

Water: Water pollution-Sources & effects, Water born diseases, Water quality parameters, Drinking water quality standards, Water treatment methods – aeration, coagulation, flocculation, filtration and chlorination.

Waste Water Engineering: Waste Water Characteristics, Primary and Secondary treatment, Effluent Treatment Plant i.e. Screening, Grit Chamber, Sedimentation Tank, Activated Sludge Process, Oxidation Ditch, Trickling Filter, Stabilisation Pond, and Anaerobic Treatment

Land: Land use changes due to human and industrial activities, land use planning and development, soil conservation, Solid waste (domestic & industrial) management and disposal

Ecology: Principles of Ecology, Ecosystem function and structure, Ecological fragility, Compensatory afforestation, Biodiversity, Endangered and Extinct species,

Hydrology: Ground water pollution, Movements of grounds, Conservation of ground resources

Noise: Sound Pressure Level, Sound Power Level, Noise Standards, Physiological effects and abatement measures,

Environmental Legislation: Water Act, Air Act, Environmental Protection Act, Forest Conservation Act, Wild Life Protection Act,

Environmental Administration: Environmental Impact Assessment (EIA), Environmental Management Plan, Environmental Auditing,

1.7 Fuel Engineering (Code: FLE)

Origin and Classification of coal.

Coal Characterisation: Chemical, Physical, Plastic and Petrographic composition

Coal Carbonisation: Fundamental of coal carbonisation, Low Temperature, High Temperature Carbonisation, Design of coke oven, By-product , Formed coke and Briquetting.

Cole Combustion: Fundamental of coal combustion, Stoichiomentry, Design of Furnaces and Boiler, Atmospheric Fluidized bed Combustion (AFBC), Circulating Fluidized bed Combustion (CFBC), Pressurised Fluidized bed Combustion (PFBC).

Coal Gasification: Fundamental of coal gasification, Kinetics of Coal Gasification and Different types of gasifiers, Different Gaseous Fuels

Clean Coal Technology: Pre-combustion cleaning, Integrated Coal Gasification Combined cycle etc.

Modelling and Simulation of some energy systems like, Integrated Coal Gasification Combined Cycle, AFBC, CFBC, and PFBC.

Liquid Fuels: Characteristics of liquid fuels like gasoline, diesel and kerosene etc

Non-conventional Energy sources: Wind, Solar, Biomass, Hydroelectricity etc.

Heat Transfer: Fundamentals of heat transfer and its application in energy related systems.

Mechanical Operation: Types of Mechanical Operations, Characteristics of particulate solids: sampling techniques, specification and screen analysis, and particle size distribution.

Principles of size reduction: Specific properties of solids for size reduction. Energy required for size reduction. Crushing and grinding efficiency. Laws of crushing, pulverization and ultrafine grinding.

1.8 Industrial Engineering & Management (Code: IEM)

1. **Principles and Practices of Management**
   - Management: concept and basic features
   - Functions of Management: Planning, Organizing, Staffing, Directing and Controlling
   - Organisation structure
   - Basic theories of Management
2. **Research Methodology and Statistics**
   - Scientific Research: Definition, problems, types of variables
   - Measures of Central Tendency and Dispersion, Probability, Sampling, and Randomness
   - Statistics: Purpose, Approach, and Method: Binomial Statistics, Normal Probability;
   - Correlation and Regression
3. **Human Resource Management**

- Training and Development, Motivation, Leadership, Job Satisfaction,
- Recruitment and Selection, Performance Appraisal

4. **Quantitative Techniques**
   - Role of quantitative techniques in managerial decision making
   - Optimization techniques: Classification and Applications
   - Linear Programming: Features, Modelling, Simplex method of solution, Transportation model, and Assignment problem
   - Queuing theory: its role in decision making
   - Concept of Information System, Basics of MIS and DSS
5. **Operations Management and Industrial Engineering**
   - Concept and measurement of Productivity
   - Work Study techniques
   - Productivity improvement through Incentive Planning, Job Evaluation, and Merit Rating
   - Inventory Management: ABC analysis and EOQ model
   - Demand Forecasting: Time series analysis
   - Concept of Quality, application of Quality Control techniques in improving product quality
   - Basics of Production Scheduling, Facility Location, and Plant Layout
6. **Project Management**
   - Concept of a Project, Project breakdown structure
   - Project Scheduling: time estimates, CPM/PERT
7. **Economics**
   - Managerial Economics: Basic Philosophy
   - Demand and Supply function: Elasticity of Demand
   - Nature and behaviour of different types of revenue and costs
   - Pricing under monopoly and oligopoly
8. **Financial Management**
   - Concept and Basic understanding on:
   - Working Capital Management
   - Capital Budgeting decisions

1.9 Mechanical Engineering (Code: MEC)

1. Mechanics of Solids

Complex stress and strains combined bending and axial torsion, Shear force and bending moment diagrams. Deflection of beams, fixed and continuous. Thick and thin cylinders, columns, springs.

2. Theory of Machines

Velocity & acceleration diagrams. Fly wheel and governors, gear profile and gear trains, balancing and vibrations.

3. Machine design

Engineering and computer graphics, basic concepts of design, CAD, design of mechanical component i.e. shaft, coupling, pulleys, gears, bearings, Engineering materials.

4. Thermal engineering

Laws of thermodynamics, entropy, enthalpy, Internal combustion engines – two-four stroke, boilers, steam turbine, mode of heat transfer, heat exchangers, refrigeration, cycles and air conditioning.

5. Hydraulics in Industrial applications

Properties of fluid, Bernoulli's equation, Euler's equation, Reynolds's equation, Navierstoke's equation flow of fluid, reciprocating and centrifugal pumps, hydraulic turbines.

6. Production Technology

Theory of metal cutting, conventional, non-conventional machining methods. Welding, foundry and forging practices, Computer integrated manufacturing, CPM and PERT

1.10 Mineral Engineering (Code: MLE)

INTRODUCTION

Definition of Ore, Mineral and gangue, Classification of common ore forming minerals, Chemical and physical and optical properties of different ores and minerals, scope and necessity of beneficiation of Ores and Minerals, Definition of liberation, Measurement of degree of liberation.

Sampling:

Definition, principles and methods, sampling theories, measurement of necessary of sampling.

Particle Sizing:

Particle characterization and measurement, Definition and shape and size and their measurements, Equivalent diameters, Measurement of particle size by sieving, sedimentation, elutriation and optical methods.

Comminution:

Fundamentals of size reduction, comminution laws, various types of crushers, Band work index and HGI. Grinding mill principles, design construction and their operation in open and closed circuit with classifiers, Principles involved in industrial screening and wet classification of ores and minerals.

Gravity Separation:

Basic principles, application criteria for gravity concentration techniques.

Jigging:

Basic principles, types of jigs and their relative merits and demerits, operation and maintenance of jigs.

Flowing Film Gravity Concentration:

Introduction to flowing film gravity concentration principles involved derivation of various coal and minerals, including tabs and spi

Band work index and HGI.

1.11 Mining Machinery Engineering (Code: MME)

1. Mechanics of Solids

Complex stress and strains combined bending and axial torsion, Thick and thin cylinder. Deflection of beams, columns, springs, Theories of failure.

2. Theory of Machine

Velocity & acceleration diagrams. Fly wheel, governors, gear train balancing, cam and follower, gyroscope, vibrations, mechanism of lower pair.

3. Machine design

Basic concept of design, CAD, design of mechanical components pulleys, shafts, couplings, gears, Engineering materials, selection of bearings applied to mining equipments.

4. Thermal engineering

Laws of thermodynamics, entropy, enthalpy, I.C. engines, heat exchanger.

5. Hydraulics in Industrial applications

Properties of fluid, Navierstoke's equation, Bernoulli's and Euler's equation,

Hydrostatic pumps, motors, valves and other components, hydrostatic systems used in industrial applications. Design of hydrostatic drives. Fluid flow machines such as pumps, fan and compressors.

6. Mining Equipments

Construction, operation and maintenance of underground and opencast equipment (coal and metal), selection and capacity calculation of mining equipment, safety aspects of mining equipment, Design and capacity estimation of mine winder, hydraulics use in mining equipment, condition monitoring of mining equipment. Construction, operation and selection of mineral beneficiation equipment – such as crushers, mills, feeders, classifiers, etc.

7. Automobile Engineering

Power transmission, gearboxes, engines, suspensions, differentials.

1.12 Mining Engineering (Code: MNE)

1. Drilling and Blasting:

Exploratory drilling techniques; Types of blast hole drills, and their applicability, advantages and disadvantages; Different types of explosives, their applicability and selection; Blasting: blast design, patterns of blasting and controlled blasting.

2. Mine Construction:

Vertical and inclined shafts: Location, shape and size, organization of sinking and construction of shaft collar, insets; Shaft sinking operations; Drilling and blasting, lining, mucking, dewatering, ventilation, surveying and lighting. Mechanized sinking; Main haulage drifts and tunnels: Purpose, shape, size and location, Tunnelling operations; Excavation, mucking, supporting and ventilation; Introduction to mine systems engineering. Methods of technological forecasting and its relevance in mine planning; Planning, scheduling and cost control of projects through network, analysis; Optimisation in production planning; project selection, blending and quality control using linear programming; sensitivity analysis.

3. Underground Coal Mining:

Choice of mining methods: Bord & pillar mining and longwall mining methods. Design of bord and pillar workings: methods of driving development galleries; sequence and manner of extraction; strata control and support in bord and pillar workings. Design of longwall workings: development of longwall panels; equipment on a longwall face; strata behaviour and support requirement; production, manpower, productivity and cost; exploitation of thick seams, thin seams and contiguous seams. Working coal seams under water bodies and surface structures.

4. Underground Metalliferous Mining:

Ore deposit characteristics, losses and dilution of ore in mining, net-smelter return to mine. Opening of deposits by adit, shaft, decline and ramp. Mine development - main horizon, raises, ore passes, discharge and haulage of ore in mine. Classification and selection of stoping method; Stoping methods: Shrinkage, Cut and Fill, Sub-level, Open stoping, Vertical Crater Retreat, Sub-level Caving, Block Caving. Recent trends in mechanization of development and stoping methods.

5. Surface Mining:

Classification of mining systems; Application and working of cyclic and continuous mining systems. Inpit-crushing - conveying systems, Cyclic and continuous excavation & loading systems; Dumper and belt conveyor (shiftable, modular and high angle) transport systems. Waste dump formation methods and corresponding equipment. Method and criteria for selection of equipment. Planning inputs and methodology. Determination of ultimate pit configuration. Design of haul roads. Analysis and design of highwall and waste dumps slopes.

6. Rock Mechanics:

Basic Rock Mechanics - Are rocks Elastic, homogeneous and isotropic? Definition of basic terminology - E_s E_t & E_o. Major Rock Mass classifications. Failure theories - their comparative study. Uniaxial compressive strength, tensile strength and shear strength, and their time dependent characteristics. Variation of UCS. In-situ stresses and their measurement. Stress around circular, elliptical and rectangular openings in elastic and homogeneous and non-homogeneous rocks. Mishaps in openings and remedial measures. Causes and precautions for subsidence. N.E.W. (Non Effective Width). Grouting and Shotcreting, Rock reinforcement, Rock Bursts. Instrumentation.

7. Mine Ventilation:

Mine gases; Heat and humidity problems in mines and ventilation thermodynamics; Natural ventilation - Air flow through mine openings; Mechanical ventilation; Ventilation Survey and Planning; Ventilation network analysis for incompressible and compressible flows; Mine fires; Mine explosions; Mine dust; Mine illumination; Controlled recirculation and Environmental monitoring.

8. Mine Surveying:

Meridian: True and Magnetic; Magnetic compass and Gyrocompass; Theodolite traverse and adjustment of the figure; Triangulation and EDM traversing; correlation - the latest trend; Determination of azimuth of reference line; Modern surveying equipment: Total station and GPS; Geological reading.

1.13 Petroleum Engineering (Code: PET)

1. Concept of worldwide Hydrocarbon exploration, General energy scenario (national and worldwide), History of Petroleum Production on-land and offshore, Petroleum Exploration organizations, Basic concepts of Fluid Mechanics, Basic Thermodynamics of single and multi-component system, Composition & Characteristics of hydrocarbons, Rheology of non-Newtonian fluids, Types & characteristics of engineering materials and their strength.

2. Basics of Well planning, Design & selection of drilling fluid, rheology of drilling fluid, cement slurry & crude oil. Operating system of drilling rigs, Factors affecting rate of penetration. Various drilling hazards. Development of oil & gas fields, Well Completion, well equipment, workover & stimulation, design and selection of artificial lift, Surface operations & transportation for oil & gas.

3. Petrophysical properties of reservoir rocks, Fluid flow through porous media. Reservoir fluid characteristics, Phase behavior, Reserve estimates, Reservoir drive mechanisms, Well Test, Analysis Petroleum Formation Evaluation. Environment management in Petroleum Operations. Characteristics of sea wave, wind and current forces, Basic concept of Offshore Drilling and Production system.

4. Occurrence of Petroleum, Various methods of petroleum exploration, Multicomponent distillation, adsorpson, dehydration, desorption & evaporation, solvent extraction, desulphurization, Heat exchangers. Theory of emulsions, Refinery products & their specifications, Coking, Cracding reforming & blending of products. Lube oil production including dewaxing process. Petrochemical feed stocks, ethylene & propylene based petrochemicals, Environmental management in Hydrocarbon industry.

5. Selection and application of different types of pumps, flow meter, fluid couplings, torque conversions, hydraulic clutches and brakes. Operations and Regulations of Air Compressors and Air Motors. Different types of hydraulic and pneumatic valves and their use in control circuits of Drilling rigs. Power plants, Tractors, Excavators and Crancs. Different types of loading and basic parts like shafts, pulleys, columns, frames, gears. Design of different types of pressure vessels. Preventive and Schedule maintenance procedures, Selection criteria of machine tools and equipment of general maintenance.

2. Science/Management/HSS Streams

2.1 Applied Geology (Code: AGL)

1. Geomorphology and Remote Sensing:

Methods of geomorphic investigations, evolution of different land forms, applications of geomorphology in different geological investigations. Principles of remote sensing, photogeology and applications of remote sensing. Geographic information system and its applications. Global positioning system.

2. Stratigraphy

Principles of stratigraphy, stratigraphic classification, stratigraphy and tectonics of Precambrian rocks of India, Phonerozoic stratigraphy of peninsular and extra peninsular India.

3. Palenontology

Theories of organic evolution, causes of extinction, morphology of common invertebrate and vertebrate fossils, Micropalentology and its applications, Paleobotany for exploration.

4. Mineralogy and Geochemistry

Crystal chemistry, phase stability and properties of different mineral groups, chemical evolution of the earth, geochemical classification and distribution of elements, geochemistry of important elements.

5. Sedimentary Petrology

Textures and structures of igneous rocks, petrology of important sedimentary rocks, paleocurrent
analysis, provenance studies, sedimentary basins in India.

6. Igneous Petrology

Textures and structures of igneous rocks, crystallization of magma and representations in phase diagrams, representations of chemical analysis of igneous rocks and their applications and limitations, petrology of different types of igneous rocks magmatism in relation to plate tectonics.

7. Metamorphic Petrology

Metamorphic textures, kinetics of metamorphic reactions, stability of common metamorphic minerals, geothermometry and geobarometry, different types of projection diagrams, metamorphism of different rocks, plate tectonics and metamorphism.

8. Structural Geology

Stress, strain, strain analysis, structural analysis, poly-deformed terrains, shear zones and migmatites; analysis of thrust belts, mechanisms of folding and fracturing. Introduction to petrofabrics.

9. Geotectonics

Variations of physical properties in the earth, crustal types and their evolution, evolution of ocean basins, concept of plate tectonics and tectonics of different types of plate boundaries with special reference to India.

10. Economic Geology

Classification of ore deposits, evolution of different types of ore deposits, origin, migration and accumulation of petroleum; coal geology and nuclear geology. National mineral policy, conservation and utilization of mineral resources.

11.Exploration Geology

Concepts of mineral exploration, methods of geological and geochemical prospecting drilling techniques, sampling, estimation of reserves, geophysical prospecting, mineral beneficiation, Marine mineral resources.

12.Engineering Geology

Engineering properties of rocks and soil, geotechnical investigations for dams, reservoirs, tunnels, and mass movements. Rocks as construction materials, landslides.

13.Hydrogeology and Environmental Geology

Hydrological characters of different rocks, aquifer evaluation, groundwater flow, characteristics of groundwater for different use, groundwater development and management, groundwater provinces of India; Groundwater recharge, Rainwater harvesting, environmental problems of mineral exploration, low temperature geochemistry, environmental planning and management.

2.2 Applied Geophysics (Code: AGP)

Solid Earth Geophysics: Earth: its rotation and figure. Gravity and its variation over the earth, Earth: surface features, continents, continental margins, oceans. Thermal history and its characteristics over various earth surface features. Earth's interior: physics status; variation of physical quantities and seismic wave velocity inside the earth, major sub divisions. Composition and structure of upper and lower continental crust, layering in oceanic crust, crustal structure studies for mountains, plateau, basins in India, Gravity and DSS studies for the Himalayas. Oceanic magnetic anomalies and their interpretations, magneto stratigraphic time scale, paleomagnetic evidences from continental drift, APWP for different continents-their main results, seismological evidences for lithospheric deformation, concept of sea floor spreading and plate tectonics, plate margins and processes at plate margins, triple junction, Characteristic movement of Indian plate and formation of the Himalayas.

Signal Analysis: Signals, noise and their classification, continuous and discrete signals. Complex exponential Fourier series, Fourier integral, Fourier transform and its properties, energy and phase spectra, Fourier transforms of some commonly used functions, utility of domain transformation; inverse Fourier transform; use of one and two dimensional Fourier transforms in solving geophysical problems, radial and angular spectra.

Reflection Seismology: Travel time relation for direct, reflected and head waves over multi layered earth. Land and marine energy sources, electromagnetic pulse and Accelerated Weight Drop. Basic theory and working principle of seismic transducers, Various refraction/transmission shooting techniques: reduction of refraction data. Seismic attenuation, reflection and transmission coefficients, Knott and Zoeppritz equations. Geometry of reflection ray path and time distance relationship, seismic noise and their cause. Methodology for 2D reflection Survey: Different kinds of spread geometries, end on, slit spread, crooked lined profiling, linear and tapered geophone arrays, effect of arrays on the seismic response, optimization of spread geometry, offset matching, source arrays. Common depth point shooting and its advantages. 3D survey designing: Different 3D geometries, swath, MESA, GEOLAND, GX-III, 3D survey design shooting-in line, slant and orthogonal, optimization of source and receiver lines in a swath, optimization of different offsets. Offshore survey: Single, streamer and multiple streamer. Processing sequences-preparation of processing geometry, quality checks, true amplitude recovery, deconvolution, filtering, velocity analysis, statics, noise elimination through multichannel filtering, parameter optimization for generation final stacked section. DMO and migration, 3D Processing techniques-generation of time slice and stacked sections.

Resistivity and IP methods: Fundamental relation between potential, apparent resistivity, transform and layer distribution of a stratified earth. Applications of linear filter theory;

determination of filter coefficients, sinc response- filter length. Potential due to a point source in an anisotropic medium, triangle of anisotropy. Partial curve matching of three layer and four layer curves, Dar Zarrouk parameters, principle of equivalence, Resistivity modeling. Mise-a-la-masse method. Sources of IP, membrane and electrode polarizations, time domain and frequency domain measurement of IP, chargeability, percent frequency effect and metal factors, apparent chargeability over layered earth, electromagnetic coupling.

Electromagnetic Method: Principle of electromagnetic induction; magnetic field due to a current carrying loop, elliptical polarization, plane of polarization, dip and tilt angles, nomograms for quantitative determination of parameters by dip angle method, VLF and AFMAG methods TURAM method. Response of a single closed conducting circuit by using a fixed horizontal transmitter-receiver system. Analysis of response function with frequency and different ranges of conductivities, amplitude and phase relations, vector diagrams and their significance. Maxwell's equations, propagation of electrical and magnetic field as a dissipative wave, diffusion equation, propagation constant.

Gravity and Magnetic method: A review of land gravimetry; gravity measurements in sea, reduction of data and interpretation of Bouger anomaly maps; ambiguity in gravity interpretation and conditions for unique interpretation; use of gravity survey in mineral and hydrocarbon exploration programs, search for metallic and nonmetallic ores, coal and lignite; mapping faults, exploring for salt domes, stratigraphic traps, uplifted horst and graben, use of gravity in regional geological studies including granitic plutons, thrust belts, accreted terrains.

Measurement of earth's magnetic field and its gradient from air and sea, instrument mounting and stability of platforms, reduction of data, preparation and interpretation of anomaly maps, Interpretation of aeromagnetic maps.

Remote Sensing and Image Processing: Sources of EMR and governing laws; interaction of EMR with atmosphere and surface of the earth. Atmospheric windows; spectral signature and spectral reflectance, spectral responses of vegetation, water, soil etc. Types of sensors-photographic, single and multi band opto mechanical, thermal sensors, LISS and sensor array: their principle and operations; spectro-radiometers, microwave sensors: SLAR and SAR Systems. Structure of Remote Sensing Images, Data format BIL, BSQ and BIP, type of data products. Image Processing technique as applied to satellite image data. Image restoration, reduction, magnification, contrast enhancement (linear and non linear), histogram equalization, rationing, filtering and edge enhancement.

Well logging: Borehole environment, Logging tools: Basic principles, calibration, environment corrections, computation of reservoir parameters and their simple applications: Resistivity: focused (SFL), micro resistivity devices, conventional induction logging tools. Self potential: electrical analogue of SP, effects of bed thickness, hole diameter, shaliness, irregular invasion on SP response. SP in tight formations, bimetallism and bimagnetism effects on SP. Natural gamma ray: Effects of borehole environment, logging speed, time constant and formation density on log response, corrections for caving and casing etc.; measurement of porosity using neutron sources: CNL SNP; compensated density and sonic tools for porosity measurements.

2.3 Chemistry (Code: CHY)

1. **Structure and bonding:** Atomic structure and periodic properties: Bonding types of bonds Structure of solid, crystal defects, properties dependent on defects, lattice energy.
2. **Quantum Chemistry:** Schrodinger equation of free particle, particle in a box degeneracy, harmonic oscillator, rigid rotor and hydrogen atom. Angular Momentum including spin. Coupling of angular momenta including spin-orbit coupling.
3. **Spectroscopy:** Spectroscopic selection rules for vibrational, electronic vibronic and Raman Spectroscopy. Theoretical treatment of rotational, vibrational & electronic spectroscopy. Principles of Magnetic resonance and photoelectron spectroscopy. Term Symbols and spectroscopic states. Application of mass. UV-VIS. IR and NMR spectroscopy for the structure elucidation of compounds.
4. **Thermodynamics:** First law of thermodynamics, relation between Cp and Cv, enthalpies of physical and chemical changes, temperature dependence of enthalpies. Second law of thermodynamics, entropy, free energy, Gibbs-Helmholtz equation. Third law of thermodynamics and calculation of entropy.
5. **Chemical Equilibrium:** Free energy and entropy of mixing partial molar quantities, Gibbs-Duhem equation, Equilibrium Constant. Temperature dependence of equilibrium constants phase diagram of one and two component system. Free energy and equilibrium constant, phase rule and phase equilibrium.
6. **Solutions:** Ideal and non-ideal solutions. Colligative properties of solutions. Debye-Huckel treatment of dilute electrolyte solutions. Molecular weight determination.
7. **Acid and Bases:** Bronsted and Lewis acids bases. pH and pKa acid concept in non-aqueous media. HSAB concept.
8. **Electrochemistry:** Electrochemical cell reactions. Nernst Equation. Electrode kinetics, electrical double layer, Batteries, primary, secondary and fuel cells. Corrosion and its prevention.
9. **Reaction Kinetics:** First, second and third order reactions, Collision theory of reaction rates. Theory of absolute reaction rates.
10. **Macromolecules:** Number average and weight average molecular weight. Determination of molecular weights. Types of polymerization reactions, Kinetics and mechanism of polymerizations.
11. **Organic Reaction mechanism:** Nucleophilic, Electrophilic, free radical substitution , addition and elimination reactions. Aldol, Perkin, Stobbe, Dieckmann condensations. Hoffmann, Schmidt, Lossen, Curtis, Beckmann and Fries rearrangements. Reimer-Tiemann, Reformatsky and Grignard reactions. Diels-Alder reactions; Claisen rearrangements. Friedel-Crafts reactions: Fittig reaction and Robinson annulations Hydroboration. Oppenaur Oxidation, MPV, Clemmensen and Birch reductions.
12. **Stereochemistry and conformational analysis:** Recognition of symmetry elements and chiral structures. R, S nomenclature, diastereoisomerism in acyclic and cyclic systems E-Z isomers, Conformational analysis of cyclic (chair and boat) and acyclic systems, Interconversion of Fischer, Newman and Sawhorse projections. Asymmetric synthesis. Stereoselective and stereospecefic reactions.
13. **Aromaticity:** Huckel's rules and concept of aromaticity (n) annulenes and hetero annulenes.

14. **Pericyclic reactions:** Selection rules and stereochemistry of electrocyclic reactions, cycloadditions and sigmatropic shifts.
15. **Synthetic methods in Organic Chemistry.**
16. **Photochemistry:** Cis-trans isomerisation, Paterno-Buchi reaction, Norrish type I and II reactions of structure of compounds.
17. **Chemistry of Transition Elements:** Coordination Chemistry of transition metal ions, stabilization of unusual oxidation states, stereochemistry of coordination compounds, Ligand Field theory, Crystal Field Theory and Molecular orbital theory of coordination compounds.
18. **Organometallic Chemistry:** Synthesis, Structure and bonding in organometallic compounds. Organometallic reagents in organic synthesis and in homogeneous catalysis (Hydrogenation, hydroforrmylation, isomerization and polymerizations) P-acid metal complexes, Fluxional molecules, Metallocenes (Synthesis, reactions and structure).
19. **Nuclear Chemistry:** Radioactive decay & equilibrium, Chemical effects of Nuclear transformations, fission & fusion, Radioactive techniques, tracer techniques, neutron activation analysis.
20. **Chemistry of Lanthanides & Actinides:** Electronic configuration, Lanthanide contraction, isolation, application of lanthanide compounds as shift reagents, spectral and magnetic properties.
21. **Chemistry of non-Transition Elements:** Properties of non-transition elements, synthesis, structure and properties of their halides and oxides, polymorphism of Carbon, phosphorous and sulphur, synthesis, structure and properties of boranes, carboranes; borazines, silicates, carbides, silicones, phosphazenes, pseudohalides and nobel gas compounds.

2.4 Computer Science (Code: CSC)

Programming Skill: Programming in C/C++

Discrete Mathematics: Set, Relation, Function, Counting, Generating Functions, Recursion, Logic and Predicate Calculus, Boolean Algebra.

Computer Organization and Architecture: Logic functions, Minimization, Combinational and Sequential Circuit Design, Data Representation, Machine Instructions, Addressing Modes, Arithmetic Processor Design, Control Unit, Arithmetic Algorithms, I/O Organization, Memory Organization.

Data Structures: Basic Data Structures, Arrays, Stacks, Queues and their Applications, Linked Lists, Trees, Graphs -Implementation and Applications, Sorting, Searching, Hashing Techniques.

Algorithm Design: Performance Analysis, Algorithm Paradigms: Divide & Conquer Method, Greedy Approach, Dynamic Programming &Backtracking.

Operating Systems: File Systems, CPU Scheduling, Memory Management, Virtual Memory, Disk Scheduling, Deadlocks, Process Synchronization.

Database: ER-Model, Relational Algebra, Tuple Calculus, SQL, Relational Database Design, Query Languages, Transactions and Concurrency Control.

Compiler Design: Lexical Analysis, Syntax Analysis/Parsing, Intermediate Code Generation, Code Optimization.

Computer Networks and Security: OSI and TCP/IP Architectures, Flow and Error Control, MAC Algorithms, Routing Algorithms, TCP and UDP, Sockets, Application Layer Protocols: SMTP, HTTP, DNS, WWW; Security: Symmetric and Asymmetric-Key Cryptography, Authentication, Hash Functions, SSL / TLS.

Software Engineering: Software Development Life Cycle, Software Requirement Specifications, System Design, Coding, Testing, Software Project Management.

2.5 English (Code: ENG)

a. Basic concepts of general and descriptive linguistics, socio- linguistics, psycholinguistics, psychology of second language learning, the sociology of language in education, literary practices;

b. English phonetics, phonology and morphology, Modern English Grammar and usage, pedagogic grammar, description of contemporary English;

c. English language and literary stylistics, Interpretation of literary tests, teaching English literature, Discourse Analysis;

d. Language use, Register, dialects, Style;

   Principles of language Teaching, History of English Language Teaching, teaching English as a Second/Foreign language, Principles of language teacher education and training, language teaching methodology, principles and practices in language teaching (including materials exploitation), language teaching technology, class room processes, video and computer assisted language learning.

e. Course design and syllabus planning, material development; materials design and production.

f. English for specific purposes, needs analyses, academic discourse and style, subject specific language.

g. Testing and Evaluation: Test of ability in language and literature techniques for testing language skills, principles of language proficiency management and basic concepts in statistics

2.6 Environmental Science (Code: ENS)

Global Environmental issues: Green House Effect, Global Warming, Acid Rain, Brown Clouds

Atmosphere: Composition and profile, Micro-Meteorology, Air pollution and its environmental effects including climate change. Vehicular emissions AND CONTROL, Photochemical Smog, Dispersion of pollutant in air, Air quality standards

Water: Water pollution – Sources & Effects, Water quality standards, Self purification of natural water, Global Hydrological Cycle, Water Treatment Methods - Coagulation & Flocculation, Filtration**,** Softening, Deflouridation, Denitrification, Chlorination

Ecology: Principles of Ecology, Ecosystem function and structure, Ecological fragility, Compensatory afforestation, Hot Spots, Biodiversity. Endangered and Extinct species

Land: Land use patterns, Land use changes due to human and industrial activities, Land use planning and development, Soil characteristics, Soil Erosion

Noise: Sound Pressure Level, Sound Power Level, Noise Standards, Physiological effects and abatement measures,

Geology: Earth's interior, important minerals and rocks, Rock classification

Hydrology: Ground water resources assessment, Aquifers – its types and parameters, Rain water harvesting

Environmental Legislation: Water Act, Air Act, Environmental Protection Act, Forest Conservation Act, Wild Life Protection Act,

Environmental Administration: Environmental Impact Assessment (EIA), Environmental Management Plan, Environmental Auditing,

2.7 Management (Code: MAN)

1. Principles and Practices of Management

Management – Concept and basic features, Functions of Management – Planning, Organising, Staffing Directing & Controlling, Organisation Structure, Basic Theories of Management

2. Research Methodology and Statistics

Scientific Research – Definition, Problems, Types of variables, Measures of Central Tendency and Dispersion, Probability, Sampling and Randomness, Statistics – Purpose, Approach and Method: Binomial Statistic: The normal probability; Correlation & Regression.

3. HRM

Meaning of Industrial Relations, Worker's Participation in Management, Training and Development Motivation, Leadership, Group Dynamics, Conflict, Job Satisfaction,

Organistional Communication, Human Resource Development, Recruitment and Selection, Performance Appraisal.

4. Quantitative Techniques

Role of quantitative techniques in managerial decision making, Optimisation Techniques – Classification and applications, Liner Programming in Features, Modelling, Simplex Method of solution, Queuing theory – Concepts and its role in decision making, MIS
– Concept and general form

5. Operations Management

Concept & Measurement of Productivity, Work Study Techniques and efficiency improvement, Inventory Management – ABC Analysis and EOQ model, Demand Forecasting
– time series analysis Concept of Quality, Application of Quality Control Techniques in Improving Product Quality.

6. Economics

Managerial Economics – Basic Philosophy, Demand and Supply Function – Elasticity of Demand Five – Year Plans of India, Nature and Behaviour of Different types of revenue and Nature and Behaviour of Different types of revenue and costs. Pricing under Monopoly & Oligopoly, Criteria of Economic Development, Foreign Direct Investment, Liberalisation and its effect on Indian Economy. International Monetary Economics: Exchange Rates, Balance of payment.

7. Finance: Concept and Basic Understanding on -

Financial Statement Analysis, Long term & Short term financing, Working capital management Capital budgeting decisions, Capital Markets and Financial Institutions.

8. Marketing Management

Concept of Marketing, Current Trends and Practices, Issues in Consumer Behaviour The marketing Mix, Marketing Research: Methods & Practices, International Marketing.

2.8 Mathematics (Code: MAT)

1. **Complex Variables**: Algebra of complex numbers, Reimann sphere and Stereographic projections, Continuity and differentiability of complex functions, Analytic functions and Cauchy-Reimann equation, Cauchy's theorem, Morera's theorem, Cauchy's integral formula, Taylor's and Laurent's series, Residues and Residue Theorem, Contour
   Integration, Conformal Mapping, Bilinear Transformation, Schwarz-Christofell Transformation.

2. **Real Analysis**: Reimann's integral, improper integrals, convergency and divergency of series, Binary operations, Boolean algebra, Fourier series, Concept of linear algebra, Linear dependence and independence of vectors, basis, quadratic forms, canonical forms, rank of matrix, Eigen values and Eigen vectors.

3. **Vector and Tensor Calculus**: Gradient, Divergence and Curl, Recurrence relations,
   Line, surface and volume integrals, Stokes' and Gauss theorems, Curvilinear coordinates and expressions for vector operations. Notion of Tensors, covariant and contravariant

Tensors, Christofell's symbols and differentiation of tensors.

4. **Differential Equations:** First order ODE, Singular Solution, General theory of homogeneous and non-homogeneous linear ODE, Variation of parameters, Solution of second order ODE in series form, ordinary simultaneous differential equations, Partial differential equations of first order, Lagrange and Charpit's method.

   Classification of PDE, Solution of PDE: Solution of Laplace, Poisson, Heat conduction and Wave equations.

5. **Special functions:** Beta, Gamma and Error functions, Bessel and Legendre functions, Hypergeometric functions, Hermite, Laguerre and Chebyshev Polynomials.

6. **Mechanics:** Generalized coordinates, Lagrange's Equations, Hamilton's Canonical equations, variational principles, Hamilton's principles and principles of least action, Two dimensional equations of rigid bodies, Euler's dynamical equations for the motion of rigid bodies, Motion about an axis.

7. **Numerical Analysis:** Finite difference operators, interpolation and extrapolation, Numerical solution of algebraic and transcendental equations.

   Solution of simultaneous linear equations, matrix inversion, Numerical integration and differentiation. Numerical solution of ordinary differential equations: Initial and Boundary value problems, Numerical solution of Laplace, Heat conduction and Wave equations.

8. **Integral Transforms:** Laplace transform and its inverse transform, convolution theorem, Fourier transform, sine and cosine transforms, inverse Fourier transform, Hankel transform and its inverse transform, Application of all the three transforms in solving ordinary and partial differential equations.

9. **Operation Research:** Linear Programming, simplex method, Assignment problems, Transportation problems, Game theory.

2.9 Philosophy (Code: PLY)

1. Philosophy of Science

Rationale for Study of Philosophy of Science, Science and Philosophy Concepts and nature of Science, Convergence of Science and Philosophy, Philosophical Analysis and Scientific Practice, Philosophers of Science – Western and Eastern, Inter-relationship of Science and Culture, Science and Human Values,

2. Ethics and Applied Ethics

Ethics and Ethos, Morality, Social Values and Individual Attitudes, The Problem of Relativism, Egoism and Altruism, Self Interest, Motivation, and Justification, Acting for Reasons, The History of Ethics, Standards and Principles, Value Judgment, Doing the Right Thing, Kant and Deontology, Existentialism, Emotivism, The Virtues and the Good Life, The Virtue of Community: Justice, Equality, Right and the Social Contract.

Duty and Responsibility of Individual for his Work, Characteristic Attitude of a Group towards the Morality of Work, Work Distribution and Management in Corporate Houses,

Human Rights, Ethics and Environmental, Impact of Modernization, Responsibilities to the Natural World, Bio-centric Ethics and the Value of Life.

3. Classical and Contemporary Indian Philosophy

Nature and Central Concepts of Indian Philosophy, Purusharthas, Vedas, Bhagavat Gita, Nyaya, Vaisesika, Yoga, Purva Mimamsa, Uttara-Mimmamsa, Advaita Vedanta, Buddhism, Jainism, Carvaka, Rabindranath Tagore, Sri Aurobindo, Mahatma Gandhi, Swami Vivekananda, Jiddu Krishnamurthy.

4. Classical and Contemporary Western Philosophy

Plato, Aristotle, St. Anslem, Aquinas, St. Augustine, Descartes, Spinoza, Berkeley, Hume, Kant, Hegel, John Locke, Marx: Theory of Alienation, Nietzsche. The Linguistic Turn, Frege, Russell, Wittgenstein, Ryle, Husserl, Heidegger, Logical Positivism, Pragmatic Theory of Meaning and Truth, Hermeneutics, Frankfort School, Structuralism and Post-Structuralism, Levi-Strauss, Derrida, Faminism, Post-modernism, Cultural Studies, Popper, Kuhn, Lakatos, Artificial Intelligence and Mind-Brain relationship.

5. Philosophical Analysis and Logic

The Principles of Logic, Analytic Truth and Logical Possibility, The A Priori, Concepts, Truth, Sources of knowledge, Meaning and Definition

2.10 Physics (Code: PHY)

1. Classical Mechanics:

Generalized co-ordinates, Lagrange's equations, Hamiltonian equations, variational principle,

Symmetries and conservation laws, central forces, collisions and scattering, Rotating co-ordinate system, Rigid body kinematics and dynamics. Euler equations-symmetrical & Assymetrical top, canonical transformations, Hamilton-Jacobi theory.

2. Special Theory of Relativity:

Frames of reference, Lorentz transformations, Doppler shift, velocity addition, time dilation, Minkowski space – four vectors, Proper time, Energy - momentum four Vector, Mass-energy equivalence, Relativistic force equation, Four tensors – Lorentz covariant & contra-variant equations.

3. Condensed Matter Physics:

Crystal classes and systems, Bonding of common crystals, Crystal structure, Symmetries, reciprocal lattice, X-ray and neutron diffraction, structure factor, point defects and dislocations. Lattice vibrations, specific heat of solids, heat capacity. Free electron theory of metals, Periodic potentials, energy bands in metals, insulators and semiconductors, Tight binding approximation, impurity levels in doped semiconductors, Electronic transport, electrical and thermal conductivity, Hall Effect. Dielectrics – Polarisation mechanisms, Clausius-Mossotti equation, Piezo, Pyro and Ferro-electricity. Dia, Para, Ferro-magnetism, Ferri- and Antiferro magnetism. Superconductivity – Phenomenology, Meissner effect, Type I and Type II super conductors, BCS theory.

4. Nuclear Physics:

General properties of nuclei, size, shape, charge distribution, spin & parity, nature of nuclear forces, nuclear models-liquid drop model, shell model and collective model. Interaction of charged particles and photons with matter, Nuclear detectors – Ionization chamber, Gas proportional counter, GM counter, Scintillation and Semi-conductor detectors. Radioactive

decays – theoretical understanding, Nuclear reactions, nuclear fission and fusion. Classification of fundamental forces and elementary particles, iso-spar strangeness, parity, symmetry and conservation laws, accelerators.

5. Quantum Mechanics:

Wave-particle duality, Heisenberg's uncertainty principle, the Schrodinger wave equation, particle in a box, Harmonic oscillator, potential barrier and tunnelling , Motion in a central potential, Hydrogen atom, commutation relations, symmetries in quantum mechanics, spin, addition of angular momenta,

Pauli's exclusion principle. Time independent perturbation theory, Fermi Golden rule, Approximation methods for bound states, WKB approximation, Time-dependent perturbation theory, scattering theory, Relativistic wave equations, second quantization.

6. Statistical Mechanics:

Phase space, microstates and macrostates, partition function, Free energy connection with thermo dynamical quantities, canonical and grand canonical ensembles, applications, kinetic theory, MB, BE, and FD statistics of ideal gas, Black body radiation and Planck's distribution law, Bose-Einstein's condensation, Einstein – Debye's theory of specific heat.

7. Atomic and Molecular Physics:

Hydrogen atom spectrum, spin-orbit coupling , fine structure, LS & JJ coupling, Zeeman, Paschen-Back and Stark effects, X-rays and Auger transitions, Compton effect, Brief idea of molecular spectra, Rotational and Rotational-Vibrational spectra of simple molecules, Frank-Condon Principle, Raman spectra. Lasers – spontaneous and stimulated emission, population inversion, optical pumping, description of He-Ne, CO_2 and Ruby Lasers.

8. Mathematical Physics:

Vector analysis, Tensor analysis, Linear vector space , Matrix theory, Functions of a complex variable, differential equations , special functions, Fourier integral and transforms, Laplace transforms.

2.11 Statistics (Code: STA)

Random variables and distribution functions, probability mass function, probability density function, joint probability distribution, expectation and moments, independent random variables, marginal and conditional distribution, moment generating function, characteristic function, moment inequalities (Chebyshev, Markov, Jensen). Convergence in probability and in distribution, weak and strong laws of large numbers and central limit theorem for independent, identically distributed random variables with finite variance.

Probability distributions: Bernoulli, binomial, multinomial, hypergeometric, Poisson, geometric and negative binomial distributions, uniform, exponential, Cauchy, beta, gamma, normal and bivariate normal distributions, functions of random variables. Sampling distributions, Chi square, t, and F distributions, standard errors and large sample distributions, distribution of order statistics and range.

Correlation and regression analysis: Product moment correlation, regression lines, multiple and partial correlations, multiple and partial regressions, plane of regression, rank correlation and intra-class correlation.

Estimation: Unbiasedness, consistency, efficiency, sufficiency, minimal sufficiency, completeness, factorization theorem, exponential family of distribution and its properties, uniformly minimum variance unbiased (UMVU) estimation, Rao-Blackwell theorem, Cramer Rao inequality, minimum variance bound estimator and its properties, Estimation by

methods of moments, maximum likelihood, least squares and minimum chi-square, Interval estimation.

Test of hypotheses: Simple and composite hypotheses, two types of errors, critical region, power function, most powerful and uniformly most powerful tests, Neyman-Pearson's lemma, likelihood ratio tests. Tests for mean and variance in normal distribution: one population and two population cases, Tests for correlation and regression coefficients, paired t-test, chi-square test for goodness of fit, contingency tables, large sample tests through normal approximations and test of independence.

Sequential Analysis: Sequential probability ratio test (SPRT), Operating Characteristic function of SPRT and Average Sample Number (ASN).

Non-Parametric tests: Sign test, run test, median test, Mann-Whitency Wilcoxon test.

Finite population sampling: Basic principles of sample surveys, simple random sampling with and without replacement, probability proportional to size sampling, Hurwitz-Thompson estimator, ordered and unordered estimates, stratified random sampling, allocation problems, post-stratification, ratio, regression and product methods of estimation, double sampling, cluster sampling, two-stage sampling and systematic sampling, Non-sampling errors, non-response problems, Warner's randomized response technique for sensitive characteristics, measurement errors in sample surveys.

Design of experiments: Analysis of variance, basic principles of design of experiments, completely randomized design (CRD), randomized block design (RBD) and latin square design (LSD). Estimation of missing observations in RBD and LSD, incomplete block design and balanced incomplete block design (BIBD). Factorial experiments: 2^2, 2^3, 3^2 and 3^2 factorial experiments, Split-plot and simple lattice designs.