3. Geology Paper II	3 hrs	200
4. Hydrogeology	3 hrs	200

Note I: Candidates competing for selection to the posts of Geologist, Geophysicist, Chemist and Junior Hydrogeologist will be required to appear in all the subjects mentioned against respective category above.

Note II: Candidates competing for selection for both the posts of Geologist and Jr. Hydrogeologist will be required to appear in all the subjects mentioned against Categories **1** and 4 above.

Note III : If any candidate failed to appear in any one or more of above papers, meant for written examination for selection to the post of Geologist, Geophysicist, Chemist, their candidature shall stand rejected and part of written examination appeared by him/her shall not be evaluated and counted for any purpose.

3. THE EXAMINATION IN ALL THE SUBJECTS WILL BE OF CONVENTIONAL (ESSAY) TYPE.

4. All Question papers must be answered in English. The Question Papers will be set in English only.

5. The standard and syllabus of the examination will be as shown in the Schedule.

6. Candidates must write the papers in their own hand. In no circumstances they will be allowed the help of scribe to write answers for them. However, blind candidates and the candidates with locomotor disability and cerebral palsy where dominant (writing) extremity is affected to the extent of slowing the performance of function (minimum of 40% impairment) will be allowed to write Combined Geo-Scientist and Geologist Examination with the help of a scribe

Compensatory time of twenty minutes per hour shall be permitted for the Blind candidates and the candidates with locomotor disability and cerebral palsy where dominant (writing extremity is affected to the extent of slowing the performance of function (minimum of 40% impairment) will also be allowed in the Combined Geo-Scientist and Geologist Examination.

7. The Commission have discretion to fix qualifying marks in any or all the subjects of the examination.

8. If a candidate's handwriting is not easily legible, deduction will be made on this account from the total marks otherwise accruing to him/her.

9. Marks will not be allotted for mere superficial knowledge.

10. Credit will be given for orderly, effective and exact expression combined with due economy of words in all subjects of the examination.

11. In the question papers wherever necessary, questions involving the Metric System of Weights and Measures only will be set.

12. Candidates should use only International form of Indian numerals (e.g. 1, 2, 3, 4, 5, 6 etc) while answering question papers.

13. Candidates are permitted to bring and use battery operated pocket calculators for answering papers in this examination. Loaning or inter-changing of calculators in the Examination Hall is not permitted.

Interview/Personality Test : The candidate will be interviewed by a Board of competent and unbiased observers who will have before them a record of his/ her career. The object of the interview is to assess his/her suitability for the posts for which he/she has competed. Special attention will be paid in the Personality Test to assessing the candidate's capacity for leadership, initiative and intellectual curiosity, tact and other social qualities, mental and physical energy, powers of practical application, integrity of character and aptitude for adapting themselves to the field life.

SCHEDULE
STANDARD AND SYLLABUS

A paper in General English is compulsory and common for all the four categories and its standard will be such as may be expected of a science graduate. 3 compulsory papers each on Geology Geophysics, Chemistry and Hydrogeology subjects will be approximately of the M.Sc. degree standard of an Indian University and questions will generally be set to test the candidate's grasp of the fundamentals in each subject.

There will be no practical examination in any of the subjects.

(1) GENERAL ENGLISH : 100 Marks

Candidate will be required to write a short Essay in English. Other questions will be designed to test their understanding of English and workmanlike use of words.

(2) GEOLOGY - PAPER I : 200 Marks

Section A : Geomorphology and Remote Sensing.

Introduction : Development, Scope, Geomorphic concepts, Types and Tools; Landforms: Role of Lithology, peneplaination, endogenous and exogenous forces responsible, climatic and Tectonic factors and rejuvenation of landforms; Denudational processes : Weathering , erosion, transportation, weathering products and soils – profiles, types, duricrusts; Hillslopes : Their characteristics and development, fluvial processes on hillslopes; River and drainage basin: Drainage pattern, network characteristics, Valleys and their development, processes of river erosion, transportation and deposition; Landforms produced by geomorphic agents: Fluvial, Coastal , Glacial and Aeolian landforms; Geomorphic indicators of neotectonic movements : Stream channel morphology changes , drainage modifications, fault reactivation, Uplift – subsidence pattern in coastal areas; Applied Geomorphology : Application in various fields of earth sciences viz. Mineral prospecting, Geohydrology, Civil Engineering and Environmental studies; Geomorphology of India: Geomorphical features and zones

Electromagnetic radiation – characteristics, remote sensing regions and bands; General orbital and sensor characteristics of remote sensing satellites; Spectra of common natural objects – soil, rock, water and vegetation. Aerial photos – types, scale, resolution, properties of aerial photos, stereoscopic parallax, relief displacement; Principles of photogrammetry; Digital image processing - characteristics of remote sensing data, preprocessing, enhancements, classification; Elements of photo and imagery pattern and interpretation, application in Geology; Remote sensing applications in interpreting structure and tectonics, Lithological mapping, mineral resources, natural hazards and disaster mitigation, groundwater potentials and environmental monitoring. Landsat, Skylab, Seasat and other foreign systems of satellites and their interpretation for geological and other studies; Space research in India – Bhaskara and IRS systems and their applications, Thermal IR remote sensing and its applications, Microwave remote sensing and its applications. Principles and components of Geographic Information System (GIS), remote sensing data integration with GIS, applications of GIS in various geological studies.

Section B: Structural Geology

Principle of geological mapping and map reading, projection diagrams. Stress-strain relationships for elastic, plastic and viscous materials. Measurement of strain in deformed rocks. Behaviour of minerals and rocks under deformation conditions. Structural analysis of folds, cleavages, lineations, joints and faults. Superposed deformation. Mechanism of folding, faulting and progressive deformation. Shear Zones: Brittle and ductile shear zones, geometry and products of shear zones; Mylonites and cataclasites, their origin and significance.Time relationship between crystallization and deformation. Unconformities and basement-cover relations. Structural behaviour of igneous plutons, diapirs and salt domes. Introduction to petrofabric analysis.

Section C: Geodynamics

Earth and its internal structure. Continental drift – geological and geophysical evidence and objections. An overview of plate tectonics including elementary concepts of plates, lithosphere, asthenosphere, types of plate boundaries and associated important geological features like oceanic trenches, volcanic arcs, accretionary wedges, topography of mid-ocean ridges, magnetic anomaly stripes and transform faults. Gravity anomalies at mid-ocean ridges, deep sea trenches, continental shield areas and mountain chains. Palaeomagnetism and its application for determining palaeoposition of continents. Isostasy, Orogeny and Epeirogeny. Seismic belts of the earth. Seismiciy at plate boundaries. Principles of Geodesy, Global Positioning System (GPS) and its application in crustal motion monitoring including neotectonics. Palaeoposition of India and Geodynamics of the Indian plate.

Section D: Stratigraphy

Principles of Statigraphy : History and Development of Statigraphy; Stratigraphic procedures (Surface and Subsurface); Concept of Lithofacies and Biofacies; Stratigraphic Correlation (Litho, Bio- and Chronostrarigraphic Correlation); Study of standard stratigraphic code (Lithostratigraphic, Biostratigraphic and Chronostratigraphic); Concepts of Magnetostratigraphy, Chemostratigraphy, Event stratigraphy, and Sequence stratigraphy; Nomenclature and the modern stratigraphic code. Radioisotopes and measuring geological time. Geological time-scale. Stratigraphic procedures of correlation of unfossiliferous rocks. Precambrian stratigraphy of India : Achaean stratigraphy - tectonic frame-work, geological history and evolution of Dharwar, and their equivalents; Easterghats mobile belt; Proterozoic stratigraphy -tectonic framework, geological history and evolution of Cuddapahs and their equivalents. *Palaeozoic stratigraphy*: Palaeozoic formations of India with special reference to type localities, history of sedimentation, fossil content. *Mesozoic stratigraphy:* Mesozoic

formations of India with special reference to type localities, history of sedimentation, fossil content. *Cenozoic stratigraphy:* Cenozoic formations of India, Rise of the Himalayas and evolution of Siwalik basin. *Stratigraphic boundaries:* Stratigraphic boundary problems in Indian geology. Gondwana Supergroup and Gondwanaland. Deccan Volcanics. Quaternary stratigraphy. Rocks record, palaeoclimates and palaeogeography.

Section E : Palaeontology

Evolution of the fossil record and the geological time scale. Basic and functional morphology of major fossil groups. Species concept; Major evolutionary theories ; Techniques in Palaeontology mega fossils- microfossils – nannofossils , ichnofossils – collection, identification and illustration – binomial Nomenclature; Invertebrate Palaeontology – A brief study of morphology, classification, evolutionary trends and distribution of Bivalves, cephalopoda and Gastropods, Echinoids, Corals and Brachiopods. Vertebrate Palaeontology – Brief study of vertebrate life through ages. Evolution of reptiles and mammals; Siwalik vertebrate fauna; Biodiversity and mass extinction events; evidence of life in Precambrian times; Palaeontological perspective : Use of palaeontological data in a) Stratigraphy b) Palaeoecology and evolution; Introduction to Micropalaeontology; Types of Microfossils; Plant fossils: Gondwana flora and their significance. Different microfossil groups and their distribution in India; Application of palynology. Basic idea about statistical application in palaeontology. Fundamentals of isotopic studies of fossils.

GEOLOGY – PAPER II : 200 Marks

Section A : Mineralogy and Geochemistry & Isotope Geology

External symmetry of crystals: Symmetry Elements, methods of projection, derivation of 32 classes, Hermaun Muguin notation. *Internal symmetry of crystals:* Derivation of 230 space groups, diffraction of crystals by X-rays, Braggs' law. *Principles of optical mineralogy* : Optical mineralogy, polarized light, behaviour of isotropic and anisotropic minerals in polarized light, refractive index, double refraction, birefringence, sign of elongation, interference figures, 2V, dispersion in minerals. Optic sign, pleochroic scheme and determination of fast and slow vibrations and accessory plates. *Introduction to mineralogy:* Definition and classification of minerals. Structural and chemical principles of crystals / minerals, chemical bonds, ionic radii, coordination number (CN) and polyhedron. *Structure, chemistry, physical and optical characters and paragenesis of mineral groups:* Olivine, pyroxene, amphibole, mica and spinel groups; Feldspar, quartz, feldspathoid, aluminum silicate, epidote and garnet groups. *Accessory minerals:* Apatite, calcite, corundum, scapolite, sphene and zircon. *Earth mineralogy:* Average mineralogical composition of crust and mantle, mineral transformations in the mantle with depth.

Earth in relation to the solar system and universe, cosmic abundance of elements. Composition of the planets and meteorites. Structure and composition of earth and distribution of elements. Trace elements and REE and their importance in fractional crystallization during magmatic / partial melting. Elementary crystal chemistry and thermodynamics. Introduction to isotope geochemistry. Geochronology and age of the Earth: Law of Radioactivity; Principles of isotopic dating, Decay schemes and Derivation of equation of age. Rb/Sr, U- Th –Pb methods of dating the rocks. Age of the Earth. Geochemistry and principles of evolution of hydrosphere, biosphere and atmosphere. Geochemical cycle and principles of geochemical prospecting.

Section B : Igneous Petrology

Origin of magmas: Mantle, onset of partial melting of mantle, processes of partial melting in mantle, mantle-magmas in relation to degree and depth-level of partial melting. *Phase equilibrium in igneous systems:* Binary and ternary systems. *Bowen's reaction principle:* Reaction series and its application to petrogenesis. *Magmatic evolution and differentiation:* Fractional crystallization, gravitational differentiation, gas streaming, liquid immiscibility and assimilation. *Structures and textures:* Definition, description, rock examples and genetic implications of common structures and textures of igneous rocks*. Classification of igneous rocks:* Mode, CIPW norm, IUGS and other standard classifications; *Magmatism and tectonics:* Inter-relationship between tectonic settings and igneous rock suites. *Igneous rock suites:* Form, structure, texture, modal mineralogy, petrogenesis and distribution of *Ultramafic rocks:* Dunite-peridotite-pyroxenite suite; kimberlites, lamprophyres, lamproites, komatiites; *Basic rocks:* Gabbro-norite-anorthosite-troctolite suite, Dolerites; Basalts and related rocks; *Intermediate rocks:* Diorite-monzonite-syenite suite; Andesites and related rocks; *Acidic rocks:* Granite-syenite-granodiorite-tonalite suite; Rhyolites and related rocks; *Alkaline rocks:* Shonkinite, ijolite, urtite, melteigite, malignite, alkali gabbros, alkali basalt, alkali granite, alkali syenite, nepheline syenite and phonolite; *Carbonatites; Ophiolite suite*.

Petrogenetic provinces : Continental areas: Volcanic-Flood basalts-Tholeiites (Deccan Trap, Columbia River basalts); Layered gabbroic intrusions: The Bushveld complex, Skaergaard intrusion, Still water complex. Plutonic: Carbonatites and alkaline rock complexes of India; Oceanic Rift valleys: MORB-Tholeiites-Ophiolites

Section C : Metamorphic Petrology & Processes

Concepts and Theory: Types of Metamorphism and their controlling factors; Common minerals of metamorphic rocks; Field observations, petrographic classification of common metamorphic rocks; Metamorphic facies and facies series. Effects of Metamorphism : Phase diagrams and graphic representation of mineral assemblages; Prograde and retrograde metamorphism, Matasomatism; Deformation textures and textures related to recrystallization; Metamorphic reactions, elemental exchange and Pressure – Temperature conditions of Isograds; Mineral assemblages equilibrium reaction textures and geo-thermo barometry. Experimental and thermodynamic appraisal of metamorphic reactions; Role of fluids in metamorphic reactions. Metamorphism types and products: Regional and thermal metamorphism of pelitic rocks. Regional and thermal metamorphism of basic and ultrabasic rocks; Regional and thermal metamorphism of impure, silicious carbonate rocks; Metamorphism of Granitoides, Charnockites and Migmatites. Metamorphism in space and time: Plate tectonics and metamorphic processes; Paired metamorphic belts, Archaean and Proterozoic terrains; Extraterrestrial Metamorphism (Impact and Shock Metamorphism); polymetamorphism

Section D : Sedimentology

(3) Provenance and diagenesis of sediments. Sedimentary textures. Framework, matrix and cement of terrigenous sediments. Definition, measurement and interpretation of grain size. Elements of hydraulics. Primary structures, palaeocurrent analysis. Biogenic and chemical sedimentary structures. Sedimentary environment and facies. Facies modeling for marine, non-marine and mixed sediments. Tectonics and sedimentation. Classification and definition of sedimentary basins. Sedimentary basins of India. Cyclic sediments. Seismic and sequence stratigraphy. Purpose and scope of basin analysis. Stratum contours and isopach maps.

Section E : Environmental Geology and Natural Hazards

Fundamental concepts of Environmental Geology - it's scope, objectives, and aims. Earth's thermal environment and Climates. Global warming. Green house effect. Ozone depletion–Ice sheets and fluctuation in sea levels. Concepts of ecosystem. Earth's major ecosystems terrestrial and aquatic. Meteorology as environmental science. Air Pollution, sources of pollution, pollution due to dust and waste disposal. National and International standards. Environmental health hazards. Mining, opencast, underground, disposal of industrial and radio-active waste, dumping stacking, rehandling, management, mineral processing, tailing ponds, acid mine drainage, siltation, case studies. Mining below water table, mine water discharges, regional effects on water regime. Noise levels- national standards, mining machinery, ill effects. Air sampling techniques – respirable dust samplers, high volume air samplers, personal sampling pumps, weather monitoring equipments, automatic recorders. Elements of Environmental Impact Assessment – impacts, primary, secondary, prediction, assessment, base-line data generation, physical, biological, cultural, socioeconomic aspects. Carrying capacity based developmental planning – Assimilative capacity – supportive capacity – Resource based planning – Institutional strategies. Sustainable Developmental Planning - Applications of GIS in Environmental Management.Environmental Legislations in India.

Concepts and principles: Natural hazards – preventive/ precautionary measures – floods, landslides, earthquakes, river and coastal erosion. Distribution, magnitude and intensity of earthquakes. Neotectonics and seismic hazard assessment. preparation of seismic hazard maps. Impact of seismic hazards on long and short term environmental conditions. Mechanism of landslides, causes of major floods, cyclones and storms. Deforestation and land degradation. Coastal erosion, its causes and control of Geological hazards and crisis management.

GEOLOGY – PAPER III : 200 MARKS

Section A: Indian mineral deposits and mineral economics

Occurrence and distribution in India of metalliferous deposits - base metals, iron, manganese, aluminium, chromium, nickel, gold, silver, molybdenum. Indian deposits of non-metals – Diamond, mica, asbestos, barytes, gypsum, graphite, apatite and beryl. Gemstones, refractory minerals, abrasives and minerals used in glass, fertilizer, paint, ceramic and cement industries. Building stones. Phosphorite deposits. Placer deposits, rare earth minerals. Strategic, critical and essential minerals. India's status in mineral production vis a vis world scenario, Changing patterns of mineral

consumption. UNFC classification, National Mineral Policy. Mineral Concession Rules. Marine mineral resources and Laws of Sea.

Section B: Ore genesis and Geophysics

Ore deposits and ore minerals. Magmatic processes of mineralization. Porphyry, skarn and hydrothermal mineralization. Fluid inclusion studies. Mineralisation associated with – (i) ultramafic, mafic and acidic rocks (ii) greenstone belts (iii) komatiites, anorthosites and kimberlites and (iv) submarine volcanism. Magma related mineralization through geological time. Stratiform and stratabound ores. Ores and metamorphism – cause and effect relations. Metallogeny and mineral belts.

Interrelationship between geology and geophysics - Role of geological and geophysical data in explaining geodynamical features of the earth. General and Exploration geophysics - Different types of geophysical methods; Gravity, magnetic, Electrical, Seismic - their principles and applications. Geophysical field operations - Different types of surveys, grid and route surveys, profiling and sounding techniques, scales of survey, presentation of geophysical data. Application of Geophysical methods - Regional geophysics, ore geophysics, engineering geophysics. Geophysical anomalies : correction to measured quantities, geophysical, anomaly, regional and residual (local) anomalies, factors controlling anomaly, depth of exploration. Integrated geophysical methods - Ambiguities in geophysical interpretation, Planning and execution of geophysical surveys.

Section C: Mineral exploration

Resource, reserve definitions; mineral resource in industries - historical perspective and present. A brief overview of classification of mineral deposits with respect to processes of formation in relation to exploration strategies. Principles of mineral prospecting and exploration - conceptualization, methodology and stages; sampling, subsurface sampling including pitting, trenching and drilling, core and non-core drilling, planning of bore holes and location of bore holes on ground. Core logging, geochemical exploration- nature of samples anomaly, strength of anomaly and controlling factors, coefficient of aqueous migration. Principles of reverse estimation, density and bulk density, factors affecting reliability of reserve estimation, reserve estimation based on geometrical models (square, rectangular, triangular and polygon blocks) regular and irregular grid patterns, statistics and error estimation. Application of Geophysical techniques, Geomorphological and remote sensing techniques and Geobotanical and geochemical methods. Application of geostatistical techniques in Mineral Exploration.

Section D: Geology of fuels

Coal and its properties: Different varieties and ranks of coal. Origin of coal. Coalification process and its causes. Lithotypes, microlithotypes and macerals: their physical, chemical and optical properties. Maceral analysis of coal: Mineral and organic matter in coal. Petrographical methods and tools of examination. Fundamentals of coal petrology, concept of coal maturity, peat, lignite, bituminous and anthracite coal. Application of coal geology in hydrocarbon exploration. Applications of coal petrography. Proximate and ultimate analyses. Indian coal & lignite deposits. Industrial evaluation of coal characteristics with reference to coal classification. Geology and coal petrography of different coalfields of India. Uses of coal for various industries e.g. carbonization, liquefaction, power generation, gasification and coal-bed methane production.

Origin, migration and entrapment of natural hydrocarbons. Characters of source and reservoir rocks. Structural, stratigraphic and mixed traps. Techniques of exploration. Geographical and geological distributions of onshore and offshore petroliferous basins of India.

Mineralogy and geochemistry of radioactive minerals. Instrumental techniques of detection and measurement of radioactivity. Radioactive methods for prospecting and assaying of mineral deposits. Distribution of radioactive minerals in India. Radioactive methods in petroleum exploration – well logging techniques. Nuclear waste disposal – geological constraints.

Section E : Engineering Geology

Geological studies and evaluation in planning, design and construction of major civil structures. Elementary concepts of rock mechanics and soil mechanics. Site investigation, characterization and problems related to civil engineering projects: geological and geotechnical investigations for dams, reservoirs and spillways, tunnels, underground caverns, bridges, highways, shorelines. Problems of groundwater in engineering projects. Coastal geotechniques. Environmental considerations related to civil engineering projects. Resource evaluation of construction materials. Geological hazards

(landslides and earthquakes), their significance, causes, preparedness and mitigation. Recent trends in geotechnical engineering. Geotechnical case studies of major projects in India.

(2) GEOPHYSICS - PAPER I: 200 Marks

PART-A: 100 Marks

a. Solid Earth Geophysics:

Introduction to Geophysics its branches and relationship with other sciences. Solar system, its origin, characteristics of planetary members, Earth; its rotation and figure. Age of earth & various methods of determination. Tectonics and Geodynamics, Thermal history and its characteristics. Gravity field of earth and Isostasy. Geomagnetism, elements of earth's magnetism: Internal, External fields and their causes, Paleomagnetism, Polar wandering paths, Seafloor spreading, geophysical evidences. Elastic waves, internal structure of earth, variation of physical properties in the interior of earth.

b. Earthquake and Engineering Seismology:

Seismology, earthquakes, focal depth, epicenter, great Indian earthquakes, Intensity and Magnitude scales, Energy of earthquakes, foreshocks, aftershocks, Elastic rebound theory, Fault plane solutions, Seismicity and Seismotectonics of India, Frequency-Magnitude relation (b values), Velocity structure, VpNs studies. Elastic waves, their propagation characteristics. Seismic ray theory for spherically and horizontally stratified earth, basic principles of Seismic Tomography and receiver function analysis, Seismic network and arrays, telemetry systems, Earthquake prediction; dilatancy theory, short-term, middle-term and long- term predictions, Seismic microzonation studies, application for engineering problems, Seismometry, Principle of electromagnetic seismograph, displacement meters, velocity meter, accelerometer, WWSSN stations, Strong motion seismograph, seismic arrays for detection of nuclear explosions, Broadband seismometry.

c. **Mathematical methods in Geophysics**:

Properties of scalars, vectors and tensors, Elements of vector analysis, Gradient, Divergence and Curl, Gauss's divergence theorem, Stokes theorem, Definition of fields, Gravitational field, Newton's Law of gravitation, Gravitation potential and fields due to bodies of different geometric shapes, Electrostatic field, Coulomb's law, Electrical permittivity and dielectric constant, Basic guiding equations, Magneto static field, Origin of Magnetic field, Ampere's law, Biot and Savart's law, Geomagnetic fields, Magnetic fields due to different type of structures, Solution of Laplace equation in Cartesian Coordinate, Cylindrical Polar Coordinate and Spherical Polar Coordinate, Complex Variables in Potential theory, Green's theorem in Potential Theory. Concept of Image in Potential Theory, Analytical continuation in Potential fields, Numerical Methods in Potential Theory. Electrical fields in geophysics, point source, continuous distribution and double layers, equipotential and line of force. Current and potential in the earth, basic concept and equations of electromagnetic, Maxwell's equations, boundary conditions, elliptic polarization, electromagnetic potential and waves, radiation from dipoles, retarded potential, near and far fields, radiation resistance, EM field of a loops of wire on half space, multi-layered media, impedance and its application.

d. Geophysical Inversion:

Fundamental concepts of inverse theory, Basic definition of inversions with application to Geophysics. Probability, Inverses with discrete and continuous models. Forward problems versus Inverse problems. Formulation of inverse problems and their relation to a matrix problem, linear inverse problems, classification of inverse problems, least square solutions and minimum norm solution, concept of norms, concept of 'a priori' information, constrained linear least square inversion, review of matrix theory Introduction to finite difference method, forward, backward and central difference mthod. Application of finite difference method for solving Helmholtz equation. Introduction to finite element method, various steps, simple examples showing application of finite element method. Models and data spaces, householder transformation, data resolution matrix, model resolution matrix, Eigen values and Eigen vectors, singular value decomposition (SVD), generalized inverses, Non-linear inverse problems, Gauss Newton method, steepest descent (gradient) method, Marquardt-Levenberg method, Earthquake location problem, tomography problem. Probabilistic approach of inverse problems, maximum likelihood and stochastic inverse methods, Backus-Gilbert method, Global optimization techniques, genetic algorithm, simulated annealing methods, examples of inverting geophysical data.

PART-B: 100 Marks

a. Mathematical Methods of Physics:

Dimensional analysis, Vector algebra and vector calculus, Linear algebra, matrices, Cayley-Hamilton Theorem. Eigen values and eigenvectors. Linear ordinary differential equations of first & second order, Special functions (Hermite, Besse!, Laguerre and Legendre functions). Fourier series, Fourier and Laplace transforms. Elements of complex analysis, analytic functions; Taylor & Laurent series; poles, residues and evaluation of integrals. Elementary probability theory, random variables, binomial, Poisson and normal distributions. Central limit theorem. Green's function. Partial differential equations (Laplace, wave and heat equations in two and three dimensions). Elements