DEPARTMENT OF GEOLOGY
B.Sc.-M. Sc. INTEGRATED SYLLABUS

Paper	Paper title	Credit	Marks
Semester I			
GEOL-UG-E101	Earth System Science, Petrology and Mineralogy	4	100
GEOL-UG-E102	Physical Sciences I	4	100
GEOL-UG-E103	Physical Sciences II	4	100
Total		**12**	
Semester II			
GEOL-UG-E201	Physical Geology and Sedimentology	4	100
GEOL-UG-E202	Physical Sciences III	4	100
GEOL-UG-E203	Computation I	4	100
Total		**12**	
Semester III			
GEOL-UG-E301	Palaeontology and Stratigraphy	4	100
GEOL-UG-E302	Computation II	4	100
GEOL-UG-E303	Computation III	4	100
Total		**12**	
Semester IV			
GEOL-UG-C401	Igneous and Metamorphic Petrology	4	100
GEOL-UG-C402	Geology of India	4	100
	English	4	100
Total		**12**	
Semester V			
GEOL-UG-C501	Structural and Engineering Geology	4	100
GEOL-UG-C502	Geochemistry and Hydrology	4	100
	Eastern Himalayan Studies	4	100
Total		**12**	
Semester VI			
GEOL-UG-C601	Economic Geology and Coal & Petroleum Geology	4	100
GEOL-UG-C602	Mini Project/Industrial Training	4	100
	Environmental Studies	4	100
Total		**12**	
Semester VII			
GEOL-PG-C101	Mineralogy and Igneous Petrology	4	100
GEOL-PG-C102	Sedimentary Geology & Basin Analysis	4	100
GEOL-PG-C103	Hydrology	4	100
GEOL-PG-C104	Geochemistry	4	100
Total		**16**	
Semester VIII			
GEOL-PG-C201	Structural Geology	4	100
GEOL-PG-C202	Metamorphic Geology	4	100
GEOL-PG-C203	Stratigraphy of India and Palaeontology	4	100
GEOL-PG-O204	Geospatial Analysis and applications	4	100
Total		**16**	
Semester IX			
GEOL-PG-C301	Ore Geology and Mineral Economics	4	100
GEOL-PG-C302	Geology of Fossil Fuels	4	100

GEOL-PG-O303	Environmental Geology and Geo-statistics	4	100
GEOL-PG-S304	Mineral Exploration, Mining and Surveying Techniques	4	100
GEOL-PG-S305	Applied River Science	4	100
GEOL-PG-S306	Isotope Geology	4	100
Total		**16**	
Semester X			
GEOL-PG-S401	Geomechanics	4	100
GEOL-PG-S402	Geodynamics and Tectonic Geomorphology	4	100
GEOL-PG-S403	Geophysics	4	100
GEOL-PG-S404	Cryospheric Science	4	100
GEOL-PG-S405	Micropaleontology	4	100
GEOL-PG-S406	Oceanography	4	100
GEOL-PG-S407	Dissertation	4	100
Total		**16**	

Semester I

GEOL-UG-E101: Earth System Science, Petrology and Mineralogy

Unit I: Concept of Earth System Sciences
Concept of earth system sciences and its branches
Formation of various spheres of earth.
Introduction to various branches of Earth Sciences.
Solar System, Age of the earth, origin of solar system. meteors and meteorites.
Introduction to Geological Time Scale.
Internal structure of Earth. Concept of Plate Tectonics and its elements.
Wilson Cycle, Orogeny, Earthquakes. Volcanoes, Tsunami
Introduction to Hydrology: Hydrologic cycle.
Introduction to Oceanography:

Unit II: Introduction to Mineralogy and Petrology
Definition and classification of Rock and minerals
Formation of Igneous, Sedimentary and Metamorphic rocks and their classification.
Rock Cycle. Common classification of minerals and their basis.
Physical Properties of the minerals.
Classification of major silicates and non silicate minerals:
Silicates: Ortho silicates, Ring & Di silicates, Chain silicates, Sheet silicates and Framework silicates. Nonsilicates: Carbonates, Sulfates, Phosphates, Tungstates, Molybdates, Borates, Oxides, Hydroxides, Halides, Sulfides and Native elements.

Unit III: Fundamentals of Crystallography
Crystallographic axes, axial ratio, 32 crystal classes and classification in seven systems.
Fundamentals of Properties of Light, Polarizing petrographic microscope.
Optical properties of common rock forming silicate minerals.

Unit IV: Practical
Field Based Practical for collection of samples and in-situ study.
Field Based Practical for identification of landforms and Earth processes.
Preparation of Thin and Polished sections of rock samples.
Study of Common Igneous, Sedimentary and Metamorphic Rocks.
Physical properties of common rock-forming and ore-forming minerals in hand specimen.

Study of common rock-forming minerals in thin section.
Study of optical properties of minerals under petrological microscope.
Study of crystal models of different classes.
Determination of Miller indices and zone axis calculations.

Suggested Readings

W. D. Nesse, (2000), Introduction to Mineralogy, Oxford University Press.
Dana's New Mineralogy: The System of Mineralogy of James Dwight Dana and Edward Salisbury Dana by Richard V. Gaines , H. Catherine W. Skinner, Eugene E. Ford, Brian Mason,Abraham Rosenzweig, 1997, 1872 pages. Publisher: Wiley-Interscience; 8 edition, P. F. Kerr Optical Mineralogy, 1959
Nesse W.D., Introduction to Optical mineralogy, 2008
Deer, W. A., Howie, R. A. and Zussman, J., An introduction to the rock forming minerals, ELBS publication,1962-1963.
Rutleys Elements of Mineralogy, 1991, Publisher: Cbs Publishers & Distributors Pages: 482.
Holme's Principles of Physical Geology. 1992. Chapman & Hall.
Emiliani, C, 1992. Planet Earth, Cosmology, Geology and the Evolution of Life and Environment. Cambridge University Press.

Semester II

GEOL-UG-E201: Physical Geology and Sedimentology

Unit I: Introduction to Physical Geology

Nature and scope of geomorphology
Evolution of geomorphological thoughts.
Basic concepts of geomorphology.
Overview of landscape evolution models, weathering and cycle of erosion.
Drainage classification and morphometry.
Geomorphic Processes and associated Landforms: Fluvial, Glacial, Aeolian, Coastal and Karstic landforms.
Structural and lithological controls on landforms.
Overview of Indian geomorphology.

Unit II: Introduction to Sedimentary Process

Sediment Size Classification
Various Classifications of Siliciclastic Sedimentary Rocks.
Sedimentary Processes: Fluid flow, sediment transport and sedimentary structures: Types of fluids, Laminar vs. turbulent flow, Reynolds number, Froude Number, Boundary layer effect, Particle entrainment, transport and deposition, sediment gravity flows.
Bouma's Sequence.

Unit III: Sedimentary Rock Classification and Structure

Introduction to Sedimentary environments and faces
Sedimentary structure: Primary and secondary sedimentary structures.
Biogenic structures Paleocurrent analysis.
Siliciclastic rocks: Conglomerates, sandstones, mudrocks (texture, composition, classification, origin and occurrence).
Nonsiliciclastic rocks: Carbonate rocks, controls of carbonate deposition, components and classification of limestone, dolomite and dolomitisation, carbonate sedimentary environments. Chert and siliceous sediments, phosphorites, carbonaceous sediments, iron rich sediments and evaporites.
Digenetic processes and its effects on silicilastic and carbonate rocks.

Unit IV: Practical
Field Based Practical for collection of samples/data and in-situ study.
Identification of various sedimentary rocks and their features.
Petrographic study of clastic and non-clastic rocks in thin sections.
Identification of sedimentary structures by diagrams and samples.
Particle size distribution and statistical treatment and paleocurrent analysis.

Suggested Readings
Bloom, A.L. 1998. Geomorphology: A systematic Analysis of Late Cenozoic Landforms (3rd Edition), Pearson Education, Inc.
Singh, S. 1998. Geomorphology. Prayag Pustak Bhavan, Allahabad.
Kale, VS. and Gupta, A. 2001. Introduction to Geomorphology. Orient Longman Ltd.
Easterbrook, D.J. 1992. Surface processes and landforms. McMillan Publ.
Prothoreo and Schwab, 2004, Sedimentary Geology, Freeman and Co. New York,
Sam Boggs, 1995, Principles of Sedimentology and Stratigraphy, Printice Hall, New Jersey, Maurice E. Tucker, 2006, Sedimentary Petrology, Blackwell Publishing.
Collinson, J.D. and Thompson, D.B. 1988, Sedimentary structures, Unwin-Hyman, London,
Lindholm, R.C., 1987, A practical approach to sedimenmtology, Allen and Unwin, London
Pettijohn, F.J. 1975, Sedimentary rocks, Harper and Row Publ. New Delhi

Semester III

GEOL-UG-E301: Palaeontology and Stratigraphy

Unit I: Introduction to Palaeontology
Introduction to fossils
Fossilization processes (taphonomy), and modes of preservation.
Basic Concepts of organic evolution and Species concept.
Methods of description and naming of fossils, code of systematic nomenclature.
Application of Fossils in the study of Palaeoecology, Palaeobiogeography and Palaeoclimate.
Palaeobotany: Early plant life, colonization of land, important stages in plant evolution.
Role of plant fossils in palaeoclimatic reconstructions.
Significance of Gondwana flora. Introduction to palynology.

Unit II: Invertebrate and Invertebrate Palaeontology
Invertebrate Palaeontology
Brief introduction to various invertebrate groups. Significance of Mollusca, trilobites, brachiopods graptolites, foraminifera and ammonoids. Classification of trace fossils
Vertebrate Palaeontology: Evolution and Classification of vertebrates.
Major steps in vertebrate evolution.
Origin, evolution and extinction of dinosaurs.
Evolution of primates with special reference to human evolution.

Unit III: Introduction to Stratigraphy
Stratigraphic principles and correlation
Unconformities and principle of cross-cutting Relationship. Facies concept.
Evolution of Geological Time Scale.
Significant events in geological time.
Introduction to lithostratigraphy, biostratigraphy and chronostratigraphy, magnetostratigraphy and chemostratigraphy.

Seismic stratigraphy, sequence stratigraphy and its application in hydrocarbon exploration.
Intoduction to Quaternary Geology and its applications.
Pleistocene Glacial-Interglacial cycles.

Unit IV: Practical
Field Based Practical for collection of samples/data and in-situ study.
Study of fossils showing various modes of fossilization.
Study of diagnostic morphological characters, systematic position, stratigraphic position and age of various invertebrate, vertebrate and plant fossils

Suggested Readings
Clarkson, E.N.K.1998. Invertebrate Palaeontology and Evolution, George Allen & Unwin.
Raup, D.M. and Stanley, S. M. 1971. Principles of Palaeontology, W.H. Freeman and Company.
Benton, M. 1997. Basic Palaeontology: An introductory text, D. Harker, Addision Wisely Longman.
Prothero, D.R. 1998. Bringing fossils to life – An introduction to Palaeobiology, McGraw Hill.
Benton, M.J. 2005. Vertebrate palaeontology (3rd edition). Blackwell Scientific, Oxford.
Brenchley, P. J., and Harper, D. A. T. 1998. Palaeoecology: Ecosystems, Environments and Evolution. By Chapman and Hall.
Schoch, R. M. 1989. Stratigraphy, principles and methods. Van Nostrand Reinhold.
Roy R. Lemon. 1990 Principles of Stratigraphy, 512 pages, Publisher: Longman Higher Education.
Condie. K.C., & Sloan, R. 1998, Origin and Evolution of Earth: Principles of Historical Geology. Prentice Hall; 1st edition 498 pages.
Weller, J. Marvin 1960. Stratigraphic principles and practice. Harper's Geoscience series.

Semester IV

GEOL-UG-C401: Igneous and Metamorphic Petrology

Unit I: Introduction to Earth's Interior
Earth’s interior structure
Physical properties of magmas.
Volcanoes and types of volcanoes. Pyroclastic deposits.
Concept of intrusion and extrusion.
Forms and types of igneous bodies:- extrusive bodies-Flood basalts.
Intrusive bodies:- concept of concordant and discordant intrusion, Dikes and sills and types of dikes, breccia pipes, laccoliths, lopoliths, stocks and batholiths.

Unit II: Introduction to Metamorphic Petrology
Definition of metamorphism
Factors controlling metamorphism.
Concept of metamorphic facies and grade.
Metamorphic zones and isograds.
Metamorphic facies series and paired metamorphic belts. Mineralogical phase rule of closed and open system.
Metamorphic mineral reactions (prograde and retrograde).
Relationship between metamorphism and deformation.
Types of metamorphism. Types of protoliths Classification of metamorphic rocks.
Textures, structures and mineralogy of metamorphic rocks.

Unit III: Introduction to Igneous Petrology
Bowen's Reaction Series
Melting and crystallization.
Classification of igneous rocks.
Textures, structures and mineralogy of important igneous suites.

Unit IV: Practical
Field Based Practical for collection of samples/data and in-situ study.
Study of igneous and metamorphic rocks in hand specimens and thin sections.
Plotting of modal analysis data of igneous rocks.
Calculation of CIPW norm for important igneous rocks.
Exercises in graphic plots for petrochemistry and interpretation of paragenetic diagrams.

Suggested Readings
John D. Winter 2001. An Introduction to Igneous and Metamorphic Petrology. Prentice Hall
Loren A. Raymond 2002. Petrology: The study of Igneous, Sedimentary and Metamorphic rocks. Mc Graw Hill .New York
Cox, K.G. Bel, J.D. and Pankthrust, R.J. 2002. The interpretation of Igneous rocks. Allen and Unwin, London
Pankthrust, 2000. Igneous and Metamorphic rocks. Prentice Hall.
Phillpots, A.R., and Ague, S.J., 2009. Principles of igneous and metamorphic petrology (2nd Edn.) Cambridge.
Gill, Robin, Igneous rocks and processes-A practical guide. Wiley-Blackwell
Wilson, M. Igneous Petrogenesis, Wiley-Blackwell.
Yardley, B W D. 1990. An introduction to metamorphic petrology. ELBS publication.
Bucher K. and Martin F. 2002. Petrogenesis of Metamorphic rocks. Springer-Verlag Publication.
Best, M.G. 2002. Igneous and metamorphic petrology. Wiley publication.
Vernon R. H. and Clarke G. L. 2008. Principles of metamorphic Petrology. Cambridge publication.

GEOL-UG-C402: Geology of India

Unit I: Geology of Indian Peninsula
Physiographic and tectonic subdivisions of India.
Tectonic evolution of cratons and mobile belts in peninsular India.
Introduction to important Hadean, Archaean, Proterozoic, Palaeozoic, Mesozoic and Cenozoic Successions of Indian Peninsula.
Quaternary stratigraphy of India.
Concept of Gondwana and its significance.
Volcanic provinces of India.
Stratigraphic boundary problems with special reference to Precambrian / Cambrian boundary, P / T and K / T boundaries in India.
Petroliferous basins of India.

Unit II: Geology of Himalayas
Physiographic and lithotectonic subdivisions of the Himalaya.
Major thrusts and their boundaries.
India & Asia collision.
Lithological characteristics of subdivisions of the Himalaya.
Sedimentation and evolution of Himalayan foreland and intracratonic basins
Palaeozoic, Mesozoic and Cenozoic succession of the Himalayas.
Stratigraphy of the Siwalik Group.

Introduction to Geology of Eastern Himalaya.
Stratigraphy of the Sikkim – Darjeeling Himalaya.
Inverted metamorphic Sequence.
Quaternary geology and Neotectonics of Eastern Himalaya.

Units III & IV: Introduction to geological mapping techniques
Field training to acquaint the students with geological characteristics of type outcrops of important geological formations of Indian peninsula and Himalayas.

Suggested Readings:
Krishnan, M.S. 1982. Geology of India and Burma, CBS Publishers, Delhi
Pascoe, E.H. 1968. A manual of the Geology of India and Burma (Vol.I-IV), Govt. of India Press, Delhi.
Doyle, P. & Bennett, M.R. 1996. Unlocking the Stratigraphic Record. John Wiley
Ramakrishnan, M. & Vaidyanadhan, R. 2008. Geology of India Volumes 1 & 2, geological society of India, Bangalore.
Valdiya, K.S. 2010. The making of India, Macmillan India Pvt. Ltd.
Naqvi S.M. 2007: Geology and evolution of Indian Plate
Bigg, G., 1999 Ocean and Climate. Springer-Verlag
Bradley, F., 2000. Paleoclimatology: Reconstructing Climates of the Quaternary. Springer-Verlag
Maher and Thompson, 2000. Quaternary Climates, Environments and Magnetism. Cambridge University Press.
Williams, Durnkerley, Decker, Kershaw and Chhappell, 1998. Quaternary Environments. Wiley and Sons.

Semester V

GEOL-UG-C501: Structural Geology and Engineering Geology

Unit I: Concept of Rock Deformation
Stress and Strain in rocks.
Strain ellipses of different types and their geological significance.
Importance of top-bottom criteria in structural geology.
Geometric and genetic classification of
i. Folds, ii. Boudins iii. Fractures iv. Faults, v. Joints, vi. Shear zones, vii. Cataclastic and Ductile deformation products.

Unit II: Mechanics of Folding and Faulting
Mechanics of folding
Buckling, Bending, Flexural slip and flow folding etc.
Origin of foliations: axial plane cleavage. Origin of lineation.
Mechanics of Faulting, Mohr Circle of failure.
Effects of topography on structural features.
Rule of V. Effects of deformation on topography.
Stereographic projections and their use in structural analysis.

Unit III: Introduction to Engineering Geology
Role of engineering geology in planning, design and construction of engineering structures
Geomechanical classification of rock mass (RMR, RQD, SMR).
Engineering classification of Soils.
Geotechnical components and classification of dams, reservoirs, spillways, tunnels, underground caverns, bridges, highways and shorelines.

Geological structures and discontinuities, engineering properties of rocks, engineering properties of jointed rocks.
Classification of construction materials and aggregates.
Geological hazards (landslides and earthquakes) their significance, causes and preventive/remedial measures.
Seismic zones of India, soil liquefaction.

Unit IV: Practical
Field Based Practical for collection of samples/data and in-situ study.
Drawing profile sections and interpretation of geological maps of different complexities. Study of 3D models of various geological structures.
Exercises of stereographic projections of mesoscopic structural data (planar, linear, folded etc.).
Solving problems related to stress and strain measurements.
Preparation and study of geological sections for feasibility and selection of sites for dams, tunnels, bridges, highways and similar civil structures.
Use of softwares for solving various geotechnical problems (Slope Stability etc).
Evaluation of mechanical properties of concrete aggregates.
Index Tests for soil, rocks and debris.
Evaluation of Atterberg limits and shear strength parameters.

Suggested Readings
Price, N.J, & Cosgrove, J.W.: Analysis of Geological Structures. 1990. Cambridge University Press.
R.G. Park: Fundamentals of Structural Geology.
Davis, GR. 1984. Structural Geology of Rocks and Region. John Wiley
Weijermars, R. 1997. Structural Geology and Map Interpretation, Alboran Science Publishing.
Billings, M.P. 1987. Structural Geology, 4th edition, Prentice-Hall.
Hatcher, Jr., R.D. 1995. Structural Geology - Principles, Concepts and Problems, Merrill Publishing Company.
Ghosh, SK. 1993. Structural geology: fundamentals and modern developments, Pergamon Press, London
Krynin, D.P. and Judd W.R. 1957. Principles of Engineering Geology and Geotechnique, McGrawHill (CBS Publ).
Johnson, R.B. and DeGraf, J.V. 1988. Principles of Engineering Geology, John Wiley & Sons, N.Y.
Goodman, R.E., 1993. Engineering Geology: Rock in Engineering constructions. Jonh Wiley & Sons, N.Y.
Waltham, T., 2009. Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.

GEOL-UG-C502: Geochemistry and Hydrology

Unit I: Introduction to Geochemistry
Stellar evolution and origin of elements
Different processes of nucleosynthesis.
Abundances of elements and Oddo-Harkin's Law,
Meteorites, Chondrites and chondritic ratios.
Geochemical Distribution of elements in solar system.
Geochemical classification of elements.
Geochemical Structure of Earth
Geochemical Properties of elements (volatiles, semi-volatiles, alkalis, alkaline earths, REE, HFS, Transition metals and noble metals).

Trace elements: Raoult's and Henry's Law.
Introduction to Radioactive and Stable Isotopes and applications.

Unit II: Hydrology
Hydrologic cycle
Vertical distribution of subsurface water.
Groundwater - Aquifer properties.
Geological classification of aquifers
Darcy's law and its validity, free and confined aquifers, phreatic and piezometric level, analysis of piezometric surface, groundwater level fluctuations.
Aquifer's hydraulic parameters. Springs.
Groundwater occurrence in igneous, metamorphic and sedimentary rocks.
Physical and chemical properties of water.
Effect of geological environment on groundwater quality.
Surface and subsurface water interaction,
Sea water intrusion in coastal aquifers.
Groundwater provinces of India.

Unit III: Ground Water Geochemistry and Exploration
Molarity and molality
Solubility product and solubility
Acids and bases, dissociation constant, pH, hydrolysis, ionic concentration.
CO2-H2O interaction to form carbonic acid, dissolution of calcite, weathering reactions.
Ground water quality and contamination.
Introduction to surface and subsurface exploration of groundwater.
Drilling and construction of wells.

Unit IV: Practical
Field based practical for sample/Data collection and in-situ study.
Determination of morphometric parameters of watersheds.
Graphical representation of chemical quality data and water classification (C-S and Trilinear diagrams).
Numerical problems based on Darcy's Law
Preparation and interpretation of water table contour maps and depth to water level contour maps.
Water potential zones of India (map study) including saline water zones.
Plotting of Geochemical analyses on various geochemical discrimination plots.
Calculation of Half life and age of the samples by Isochron and Model age method.
Plotting of Normalised Trace element and Rare earth element plots.
Demonstration of Geochemical analytical methods.

Suggested Readings:
Walther John, V., 2009. Essentials of geochemistry, student edition. Jones and Bartlett Publishers.
Mason, B (1986). Principles of Geochemistry. 3rd Edition, Wiley New York.
Hugh Rollinson (2007) Using geochemical data – evaluation, presentation and interpretation. 2nd Edition. Publisher Longman Scientific & Technical.
Todd, D.K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.
Davis, S.N. and De Weist, R.J.M. 1966. Hydrogeology, John Wiley & Sons Inc., N.Y.
Karanth K.R., 1987, Groundwater: Assessment, Development and management, Tata McGraw-Hill Pub. Co. Ltd.
Fetter, C.W. 2001. Applied Hydrogeology, Prentice Hall Inc., N.J.

Semester VI

GEOL-UG-C601: Economic Geology, Coal and Petroleum Geology

Unit I: Economic Geology

Definition of Ore and gangue, tenor and grade, ore bodies and lodes.
Resources and reserves. Classification of economic deposits.
Introduction to processes of formation and enrichment of economic deposits.
Metallogeny and Plate tectonics.
Distribution of economic deposits in India.
Metallic ores: Native metals, oxides of Fe, Mn, Cr, W and sulphides of Cu, Pb, Zn, metallogenic provinces and epochs.
Atomic minerals.
Nonmetallic and industrial rocks and minerals, their nature and distribution in space and time in India: Refractory, chemical, fertilizer, cement, chemical and gemstone industry including building stones.

Unit II: Coal Geology

Coal Classification and ranks of coal.
Coalification process and its causes;
Lithotypes, microlithotypes and macerals: their physical, chemical and optical properties.
Mineral and organic matter in coal.
Proximate and ultimate analyses.
Introduction to geology of different Tertiary and Gondwana coalfields of India.
Uses of coal for various industries e.g. carbonization, liquefaction, power generation, gasification and coal-bed methane production.

Unit III: Petroleum Geology

Origin of petroleum, Maturation of kerogen.
Classification of Crude oil.
Reservoir rocks: general attributes
Classification of reservoir rocks - fragmental reservoir rocks and chemical reservoir rocks; Migration of oil and gas: primary and secondary migration; geologic factors controlling hydrocarbon migration.
Classification of hydrocarbon traps - structural, stratigraphic and combination.
Cap rocks - definition and general properties.
Formation water characteristics.
Plate tectonics and global distribution of hydrocarbon reserves.
Introduction to petroleum geology of Assam, Bengal, Cauvery, Krishna-Godavari, Cambay and Bombay offshore basins.

Unit IV: Practical

Field based practical for sample/Data collection and in-situ study.
Megascopic identification of different varieties of coal.
Interpretation of geologic structures from surface geological maps and bore hole data;
Construction of Panel and Fence diagram.
Preparation of structure contour and isopach maps of reservoir facies and drawing oil/water contact from bore hole data.
Problems on porosity and permeability
Calculation of oil reserves in defined structure.
Study of physical properties of ore forming minerals.
Study of optical properties of common ore forming minerals.

Study of association of ore forming and typical gangue minerals.
Preparation of maps showing distribution of important ores and other economic minerals in India.

Suggested Readings:

Evans, A.M. 1993. Ore Geology and Industrial Minerals. Blackwell ScLPubl.Guilbert, J.M. and Park Jr., C.F. 1986. The Geology of Ore deposits. Freeman & Co.
Bateman, A.M. and Jensen, M.L. 1990. Economic Mineral Deposits. John Wiley. Gokhale, K.V.G.K. and Rao, T.C. 1978. Ore deposits of India their distribution and processing, Tata-McGraw Hill, New Delhi.
Deb, S. 1980. Industrial minerals and rocks of India. Allied Publishers
Mukherjee Ashok Coal Geology: Larry Thomas, 2002, Wiley and Sons.
Coal: it's composition, analysis, utilisation and valuation: E.E. Somermier 2008, Mc GrawHill
Petroleum Geology: F.K.North, 1986, Allen and Unwin
Petroleum Formation and Occurrence: B.P.Tissot and D.H.Welte 1978, Publisher: Springer-Verlag
Elements of petroleum Geology: R.C. Shelley 1998, Academic press
Petroleum Development Geology: P.A. Dickie, 1986, Publisher: Pennwell Publishing, Tulsa, Oklahoma
Petroliferous basins of India: Publisher: KDMIPE, ONGC, 1986.

GEOL-UG-C602: Mini Project/Industrial Training

For Mini Project the student may carry out a study of geological interest (petrology, landslides, hydrological, environmental problems etc) in consultation with the course supervisor and submit a project report and make presentations.
For industrial training the student may undergo a short training at DST & CSIR labs or in organizations such GSI, NHPC, CGWB etc and submit a report and make presentations.

Semester VII

GEOL-PG-C101: Mineralogy and Igneous Petrology

Unit I: Mineralogy

Types of bonding in minerals
Chemical composition and unit cell content.
Isomorphism. Solid solution and different types of polymorphic transformations.
Silicate structure. 2 component diagrams. Solid Solution.
Development of intergrowths, zoning and twinning.
Structure, P-T stabilities, paragenesis and mode of occurrence of silicates, oxides, carbonates, phosphates, sulphides and halides.
Mineral Optics: Behavior of light in isotropic, uniaxial and biaxial crystals.
Interference figures. Universal stage.
Introduction to spectroscopic study of minerals. Application of X-ray Diffraction, EPMA and SEM-EDX. Calculation of mineral formula from chemical analysis.

Unit II: Igneous Processes

Crystallization of magma and their representations in phase diagrams (binary system and ternary diagrams)
Partial melting, fractional crystallization, contamination and assimilation fractional crystallization.

Geochemical characteristics of igneous rocks as Petrogenetic indicators.
Geological controls and application of major, trace and Rare earth elements in petrogenesis.
Quantitative approach to partial melting and fractional crystallization using different types of trace elements.
Concept of mantle metasomatism and role of fluids in magma generation.
Magmatism in Global Tectonic Scenario. Magmatism in i. Constructive Plate Margins, ii. Destructive Plate Margins, iii. Within Plate Magmatism.
Archaean & Proterozoic Crustal Evolution. TTG Suites.

Unit III: Igneous Rock Classification
Granites and their origin
I-, S-, A- type granites.
Pegmatites, their nature, occurrence and petrogenesis.
Alkaline rocks and their origin.
Anorthosites and their petrogenesis.
Lamprophyres and their petrography and origin.
Ultramafic and layered rocks, nature and origin.
Carbonatites, petrography and their petrogenesis.
Kimberlites and their origin.
Lunar rocks.

Unit IV: Practical
Field based practical for sample/Data collection and in-situ study.
Study of igneous rocks and textures using polarizing microscope,
Calculation of mineral formulas.
Exercises related to partial melting and fractional crystallization
Estimation of ε values, model ages and plotting of isochrons of the various data suites.
Plotting and interpretation of trace element and REE characteristics of igneous rocks.
Powder XRD analysis of minerals and determination of unit cell parameters, identification of unknown minerals by search-match methods.

Suggested Readings:
Marjorie Wilson, 1989. Igneous petrogenesis
Cox, KG, Bell, JD and Pankhurst, RJ, 1993. The Interpretation of Igneous Rocks. Chapman & Hall, London
Philpotts, AR and Ague, JJ. 2009. Principles of Igneous and Metamorphic Petrology. 2nd Edition
Winter, JD, 2001. An introduction to Igneous and Metamorphic petrology, Prentice Hall
Rollinson, HR 2007. Using geochemical data-evaluation, presentation and interpretation. 2nd edition. Longman Scientific & Technical
Putnis, Andrew 1992. Introduction to Mineral Sciences, Cambridge Univ. Press.
Deer, W.A., Howie, R.A. & Zussman, J. 2002. Rock forming minerals. Vol. 1 to 5. Longmans, London.

GEOL-PG-C102: Sedimentary Geology & Basin Analysis

Unit I: Sedimentary Rocks:Structure and Classification
Nature and origin of sedimentary rocks composition and classification
Earth surface processes.
Texture & Classification of sediments.
Sediment transport in different systems.
Sedimentary structures and their genetic significance and importance in rock record.

Biogenic structures.
Diagenesis.
Palaeocurrent analysis: Vector properties and palaeocurrent, scalar properties and palaeocurrent, presentation and interpretation of palaeocurrent data.

Unit II: Sedimentary Environment
Concepts of sedimentary environment
Environmental parameters and controls.
Classification of environments: Clastic and Chemical.
Facies model and environmental reconstruction.
Glacial Environment.
Alluvial environment (Braided, Meandering).
Marginal marine and Neritic environment.
Deltaic models (Fluvial, wave), coastal (interdeltaic) model – barrier islands and lagoons, tidal channels, tidal deltas and Estuaries.
Deep marine sedimentation: Slope and Basin-floor fans (Point and Line source).
Carbonate sedimentation model. Geometry of carbonate platforms; Ramp, Rimmed shelves, Isolated platform, Reefs.
Cyclic sediments: Allokinetic and Autokinetic controls.
Role of environmental analysis in petroleum exploration.

Unit III: Basin Analysis
Definition and scope of basin analysis
Introduction to Sequence Stratigraphy.
Basin mapping methods: structure and isopach contouring, lithofacies maps.
Geohistory analysis. Thermal history, Porosity and Burial depth.
Regional and global stratigraphic cycles.
Tectonic classification and evolution of sedimentary basins.
Subsidence and Thermal history of divergent margin basins, convergent margin basins, transform and transcurrent fault basins, basins developed during continental collision and suturing and cratonic basins.
Review of Indian Sedimentary basins.

Unit IV: Practical
Field based practical for sample/data collection and in-situ study.
Identification and study of sedimentary and Digenetic rocks in hand specimen and thin sections.
Analysis of Sedimentary structures and determination of paleocurrent directions.
Preparation of Fence diagram, Panel diagram, Interpretation.
Preparation of isopach and paleocurrent maps and basin analysis.
Problems on porosity and burial depth determination.

Suggested Readings:
Principles of Sedimentology and Stratigraphy, 2006. Sam Boggs (Jr.), Prentice Hall
Sedimentary Environments: Processes, Facies and Stratigraphy: (1996) H.G. Reading. Blackwell Publishers
Carbonate Sedimentology: M.E. Tucker and V.P. Wright (1990), Blackwell.
Sedimentary Basins: Gerald Einsele (2000), Springer
Facies Models revisited: H.W. Posamentier and R. G. walker (2006), SEPM
Principles of sedimentary basin analysis: A.D. Miall (1999), Springer
Sedimentology and Stratigraphy: Gary Nichols (2009), Wiley-Blackwell

GEOL-PG-C103: Hydrology

Unit I: Fundamentals of Hydrology

Origin of Water & Hydrologic cycle and its components
Surface water and groundwater interaction.
Classification of aquifers.
Hydrological properties of rocks - specific yield, specific retention, porosity, hydraulic conductivity, transmissivity, storage coefficient.
Unconfined, confined, steady, unsteady and radial flow conditions. Pumping tests. Flow nets.
Water table fluctuations - causative factors, concept of barometric and tidal efficiencies. Evaluation of aquifer parameters using Thiem, Theis, Jacob and Walton methods.
Theory of groundwater flow, Bernoulli's equation and its applications. Hydraulic head. Potentiometric surface and potential surface. Darcy's law.

Unit II: Ground water exploration

Geological, Meterological and Geophysical methods.
Application of Remote sensing in ground water exploration. Hydrogeomorphic mapping
Types of wells. Well development and design.
Groundwater quality - physical and chemical properties of water, Hill and Piper and Durov diagrams and Chebotareb sequence.

Unit III: Application of Hydrology

Rain water harvesting and Artificial recharge methods
Groundwater contamination and saline water intrusion in coastal and other aquifers and its prevention.
Ground water problems and management related to mining, foundation work of canals, tunnels. Problems of overexploitation
Conjunctive use of ground water and surface water
Hydrogeology of arid Zones of India
Ground water provinces of India - their aquifer characteristics.

Unit IV: Practical

Field based practical for sample/data collection and in-situ study.
Deciphering of hydro-geological boundaries on water table contour maps
Analysis of Hydrographs
Determination of permeability.
Groundwater quality study using Trilinear (Hill-Piper), C-S diagrams etc.
Problems on radial flow to a well in confined and unconfined aquifers
Exercises on step drawdown test
Determination of aquifer parameters using Theis and Jacob's methods
Calculation of salt water encroachment in coastal aquifers
Electrical resistivity surveys for aquifer delineation
Application of Aquachem, Modflow, etc

Suggested Readings:

Fetter, C.W., 2001, Applied Hydrogeology, Prentice Hall Inc., N.J.
Fitts, C.R., 2006. Groundwater Science, Academic Press.
Freeze, R.A. and Cherry, J.A., 1979. Groundwater, Englewood Cliffs, New Jersey: Prentice-Hall.
Raghunath, H.M., 2007, Third Edition, Ground Water, New Age International Publishers, New Delhi.
Mansell, M.G., 2003. Rural and Urban Hydrogeology, Thomas and Telford

Bryirely, G and Fryirs, K. 2005. Geomorphology and river management. Blackwell Pub.Vanoni, V.A., 2006. Sedimentation Engineering, ASCE, Manual.
Davie, T., 2008. Fundamentals of hydrology. Routledge Publications.
Knighton, D., 1998. Fluvial forms and processes: A new perspective. Arnold Pubs.
Richards. K., 2004. Rivers: Forms and processes in alluvial channels. Blackburn Press.
Julien, P.Y., 2002. River Mechanics. Cambridge University Press.

GEOL-PG-C104: Geochemistry

Unit I: Fundamentals of Geochemistry

Origin and abundance of elements in the solar system and in the Earth
Geochemistry of atmosphere, hydrosphere and lithosphere.
Geochemical classification of elements.
Properties of LILE, HFSE and Rare Earth Elements.
Concept of free energy, activity, activity coefficient, fugacity and equilibrium constant, thermodynamics of ideal, non-ideal and dilute solutions.
Principles of ionic substitution in minerals.
Geochemical Cycle. Cycles of C-H-O-N and Sulfur.

Unit II: Geochemical Reactions

Concept of simple distribution coefficients and exchange reaction distribution coefficients
Element partitioning in mineral assemblages and its use in the pressure-temperature estimation.
Chemistry of natural waters. Mineral stability in Eh-pH diagram. Elemental mobility in surface environment.
Oceans and atmosphere: their compositions, evolution, steady state, and global mass balance. Rock water interaction: congruent and incongruent dissolution, redox reactions, ionic strength of electrolyte solutions. Debye-Huckel theory.

Unit III: Isotope Geochemistry

Theory and mechanism of decay
Abundances of unstable nuclides in earth, core, mantle, crust, oceans and different rock types;
Mass spectrometer: Instrumentation, chemical separation, isotope dilution and ratio analysis.
Methods of dating: Isochron method, model/mineral ages, Fission track, 40Ar-39Ar, U and Th disequilibrium, choncordia method, 14C, Be and Al.
Interpretation and geological significance of ages.
Isotope systematic of K-Ar, Rb-Sr, Sm-Nd, U-Th-Pb in igneous, metamorphic and sedimentary rocks.
Stable isotopes of oxygen and hydrogen, carbon, nitrogen and sulphur.
Fractionation of stable isotopes in lithosphere, hydrosphere and atmosphere.
Stable isotope geothermometry and geobarometry.
Application of Isotopes in mineral exploration, petroleum exploration, paleo-climate evaluation, health and environmental aspects.

Unit IV: Practical

Introduction to geochemical analytical methods.
Flame photometer, XPS, XRF, AAS, ICP-MS, XRD.
Preparation of Solution A & Solution B.
Plotting and interpretation of Geochemical Data of various rocks suites.
Calculations of Model ages, ε values, and isochron for radioactive isotope pairs.
Determination of fractionation using stable isotope ratios.

Suggested Readings:

Faure, G. (1986). Principles of Isotope Geology. John Wiley
Dickin, A.P. (2005). Radiogenic Isotope Geology, Cambridge University Press
Doe, B.R. (1970) Lead isotopes. Springer Verlag
Faure, G. and Powell, J.L. (1972) Strontium Isotope Geology. Springer Verlag

Semester VIII

GEOL-PG-C201: Structural Geology

Unit I: Introduction to Rock Mechanics

Stress at a point in a solid body: 3-D Stress Tensor; Homogeneous and heterogeneous stress: stress functions. Concept of deformation: distortion, rotation, dilatation etc.
Analysis of homogeneous deformation: strain ellipses of different types and their geological significance. Concept of stress-strain compatibility.
Mohr diagrams for stress and strain and their use.
Behaviour of rocks under stress: elastic, plastic, viscous and visco-elastic responses and their geological significance. Concept of continuous and discontinuous media.
Mechanics of rock fracturing: fracture initiation and propagation. Coulomb's criterion and Griffith's theory; Crack linkage and their importance.
Effect of strength anisotropy on fracturing; Role of fluid in rock fracturing.

Unit II: Deformational Structures

Folds , Fold interference and superposed folds.
Strain distribution in a folded layer and its significance.
Evolution of axial planar and transected cleavages with folds; fold-related lineations.
Balanced cross sections and constructions of folds.
Faults and Joints: Mechanics of faulting: Anderson's theory and its limitations.
Complex geometry of normal, strike slip and thrust faults with natural examples.
Palaeostress analysis using fault-slip data.
Geometric analyses of joints – mesofracture analyses.

Unit III: Structural Analysis

Ductile Shear Zones & their significance in continental crustal evolution and metallogeny
Shear/fault zone rocks: mylonite, cataclasite and pseudotachylyte;
Kinematics of flow in a shear zone. Microstructures associated with Shear zones.
Dislocation and diffusion creep, strain hardening and softening mechanisms, lattice preferred orientation and superplasticity.
Crustal deformation: Deformation behavior of quartzo-feldspathic rocks. Brittle-plastic transition and seismic behavior of the upper crust.
Plate convergence and continental deformation.
Transpressional and Transtensional tectonics: Indian and overseas examples.
Structural Analysis.
Introduction to Experimental Structural Geology:
High P-T experiments with rock samples: basic concepts and important examples.
Analog modeling of deformational structures and its geological importance: concept of experimental scaling.

Unit IV: Practical

Field based practical for sample/data collection and in-situ study.
Problems related to practical strain measurement (Rf-φ method, Fry method etc.)
Construction of balanced cross-sections.

Analysis and interpretation of geological maps of various complexities.
Stereographic techniques: contour diagrams and orientation analyses of foliation and lineation data for regional structural geometry.
Laboratory demonstrations of analog modeling experiments.

Suggested Readings:

Bayly, B., 1992. Mechanics in Structural Geology, Springer.
Davis, G.H. and Reynolds, S.J., 1996. Structural Geology of rocks and regions, John Wiley. and Sons.
Ghosh, S.K., 1993. Structural Geology: Fundamentals and modern developments, Pergamon Press.
Leyson, P.R. and Lisle, R.J., 1996. Stereographic projection techniques in structural Geology, Cambridge University Press.
Passhier, C. and Trouw, RAJ, 2005. Microtectonics. Springer, Berlin.
Pollard, D.D. and Fletcher, R.C., 2005. Fundamentals of structural geology, Cambridge University Press.
Ramsay, J.G. and Huber, M.I., 1983. Techniques of Modern Structural Geology: Vol. I & II. Academic Press
Ramsay, J. G., 1967. Folding and Fracturing of Rocks, McGraw-Hill Book Company, New York.
Rowland, S.M., Duebendorier, E. and Schiefelbein, I.M., 2007. Structural analysis and synthesis: a laboratory course in structural geology, Blackwell Pub.
Suppe, J., The Principles of Structural Geology, Prentice-Hall, Inc., New Jersey, 1985.
Twiss, R.J. and Moores, E.M., 2007. Structural Geology. Freeman.
Van der Pluijm, B.A. and Marshak, S., 2004. Earth structure: an introduction to structural geology and tectonics, W.W. Norton & Company Ltd.

GEOL-PG-C202: Metamorphic Geology

Unit I: Fundamentals of Metamorphic Processes

Nature and scope of metamorphism
Types of metamorphism. Metamorphic textures.
Fundamentals of thermodynamics of homogeneous and hetrogeneous systems.
Nucleation and crystal growth in metamorphism.
Metamorphic paragenesis.
Advantages and limitations of Metamorphic facies classification.
Mineralogical changes during progressive metamorphism of pelitic, calcareous and mafic rocks and control of bulk composition on metamorphic assemblages.

Unit II: Compositional Plots and Projective analysis

Construction and interpretation of ACF, AKF and AFM diagrams.
Schrienmaker's rule and construction of petrogenetic grid.
P-T diagrams, Psuedo-sections. Orogenic processes and metamorphism. Relationship between deformation and metamorphism.
Metamorphic differentiation, geothermobarometery, compositional zoning and P-T-t paths, and their tectonic significance.

Unit III: Tectonics and Metamorphism

Global Tectonic Context of Metamorphism
Role of fluids in metamorphism.

Metasomatism, Granitization, Migmatities, Paired Metamorphic zones, Ultra-high temperature and Ultra-high pressure metamorphism. Inverted Metamorphic sequences.
Time-scales of metamorphism and implications on thermal history of the crust.

Unit IV: Practical
Field based practical for sample/data collection and in-situ study.
Introduction to interpretation of metamorphic assemblages textures in relation to fabric elements.
Introduction to relevant softwares.
Cation calculation using excel spreadsheet,
Use of petrogenetic grid and compositional plots,
Construction of schreinemakers bundles in non-degenerate and degenerate 3-component systems.
Geothermobarometric calculations.

Suggested Readings:
Philpotts, A.R. & Ague, J.J. 2009. Principles of igneous and metamorphic petrology. Cambridge University Press.
Bucher K. and Martin F. 2002. Petrogenesis of Metamorphic rocks. Springer-Verlag Publication.
Vernon R. H. and Clarke G. L. 2008. Principles of metamorphic Petrology. Cambridge Publication.
Spears F. 1993. Metamorphic Phase Equilibria and Pressure-Temperature-Time Paths. AGU Publication
John D. Winter 2001. An Introduction to Igneous and Metamorphic Petrology. Prentice Hall Inc

GEOL-PG-C203: Stratigraphy of India and Palaeontology

Unit I: Stratigraphic Codes and of Indian Straigraphy
Code of stratigraphic nomenclature
Concept of stratotype, types of stratotype. Global stratotype section and point (GSSP). Geomagnetic Polarity Time Scale (GPTS).
1. Stratigraphy of Gondwana sedimentary units. 2. Traps: Deccan, Rajmahal, Sylhet and Rajahmundry Traps and their correlations. 3. Marine Mesozoics of coastal India viz Cretaceous of Trichinapalli and Jurassic of Kutch. 4. Stratigraphic Boundary Status: Precambrian-Cambrian, Permo-Triassic, Cretaceous- Tertiary, Neogene-Quaternary. 5. Phanerozoics of Extra Peninsula**:** Spiti, Kashmir and Salt Range. 6. Lithostratigraphy of different sedimentary cycles vis-à-vis major geologic and tectonic events of the Himalayas. 7. Lithostratigraphy of Siwalik Sediments. 8. Tertiary formations of Kutch and Assam -Arakan geological provinces. 9. Precambrian belts of India (South India, Central India, Rajasthan, Eastern Ghat, Singhbhum-Orissa): Age correlations, metamorphism, tectonics and evolution. 10. Archean-Proterozoic boundary problem in India. 11. Concept of Precambrian supercontinents 12. Important Proterozoic basins of Peninsular India: Sedimentation, correlation and evolution.

Unit II: Introduction to Micro-Palaeontology
Introduction to various groups of microfossils
Techniques of separation of microfossils from different types of sedimentary rocks. Foraminifera and Ostracoda - their morphology, orientations, growth, reproduction, ecology and palaeoecology, classification, evolutionary trends and stratigraphic distribution. Conodonts - Morphology, classification, biological affinity and stratigraphic distribution. Application of micropaleontology in fossil fuel exploration, and paleoclimate.
Introduction to palynology and Palaeobotany.

Unit III: Vertebrate and Invertebrate Palaeontology

Significance and distribution of Mollusca, trilobites, brachiopods graptolites, foraminifera and ammonoids.

Vertebrate Palaeontology: Characteristic features of vertebrates - Skeletal elements of their fossil remarks. Origin of vertebrates and their general evolutionary patterns; outline classification of vertebrates. Classificatory characters and divisions of the vertebrate; Agnathans, Fishes, Amphibia, Reptilia, Aves and Mammalia.

Evolution of mammalian dentition. Phyllogeny of Equids, Proboscids and Hominids. Origin, evolution and extinction of life.

Dinosaurs and their extinction.

Unit IV: Practical

Field based practical for sample/data collection and in-situ study.

Techniques of separation of microfossils from matrix.

Study of Morphology of important foraminifera, Ostracoda, Vertebrate and Invertebrate fossils.

Suggested Readings:

Bignot, G., 1985. Elements of micropalaeontology; Microfossils, their geological and palaeobiological applications, Graham & Trotman, London, United Kingdom.

Braiser, M.D., 1980. Microfossils, Geogrge Allen and Unwin Publisher.

Hasllett, S.K., 2002. Quaternary Environmental Micropalaeontology, Oxford University Press, New York.

Jones, R.W., 1996. Micropaleontology in Petroleum exploration, Clarendon Press Oxford.

Kennett and Srinivasan, 1983. Neogene Planktonic Foraminifera: A phylogenetic Atlas, Hutchinson Ross, USA.

Sinha, D.K., 2007. Micropaleontology: Application in Stratigraphy and Paleoceanography, Alpha Science International, Oxford & Narosa Publishing House Pvt. Ltd. Delhi.

Naqvi, S.M Geology and Evolution of Indian Plate

Geology of India. Geol Soc of India

Krishnana M.S. Geology of India and Burma

GEOL-PG-O204: Geospatial Analysis and applications

Unit I: Concept of Geospatial analysis

Principles of remote sensing.

The nature and generation of electromagnetic radiation. Spectral bands, resolution and reflectance curves, interaction of EMR with atmosphere, rocks, minerals and soil, vegetation and water.Sensor systems and platforms.

Aerial remote sensing, aerial photography, properties of aerial photographs, elements of photointerpretation.

Interpretation of geographical, geomorphological, structural and lithological features from aerial photographs.

Radar remote sensing. Satellite remote sensing: LANDSAT, SPOT and IRS systems. Introduction to digital image processing.

Applications: Remote sensing in Geological mapping, Mineral Exploration, Ground water Exploration, Petroleum Exploration, Engineering Geology and Environmental studies.

Unit II: 3D Analysis

Displaying & Exploring the data, converting the data, using an analysis mask, coordinate system and creating 3D model, surface analysis- creating contours, slope date sets, aspect datasets,

hillshade datasets & view datasets, calculation of straight line distance and cost weight distance, performing shortest path etc.
Introduction to Decision Support Systems, Multicriteria analysis using GIS.
Application for Environmental Impact assessment, Land Use Planning and Hazard mitigation.
Quantitative models in Remote Sensing
Canopy reflectance modelling and estimation of biophysical variables.
Soil and Snow reflectance modelling, Topographic correction methods
Change detection analysis.

Unit III: Introduction to GIS
Geographical Information System: Introduction and Definitions
Technology and concepts; Components of GIS; Developments in GIS.
GIS data modelling, data analysis – Overlay, DEM and DTM.
Topological modelling; Spatial operations, Map integration, Multi-criteria evaluation.
Steps in a GIS project: Identification of project objectives, Creation of project database, Analysis of data, and Data integration, and Presentation of map output.
Overview of GIS softwares, viz. ArcGIS, ILWIS, ENVIS, Geomatica and MapINFO.

Unit IV: Practical
Testing of Stereovision and examination of stereo aerial photograph under mirror stereoscope.
Spectral signature and analyses the given set of Spectral reflectance curves for Water, Soil and Vegetation within visible and near infrared wavelength.
Study and identification of major Geomorphologic features on stereo aerial photograph under Mirror stereoscope.
Study of given False Color Composite (FCC) and interpreting various Geomorphologic terrain/features.
Digital Enhancement of Images as aid for geological interpretation.
Handling of RS and GIS softwares.

Suggested Reading:
Rajiv Gupta & Mukesh Kumar Rohil, 'Computing Aspects of Geographical Information Systems'
Thomas M Lillesand, and Rralph W Kiefer; "Remote sensing and Image Interpretation", John Wiley & Sons, 1994, 3rd ed.
Michael F. Worboys, "GIS: A Computing Perspective", Taylor & Francis Ltd; 1995, first ed.

Semester IX

GEOL-PG-C301: Ore Geology and Mineral Economics

Unit I: Fundamentals of Ore Geology
Ore Minerals
Ore texture and structure.
Development of ore minerals in open space and polycrystalline aggregates.
Endogenous, Exogeonus processes and Transformation Processes of Ore formation.
Crustal evolution and metallogenesis.
Fluid inclusions and their applications.

Unit II: Petrological Ore Association
Petrological ore association-consideration with reference to distinct ore types

Ore associated with ultramafic and related mafic plutonic rocks: Sudbury _type Fe -Ni –Cu sulphides, apatite rich and Ti -V bearing magmetites. Fe-Ti oxides and anorthosites
Ores associated with felsic plutonic rock: porphyry deposit of Cu, Mo. Greisen & Skarn deposit of W and Sn. Various Pegmatoid deposit.
Ores associated with acid/mafic volcanic rocks, including those in greenstone belts: Kambalda type, Kuroko type and Cypruss Types of ores.
Stratabound ore deposit associated with nonvolcanic, Meta Sedimentary rocks, Kupferschiefer, Rhodesia –Katanga, Broken Hill.
McArthur, Mississippi valley type, Witwatersrand type, Bog iron manganese ores ironstone, Banded iron formation.
Manganese ores. Orthoquartzite-clay association, Jaspilite and volcanic association, metamorphosed manganese ores. Colorado Plateau type U-V ores, Surficial deposits.
Lateritoid and Karst deposit of Fe, Mn, Al, and Ni.
Placer deposit of Gold, Tin, Tungsten, monazite. oxidation and supergine enrichment sulphide enrichment.
Ocean floor deposit of Mn, Ni-Cu-Co.

Unit III: Mineral Economics
Importance of Minerals in National Economy
Current National Mineral Policy.
Classifications of mineral resources – IMM, JORC, SAMERC, ISP and UNFC schemes. Basic pattern of Mineral economy and changing mineral requirements.
Concepts of strategic Minerals
World resources of minerals and production of important mineral.
Developing substitute to cover internal shortage, production cost & its relation to mineral in short supply.
Internal controls (monopolies and cartel), trade restriction and production incentives.
Importance of steel & Fuels in Modern Economy.
Impact of atomic Energy over conventional fuels.
Conservation of non renewable & associated Renewable resources.

Unit IV: Practical
Field based practical for sample/data collection and in-situ study.
Introduction to ore microscopy: Concept of reflected light microscopy and description of optical properties of ore minerals.
Ore microscopic study of important oxide minerals and complex minerals.
Ore microscopic study of important sulfide minerals.
Textural and micro-structural features of ore mineral assemblages.
Determination of Paragenetic order of the ore minerals.
Characterization of Fluid Inclusions.
Applied Ore microscopy: Particle size measurement and applications in the liberation characteristics of complex mineral assemblages for mineral beneficiation and in other areas.

Suggested Readings:
Barnes, H.L., 1979. Geochemistry of Hydrothermal Ore Deposits, John Wiley.
Evans, A.M., 1993. Ore Geology and Industrial Minerals, Blackwell.
Guilbert, J.M. and Park, Jr. C.F., 1986. The Geology of Ore Deposits. Freeman.
Klemm, D.D. and Schneider, H.J., 1977. Time and Strata Bound Ore Deposits. Springer Verlag.
Stanton, R.L., 1972. Ore Petrology, McGraw Hill.
Mookherjee, A., 2000. Ore Genesis – A Holistic Approach. Allied Publisher.
Craig J.R. and Vaughan, D.J. 1994. Ore Microscopy and Ore Petrography

McKinstry, H.E. 1962. Mining Geology (2nd Ed.) Asia Publishing House.
Clark, G.B. 1967. Elements of Mining. 3rd Ed. John Wiley & Sons.
Arogyaswami, R.P.N. 1996 Courses in Mining Geology. 4th Ed. Oxford-IBH.
Chatterjee, K.K. 2008 An Introduction To Mineral Economics

GEOL-PG-C302: Geology of Fossil Fuels

Unit I: Coal Geology

Coal and its properties
Different varieties and ranks of coal.
Origin of coal.
Type of depositional processes. Coalification process and its causes.
Introduction to Organic Petrology and Organic Geochemistry.
Sediments closely associated with coal (coal balls, tonsteins, seat-earths, under-clays, fire-clays and soils).
Coal Petrography: Lithotypes, microlithotypes and macerals: their physical, chemical and optical properties. Applications of coal petrography
Maceral analysis of coal: Mineral and organic matter in coal.
Proximate and ultimate analyses.
Industrial evaluation of coal characteristics with reference to coal classification.
Methods of coal prospecting and estimation of coal reserves
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.

Unit II: Petroleum Geology

Origin of petroleum
Petroleum: its different states of natural occurrence.
Basic concepts of petroleum geochemistry.
Maturation of kerogen; Biogenic and Thermal effect.
Distribution of Petroleum in space and time.
Introduction to migration of oil and gas: geologic framework of migration; short and long distance migration, primary and secondary migration; geologic factors controlling hydrocarbon migration; forces responsible for migration, migration routes and barriers.
Oil field water- characters and classifications.
Reservoir rocks: general attributes and petrophysical properties.
Classification & Characterization of reservoir rocks - Clastic and Carbonate reservoirs.
Hydrocarbon traps: definition; classification of hydrocarbon traps - structural, stratigraphic and combination; time of trap formation and time of hydrocarbon accumulation.
Cap rocks - definition and general properties.
Petroleum Geology of important Indian basins (offshore and onshore).
Introduction to oil and gas exploration.

Unit III: Coal Bed Methane and Gas Hydrates

Coal bed methane: Coal bed methane generation and accumulation.
Geological and petrographic influences on coal, Pore geometry, Micropore, Mesopore and macropore, cleat system.
Sorption – principles, sorption isotherms – types and interpretation.
CO_2, CH_4 and N_2 adsorption – desorption, hysterisis, Langmuir isotherm, Swelling of coal matrix isotherm construction.
CH4 content determination in coal seams.

Potential coal bed basins and production, hydraulic fracturing of coal seams, CBM exploration.
In-situ gasification. Introduction to shale gas. Carbon dioxide sequestration.
Gas Hydrate: Gas hydrate, occurrence and origin; structure of gas hydrate.
Types of gas hydrate. Geological setting of Hydrate. Stability of gas hydrates.
Gas hydrate reservoir. Volume of gas in hydrate. Inhibitors.
Geological exploration of gas hydrate. Prospect and potentialities of gas hydrate in India.

Unit IV: Practical

Field based practical for sample/data collection and in-situ study.
Megascopic identification of different varieties of coal.
Identification of macerals and minerals under transmitted light and reflected light.
Reflectance measurements and rank determination of coal.
Location of coalfields on geographical maps with comments about quality of coal, seam formation curve.
Estimation of coal reserve.
Interpretation of geologic structures from surface geological maps and bore hole data;
Preparation of structure contour and isopach maps of reservoir facies and drawing oil/water contact from bore hole data.
Calculation of oil reserves in defined structure.

Suggested Readings:

Coal Geology: Larry Thomas, 2002, Wiley and Sons.
Coal: it's composition, analysis, utilisation and valuation: E.E.Somermier 2008, Mc GrawHill
Petroleum Geology: F.K. North, 1986, Allen and Unwin
Petroleum Formation and Occurrence: B.P. Tissot and D.H. Welte 1978, Publisher: Springer-Verlag
Elements of petroleum Geology: R.C. Shelley 1998, Academic press
Petroleum Development Geology: P.A. Dickie, 1986, Publisher: Pennwell Publishing, Tulsa, Oklahoma
Petroliferous basins of India: Publisher: KDMIPE, ONGC, 1986

GEOL-PG-O303: Environmental Geology and Geo-statistics

Unit I: Introduction to Environmental Geology

Changes in the environment caused by geological activities of man
Inorganic and organic contaminants. Drinking water standards.
Surface and ground water pollution.
Geochemistry of toxic elements in natural waters.
Environmental problems connected with exploitation of minerals and energy resources.
Acid mine drainage.
Land use and land degradation due to mining.
Study of surface geological processes, earthquakes and volcanism with reference to their impact on environment.
Soils, erosion and conservation.
Introduction to Medical Geology.
Geological solutions to environmental problems.
Role of geology in nuclear waste disposal, Global warming, Climate change and Mitigation.
Environmental planning, management and economics (EMP and EIA).

Unit II: Introduction to Geostatistics

Classical Statistics: Universe, Population and Sample; Concept of Random variable; Probability distributions, viz. Normal (Gaussian) and Lognormal distribution.

Concepts of Geostatistics: Support, Autocorrelation, Random Function, Regionalized variable.

Exploratory Data Analysis.

Semi-variogram**:** definition, properties, calculation of experimental semi-variograms in 1-, 2-, and 3-dimensions.

Mathematical models of semi-variogram; Techniques of model fitting, Practical difficulties associated with semi-variography.

Extension and Estimation Variance: definition, formulation, and methods of calculation, viz. method of discretization and use of auxiliary functions.

Dispersion variance – definition, formulation and its calculation.

Unit III: Geostatistical Analysis

Kriging: Introduction and definition; Linear kriging – Ordinary kriging and Simple kriging; Solving kriging system of equations for Point and Block Kriged Estimate and Kriging Variance – case with two samples, general case with many samples.

Nugget effect. Influence of Nugget effect on kriging weights; Properties of kriging, viz. Screen effect and Shadow effect.

Practice of Kriging: Geostatistical evaluation of mineral deposit, extent of pollution, ore body modelling, calculation of mineral inventory, establishment of grade-tonnage relationships.

Role of kriging variance in optimization of exploration drilling and misclassified tonnages.

A brief introduction to Geostatistical Conditional Simulation.

Unit IV: Practical

Field based practical for sample/data collection and in-situ study.

Histogram plotting and estimation of mean, median, mode, skewness and kurtoisis;

Fitting of Probability distributions to sample distribution, viz. Normal and Lognormal; Chi-squared goodness of fit;

Computation of Semi-variograms in 1-, and 2-dimensions; Semi-variogram modeling;

Computation of estimation variance; Exercises on kriging.

Use of Statistical Softwares.

Suggested Readings:

Webster Richard & Oliver Margaret A. Geostatistics for Environmental Scientists Second Edition 2007, John Wiley & Sons PP333.

Trosset, Michael W. An Introduction to Statistical Inference and Data Analysis

Essentials of Medical Geology Impacts of the Natural Environment on Public Health: Editor Olle Selinus, 2005, Elsevier Academic Press. PP: 826

Clark, Isobel., Practical Geostatistics 1979 Elsevier Applied Science

Sahu, B.K. Satistical Models in Earth Sciences, BS Publications

Sharma, D.D.. Geostatistics with Applications in Earth Sciences. Springer, 2005

Clark, Isobel and Harper, Bill. Practical Geostatistics 2000/2010. Geostokos (Ecosse) Limited

GEOL-PG-S304: Mineral Exploration, Mining and Surveying Tech

Unit I: Geological Prospecting and Exploration

Definitions and Principles.

Methods of Prospecting. Methods of Exploration. Radiometric survey.

Sampling: theory and methods; Geological plans and sections for ore body evaluation; Exploration drilling, drill core logging and sampling.
Cut-off grade concepts and applications; Resources and Reserves.
Estimation of reserves – methods and practice.

Unit II: Geochemical Exploration
Introduction, Geochemical cycle, geochemical mobility and association of elements. Pathfinder and target elements for geochemical exploration. Primary and secondary dispersions of elements. Determination of background, and geochemical anomalies. Geochemical methods of mineral exploration: Procedures for geochemical sampling; Interpretation of geochemical surveys. Indian case studies.
Collection of data along Geological (G), Feasibility (F) and Economic (E) axes during various stages of exploration.

Unit III: Introduction to mining
Elements of mining, definitions and explanation of different mining terms.
Introduction to surface mining. Deposits amenable to surface mining.
Classification of surface mining systems. Rippling, drilling and blasting.
Introduction to underground coal mining.
Underground coal mining terms and their explanations.
Classification of underground coal mining methods. Bord and Pillar method – general description. Panel system of mining and its advantages and disadvantages, Longwall method. Introduction to PSLW technology with shearer.
Introduction to underground metal mining; Deposits amenable to underground metal mining;, modes of entry to underground mineral deposits; Mine development: drifting, raising and winzing; Classification of underground metal mining methods: general description, applicability and operations involved.
Introduction to Mineral Beneficiation.

Unit IV: Practical
Introduction to Surveying principles and methods
Preparation of base maps using Prismatic Compass & Tape, Chain, Plain Table, Theodolite and Total Station.
Measurement of slope heights, aspects and gradients. Use of abney level
Field Survey by using : Compass and Tape Survey, Plain Table Survey, and Total Station

Suggested Readings:
Evans, A.M. 1993. Ore Geology and Industrial Minerals. Blackwell ScLPubl. Guilbert, J.M. and Park Jr., C.F. 1986. The Geology of Ore deposits. Freeman & Co. Bateman, A.M. and Jensen, M.L. 1990. Economic Mineral Deposits. John Wiley
Gokhale, K.V.G.K. and Rao, T.C. 1978. Ore deposits of India their distribution and processing, Tata-McGraw Hill, New Delhi.
Deb, S. 1980. Industrial minerals and rocks of India. Allied Publishers
Singh, R.D. Principles and Practices of Modern Coal Mining. 1997 New Age International
Hartmann H.L., Introductory Mining Engineering, 2Nd Ed Wiley
Punmia, B, Jain, A.K. & Jain, A.K., Surveying (Volume - 1), 2005, Laxmi Publication Ltd.
Basak N N., Surveying and Levelling , 2001 (1st Edition) Tata Mcgraw Hill Education Private Limited
Bannister, A., Raymond, S. & Baker, R. Surveying 7th Edition, 2006, Pearson Education Singapore Pte Ltd.

GEOL-PG-S305: Applied River Science

Unit I: Basic stream hydrology
Physical properties of water, sediment and channel flow, River discharge, River hydrographs (UH, IUH, SUH, GIUH) and its application in hydrological analysis, Flood frequency analysis;

Unit II: River Basin Analysis
River basin
Sediment source and catchment erosion processes, Sediment load and sediment yield, Sediment transport process in rivers, Erosion and sedimentation processes in channel. Drainage network, Quantitative analysis of network organization – Slope analysis, morphometry, Random Topology (RT) model and fractal analysis, Role of drainage network in flux transfer, Evolution of drainage network in geological time scale.

Unit III: River Diversity
River diversity in space
Patterns of alluvial rivers - braided, meandering and branching channels, Dynamics of alluvial rivers, Channel patterns in stratigraphic sequences, Different classification approaches in fluvial geomorphology and its applications.

Unit IV: Neotectonics and Stream Flow
Bedrock channels, Bedrock incision process, River response to climate, tectonics and human disturbance, Bedrock channel processes and evolution of fluvial landscapes; Fluvial hazards, Integrated approach to stream management, Introduction to river ecology; Techniques of artificial stream modification for the control of water flow, mitigation of floods and erosion.

Suggested Readings:
Davie, T., 2008. Fundamentals of hydrology. Routledge Publications.
Knighton, D., 1998. Fluvial forms and processes: A new perspective. Arnold Pubs.
Richards. K., 2004. Rivers: Forms and processes in alluvial channels. Balckburn Press.
Bryirely and Fryirs, 2005. Geomorphology and river management. Blackwell Pub.,
Julien, P.Y., 2002. River Mechanics. Cambridge University Press.
Robert, A., 2003. River Processes: An introduction to fluvial dynamics. Arnold Publications.
Vanoni, V.A., 2006. Sedimentation Engineering. ASCE Manual, Published by American Society of Civil Engineering.
Tinkler, K.J., Wohl, E.E. (eds.) 1998. Rivers over rock. American Geophyscial UnionMonogrpah, Washington, DC.

GEOL-PG-S306: Isotope Geology

Unit I: Fundamentals of Isotope Geology
Fundamentals of radioactivity
Stable and radiogenic isotopes.
Nuclear structure, atomic weights, nuclear stability and abundance.
Theory and mechanism of decay, particles emitted, positron, negatron and alpha decay, effect of mineral/crystal structures, growth and retention of daughter isotopes in earth systems.
Abundances of unstable nuclides in earth, core, mantle, crust, oceans and different rock types; their decay schemes, radioactive elements as major elements, minor elements and trace elements and their geochemical behaviour.

Unit II: Isotopic Analysis

Mass spectrometer
Instrumentation, chemical separation, isotope dilution and ratio analysis.
Methods of dating: Isochron method, model/mineral ages, Fission track, 40Ar-39Ar, U and Th disequilibrium, choncordia method, 14C, Be and Al.
Interpretation and geological significance of ages.
Isotope systematics of K-Ar, Rb-Sr, Sm-Nd, U-Th-Pb.

Unit III: Stable Isotopes
Stable isotopes of oxygen and hydrogen, carbon, nitrogen and sulphur
Fractionation of stable isotopes in lithosphere, hydrosphere and atmosphere.
Stable isotope geothermometry and geobarometry.
Environmental and sediemntological studies using Stable isotopes.

Unit IV: Applied Isotope Geology
Isotopes in mineral exploration
Petroleum exploration, paleo-climate evaluation, health and environmental aspects.
Case studies and data analysis and interpretation.

Suggested Readings
Faure, G. (1986). Principles of Isotope Geology. John Wiley, 589p.
Dickin, A.P. (2005). Radiogenic Isotope Geology, Cambridge University Press, 512p
Doe, B.R. (1970) Lead isotopes. Springer Verlag, 137p.
Faure, G. and Powell, J.L. (1972) Strontium Isotope Geology. Springer Verlag, 188p.

Semester X

GEOL-PG-S401: Geomechanics

Unit I: Fundamentals of Geomechanics
Definition of geomechanics and classification of geological materials
Relationship between Stress and Strain and their measurement in rock mass and Mohr circles.
Rock Properties – density, hardness, abrasion, slake durability, permeability.
Strength of rocks – tensile, compressive and shear strength, Determination of elastic moduli.
Rock mass classification systems – RQD, Q system, RMR and SMR classification.
Laboratory measurements of rock strength, Uniaxial and triaxial tests, Stress-strain relationships.
Determination of principal stresses.
Rock bursts and bumps; Subsidence - causes, prediction, monitoring and prevention. Techniques in Bore logging, Core logging and drift logging.

Unit II: Geomechanical Characteristics
Size analysis
Atterberg limits (plastic and liquid limits).
BIS Classification system, Consolidation parameters, Swelling/Shrinking Index, Void Ratio, Effective stress concepts in soil – Total, neutral and effective stress distribution in soil, Permeability, Darcy's Law, Permeability measurement in the laboratory – quick sand condition, Seepage, Laplace Equation, Liquifaction and Condensation.
Measurement of shear strength, direct shear, Triaxial compression, UCC and Vane shear tests. Types of shear tests, Drained and undrained behaviour of clay and sand.
Stress path for conventional triaxial test, cyclic shear test.
Techniques in slope stability analysis

Unit III: Geotechnical Investigations
Physicomechanical properties of building stones and aggregate, alkali aggregate reaction

Geotechnical investigation for dam site, reservoir site; geotechnical study for road alignment, geotechnical evaluation of tunnel alignment, methods of tunneling, classification of ground for tunneling purposes.
Types of support system.
Geotechnical investigations for bridge foundation and building foundation.
Mass movements, slope stability problems, their predictions and optimum design of slope (natural slope, benches in mines, mine dumps).
Earthquakes and seismicity, seismic zones of India, soil liquefaction, earthquake resistance design of building. Influence of geological condition of foundation and design of buildings. Shoreline engineering geology.

Unit IV: Practical
Field based practical for sample/data collection and in-situ study.
Grain Size Analysis
Density Determination
Atterbergs Limit Tests
Compaction Test
Consolidation Test
Direct and Triaxial Shear Test
Compressive Strength Test
Abrasion and slake durability test
Permeability Test
Selection of sites using topographic maps for dams, tunnels, bridges, highways and similar civil structures.
Computation of reservoir area, catchment area, reservoir capacity and reservoir life, discharges and sedimentation rates.
Use of softwares for solving various geotechnical problems.

Suggested Readings:
Rock Mechanics for Underground Mining by Brady and Brown; Chapman and Hall, 1993.
Engineering Rock Mass Classifications by Bieniawski; Wiley, 1989.
Rock Mechanics by Fairhurst
Punmia P.C., "Soil Mechanics and Foundations", Laximi Publications Pvt. Ltd., New Delhi, 1995.
Gopal Ranjan and Rao A.S.R., "Basic and applied soil mechanics", New Age International Publishers, New Delhi, 2000.
Krynin, D.P. and Judd W.R. 1957. Principles of Engineering Geology and Geotechnique, McGraw Hill (CBS Publ).
Johnson, R.B. and DeGraf, J.V. 1988. Principles of Engineering Geology, John Wiley & Sons, N.Y.
Goodman, R.E., 1993. Engineering Geology: Rock in Engineering constructions. Jonh Wiley & Sons, N.Y.
Waltham, T., 2009. Foundations of Engineering Geology (3rd Edn.) Taylor & Francis.

GEOL-PG-S402: Geodynamics and Tectonic Geomorphology

Unit I: Geodynamics
Internal structure of the earth
Variation of physical properties in the earth.
Detailed structures of core, mantle and crust, including their geophysical properties and composition.

Main features of ocean basins and deep ocean floor and continental Crust.
Characters of oceanic ridges. Stages in the evolution of ocean basins.
Different types of continental margins and their characters.
Historical background of plate tectonics.
Earlier hypotheses of orogenesis, continental drift, palaeomagnetic study, sea-floor spreading, and Isostasy.
Distribution of tectonically active zones.

Unit II: Plate Tectonic
Plate geometry and plate boundaries. Triple junctions
Plates in velocity space. Spherical coordinates and reference frame.
Cartesian coordinates. Finding Euler's pole. Velocity due to rotation about an Euler's pole. Angular velocity vectors.
Mechanisms of plate motion: mantle plume model, convection model, viscous drag and buoyancy model.
Tectonics of different plate boundaries.
Different types of tectonic settings: extensional, compressional and transformal.
Petro-tectonic assemblages at different plate boundaries.
Activation model and collision model of orogeny. Pacific and Andean type orogeny.
Configuration of the Indian plate and origin of the Himalayas.
Mountain building process.
Thrust and fold belts; Active faults: concepts and methods.

Unit III: Introduction to Neotectonics
Introduction to Neotectonics and active tectonics Geomorphic markers of tectonic deformation.
Active tectonics and alluvial rivers.
Tectonics and erosion.
Tectonic-climate interaction.
Landscape response to active tectonics.
GPS geodesy and its applications to lithospheric deformation.
Rate of deformation and seismicity; Introduction to paleoseismology.
Tectonic geomorphology of mountains.
Application of isotopic and fission-track data for uplift-erosion-incision relationships.

Unit IV: Introduction to Earth Surface Processes
Introduction to earth surface processes & terrestrial relief
Scales in geomorphology, energy flow and relative energy of surface processes. Morphometric analysis of drainage basin and geomorphology-hydrology relationship.
Rates and changes in surface processes.
Techniques for process measurement- sediment budgeting, rock magnetism, Isotope geochemical tracers, cosmogenic nuclides, OSL & C-14 dating.
Introduction to Anthropocene.
Geomorphic concepts in cause-effect relationship – Spatial & temporal scales, geomorphic system, connectivity, buffering, magnitude-frequency concept, time-lag, sensitivity, equilibrium, threshold, non-linearity & complexities.
Mega-geomorphology and process interrelationship, Applied aspects of geomorphology. Introduction to planetary geomorphology.

Suggested Reading:
Geodynamics: 2nd Ed, Turcotte, D. L. and Schubert, G., John Wiley & Sons, NY, 2002.
Mantle Convection in the Earth and Planets, Schubert, G., Turcotte, D. L. and P. Olson, Cambridge University Press, 2001.

Burbank, W.B., and Anderson, R.S., 2001. Tectonic Geomorphology, Blackwell Science.
Bull, W.B., 1991. Geomorphic Response to Climate Change, Oxford University Press.
Bull, W.B., 2007. Tectonic Geomorphology of Mountains, Blackwell Publishing.
Keller, E.A. and Pinter N., 2001. Active Tectonics: Earthquakes, Uplift, and Landscape, Prentice Hall.
McCalpin, J., 1998. Paleoseismology, Academic Press.
Schumm, S.A. and Holbrook, 2000. Active Tectonic and Alluvial Rivers, Cambridge University Press.
Allen, P.A., 1997. Earth Surface Processes, Blackwell publishing.
Bloom, A.L., 1998. Geomorphology: A Systematic Analysis of Late Cenozoic Landforms, Pearson Education.
Bridge, J.S. and Demicco, R.V., 2008. Earth Surface Processes, Landforms and Sediment Deposits, Cambridge University Press.
Easterbrook, D.J., 1992. Surface Processes and Landforms, MacMillan Publ.
Kale, V.S. and Gupta, A., 2001. Introduction to Geomorphology, Orient Longman Ltd.
Wilcock, P.R., Iverson, R.M. (2003) Prediction in geomorphology, AGU Publication

GEOL-PG-S403: Geophysics

Unit I: Introduction to Geophysics

Introduction to methods of Geophysical Investigation

Gravity method: Basis for gravity exploration, concept of geoid, international gravity formula, unit of gravity.

Gravimeters: Spring-mass system as basic gravimeters, principles of working of unstable gravimeters, zero length spring, La-Coste-Romberg and Worden gravimeters. Drift. correction. Gravity effect due to buried sphere. Densities of common rocks and minerals.

Unit II: Magnetic and Resistivity Methods

Magnetic method

Magnetic susceptibility of rocks and their ranges, elements of earth magnetic field; Magnetometers: Fluxgate and Proton Precession Magnetometers Diurnal Correction; Magnetic effect due to isolated pole.

Resistivity Method: Resitivities of common rocks and minerals, True and apparent resistivity, Electrode configurations-Schlumberger and Wenner, Electrical profiling Vertical Electrical Sounding. Interpretation of two layered VES curves.

Unit III: Seismic Method

Principles of Geometrical Optics, generation and propagation of seismic waves, seismic energy sources, geometry of refraction and reflection, interpretation of travel time curves for two layered earth· horizontal and dipping interface, field procedure-profile and broad side shooting, fan shooting, end on and split spread arrangements.

Seismic Stratigraphy and its applications.

Principles of Seismometry. Seismograms as signals. Earthquakes and source theory: Green’s function and the moment tensor, Earthquake faults, radiation pattern and beach balls, Stress drop, earthquake b-value, Finite slip model, the heat flow paradox. Seismology and Tectonics. Continental tectonics and intraplate earthquakes.

Unit IV: Geophysical Well logging

Introduction to geophysical well logging

Introduction to techniques of Mud Logging.

Borehole environment, surface logging setup. Archie's law and Darcy's law. Principles and instrumentation. SP log, Natural Gamma Ray log, Formation Water resistivity Logs, Porosity

Log, Neutron Log, Lithology-Porosity Logs, resistivity Logs, Induction Logging, Electromagnetic Propogation Logs and Well bore Seismic Logging.

Suggested Readings:

The Solid Earth: An Introduction to Global Geophysics (2nd ed. 2005) by CMR Fowler, Cambridge University Press.
Applied Geophysics by Telford W.M., Geldart L.P. and Sheriff R.E., Cambridge University Press.
Lowrie Richard. Geophysics. 2007 Cambridge University Press
Schlumberger Log: Interpretations, Principles/Applications 1989, Schlumberger.
Introduction to Seismology (2nd Ed) by Peter Shearer, Cambridge University Press.
Modern Global Seismology by Thorn Lay and Terry Wallace by Academic Press.

GEOL-PG-S404: Cryospheric Science

Unit I: Fundamentals of Cryospheric Sciences

Quaternary glaciations in India
Climate change in Quaternary – case studies from Himalaya (Ladakh, Uttarakhand, western UP, Sikkim), Rajasthan and Ganga Plains, correlation with Guliya and Greenland ice core, glacier types, dry and wet based glaciers and factors responsible, sediment transport and deposition by glaciers, techniques employed for the dating of glaciogenic deposits and their limitations, physics of glacier ice and snow.

Unit II: Glaciology

Movement of glacier, surface and subsurface features of glacier
Meterological parameters vis-a-vis glacier, affect of debris/aerosols on glacier surface, energy balance, mass balance study of glaciers, various methods of mass balance study, isotope study of glacier ice and snow vis-à-vis climate change, chemistry of snow/ice, sediment discharge by meltwater and chemistry of meltwater, snout monitoring techniques, remote sensing and GIS application in the study of glaciers.

Unit III: Mass Movements in Petrmafrost Regions

Characteristics of permafrost areas, rock and soil characters in cryosphere
Mass movement in petrmafrost areas- causes and mitigation
Snow avalanches – snow packages and density, avalanche types, characteristics of avalanche, avalanche prone areas and their mitigation.

Unit IV: Case Studies

Brief history of glaciological studies on Indian Himalayan glaciers
Case study of Himalayan glaciers**.**
Case study of Glaciers in Sikkim. Rathong, Talong, Chamgme-Khangpu and Zemu glaciers.

Suggested Readings

Maher and Thompson 2000 Quaternary climates, environments and magnetism. Cambridge Univ. Press
Williams, D. et al. 1998 Quaternary Environments. Wiley & Sons.
Raina ,V.K., Glaciers The Rivers of Ice 2005. Geological Society of India ISBN 10: 8185867739
Raina, V.K. and Srivastava, D. "Glacier Atlas of India, 2008, Geological Society of India.

GEOL-PG-S405: Micropalaeontology

Unit I: Calcareous Microfossils

Foraminifera: Planktic Foraminifera, their modern biogeography, coiling, surface ultrastructure, outline of morphology. Benthic foraminifera, their brief morphology. Larger Foraminifera, their outline of morphology, application in oceanography.

Calcareous nannofossils: Outline of morphology, modern biogeography, application in Oceanography; outline morphology and wall structure of ostracoda, significance of ostracoda in Quaternary paleoceanographic and paleoclimatic studies.

Unit II: Siliceous and Phosphatic Microfossils

Outline morphology, modern biogeography of radiolarian, diatoms and Silicoflagellates, their application in interpreting SST and palaeo-climates

Phosphatic Microfossils- Outline morphology, paleo-ecologfy and environmental significance of conodonts.

Unit III: Applied Micropalaeontology

Organic Walled Microfossils

Environmental significance of Acritarchs and Dianoflagellates.

Palynology: Outline of morphology of Pollens and Spores. Pollens and Spores in marine realm. Environmental application of Pollen and Spores.

Application of Micropaleontology and palynology in Petroleum Exploration

Unit IV: Practical

Techniques of separation of microfossils from matrix

Types of microfossils: Calcareous, Siliceous, Phosphatic and organic walled microfossils

Study of important planktic foraminifera useful in surface water paleoceanography and biostratigraphy

Study of larger benthic foraminifera useful in Indian stratigraphy with special reference to Cenozoic petroliferous basins of India

Study of modern surface water mass assemblages of planktic foraminifera from Indian, Atlantic and Pacific Ocean

Depth biotopes and estimation of paleodepth of the ocean using benthic foraminiferal assemblages

Identification of benthic foraminifera characteristic of various deep sea environment

Identification of planktic foraminifera characteristic of Warm Mixed Layer, Thermocline and deep surface waters of the modern oceans

Identification of modern and ancient surface water mass with the help of planktic foraminifera

Suggested Readings:

Bignot, G., 1985. Elements of micropalaeontology; Microfossils, their geological and palaeobiological applications, Graham & Trotman, London, United Kingdom.

Braiser, M.D., 1980. Microfossils, Geogrge Allen and Unwin Publisher.

Hasllett, S.K., 2002. Quaternary Environmental Micropalaeontology, Oxford University Press, New York.

Jones, R.W., 1996. Micropaleontology in Petroleum exploration, Clarendon Press Oxford.

Kennett and Srinivasan, 1983. Neogene Planktonic Foraminifera: A phylogenetic Atlas, Hutchinson Ross.

Sinha, D.K., 2007. Micropaleontology: Application in Stratigraphy and Paleoceanography, Alpha Science International, Oxford & Narosa Publishing House Pvt. Ltd. Delhi.

GEOL-PG-S406: Oceanography

Unit I: Physical Oceanography

Methods of measuring properties of sea water. Molecular structure of water. Temperature and salinity distribution in surface of the ocean. Salt composition and residence time. Dissolved gases in seawater. Carbon dioxide and carbonate cycle.

Ocean circulation: The Ocean Conveyor belt and its role in controlling world's climate. Surface circulation; concept of mixed layer, thermocline and pycnocline, Coriolis Force and Ekman Spiral, Upwelling, El nino. Processes affecting biological productivity of ocean margin waters. Deep Ocean Circulation, concept of thermohaline circulation, formation of bottom waters; water masses of the world oceans. Oxygen minimum layer in the ocean. Major currents of the world's ocean.

Unit II: Deep-Sea Sediments and Processes

Deep-sea sediments and their relation to oceanic processes such as solution, productivity, and dilution. Sediment distributions in time and space as related to tectonic models. Deep Sea hiatuses and their causes. Calcite and Aragonite Compensation depth and significance.

Ocean Resources: Mineral resources of the ocean including polymetalic nodules. Marine Gas Hydrates and their economic potential.

Unit III: Marine Pollution

Marine Pollution emphasizing geochemical aspects of the sources, transport, and fate of pollutants in the coastal marine environment. Interpreting marine pollution with the help of microfossils during Quaternary.

Paleoceanography: Ocean Floor Morphology, Oceanic Crust and Ocean Margins. Approaches to Paleoceanographic reconstructions. Paleoceanographic changes in relation to earth system history including impact of the oceans on climate change. Deep Sea Drilling Project (DSDP); Ocean Drilling Program (ODP) and Joint Global Ocean Flux Studies (JGOFS) and their major accomplishments. Integrated Ocean Drilling Program (IODP) and its aims and objectives.

Unit IV: Evolution of Oceans in the Cenozoic

Ocean Gateways of the Cenozoic and their role in controlling global climates. Sea level changes during Quaternary with special reference to India. Application of stable isotopes (Oxygen and Carbon) in Paleoceanography and Paleoclimatology. Paleoclimatic reconstructions from ice cores. Marine Stratigraphy, correlation and chronology.

Suggested Readings:

Fischer, G. and Wefer, G., 1999. Use of Proxies in Paleoceanography: Examples from the South Atlantic, Springer.

Gross, M.G., 1977. Oceanography: A view of the Earth, Prentice Hall.

Haq and Boersma, 1978. Introduction to Marine Micropaleontology, Elsevier.

Tolmazin, D., 1985. Elements of Dynamic Oceanography, Allen and Unwin.

GEOL-PG-S407: Dissertation

The students are expected to submit their dissertation by the end of the tenth semester.

The dissertation will be evaluated by an external examiner and internal examiner (supervisor). There will be an open presentation and viva-voce.

Syllabus of Elective Papers

GEOL-UG-E102: Physical Sciences I

Unit I: Introduction to Mechanics

Scalar and vector fields, Scalar and vector products, polar and axial vectors, triple products, directional derivative, Gradient, Curl, Divergence, Laplacian, line and surface integrals, theorems of Green, Gauss and Stokes, line integrals independent of path.

Newton's laws of motion, conservation of linear momentum, centre of mass, work energy theorem, Rotational motion, torque and angular momentum, kinetic energy of rotation, rigid body rotation dynamics, moment of inertia, conservation of angular momentum, comparison of linear and angular momentum, Simple harmonic motions.

Concept of Gravitational force and acceleration, Keplers' Laws, Gravitational Potential energy, Earth satellites,

Mechanical properties of solids (Elasticity, stress and Strain, Hooke's Law, Stress strain Curve, elastic moduli) and liquids (pressure, streamline flow, Bernoulli's principle, viscosity, Reynolds, Surface tension).

Unit II: Optics

Geometrical Optics: Reflection and refraction from plane and curved surface.

Wave optics: Interference, division of amplitudes, Young's double slit, Fresnel's biprism, and interference in thin films, Fraunhoffer diffraction, single slit, double slit, plane transmission grating, Rayleigh's criteria of resolution, resolving power of a telescope and a microscope, resolving and dispersive power of a plane transmission grating.

Polarization: Polarization by reflection and refraction, Brewster's law, double refraction, nicol prism, quarter and half-wave plates, Production and analysis of circularly and elliptically polarized light.

Photoelectric Effect, Wave particle Duality.

Unit III: Electromagnetism and Electronics

Electric Charge, Coulombs law, Electric field, potential due to a charge distribution and due to a dipole, electrical potential energy, flux, Gauss's law, electric field in a dielectric, polarization, energy stored in an electric field.

Conductors and insulators, Electric current, ohms law, resistivity and resistance.

Magnetic Field, Biot-Savart law, magnetic force on a current, Lorentz force, electromagnetic induction, Lenz's law, magnetic properties of matter, para- dia- and ferromagnetism, magnetic dipole.

Electromagnetic Radiation and Introduction to Maxwell's equations.

Introduction to electronic devices e.g. Capacitor, Resistance, Diode, transistor and ICs, Number systems (binary, BCD, octal and hexadecimal), 1's and 2's complements. Logic gates, AND, OR, NAND, NOR, XOR and NXOR. Boolean algebra (Boolean laws and simple expressions), binary adders, half adder, half subtractor, full adder and full subtractor.

Unit IV: Practical

Determination of spring constant of a spring by (i) static, and (ii) dynamic methods.

Determination of g by Simple Pedulum.

Determination of g by Kater's pendulum or Bar pendulum.

Measurement of Resistance by Meter Bridge.

Sereis and Parallel Combination of Resistances by PO box

To determine resistance per unit length of a given wire by plotting a graph of potential difference versus current.

Determination of Viscosity of a liquid using Stokes Law.
Determination of Youngs Modulus of a solid.
To find the focal length of a convex lens by plotting graphs between u and v or between 1/u and 1/v.
To find the focal length of a concave mirror.
Determination of wavelength of light by Fresnel's biprism.
Determination of wavelength of sodium light using a plane transmission grating and resolving power of a diffraction grating.
Determination of specific rotation of cane sugar solution using a polarimeter
To verify experimentally OR, NAD, NOT, NOR, NAND gates.
Study of Half-Adder/ Subtractor.

Suggested Readings:

Spiegel, M. R. Vector Analysis Schaum's Outline Series. McGraw-Hill Book Co.: Singapore (1974)
Beiser, A. Concepts of Modern Physics McGraw-Hill Education (2002).
Resnick, R., Halliday, D. & Krane, K. S. Physics Vol. I and II 5th Ed. John Wiley & Sons (2004)
Serway, R. A. & Jewett, J. W. Physics for Scientists and Engineers 6th Ed.
Ghosh, N.N. Introductory Physics, Part-I & II. Bharati Bhawan, 1997.
Griffiths, D. J. Introduction to Electromagnetism 3rd Ed. Prentice-Hall (1999).
Malvino, A.P. & Leach, D. P. Digital Principles and Applications, Tata McGraw-Hill (2008).
Ryder, J. D. Electronic Fundamentals and Applications: Integrated and Discrete Systems. 5th Ed. Prentice-Hall, Inc. (2007).
Floyd, T. L. & Buchla, D. M. Electronics Fundamentals: Circuits,Devices and Applications (8th Ed.) Prentice-Hall (2009)

GEOL-UG-E103 Physical Sciences II

Unit I: Planetary Sciences

General characteristics and Origin of the Universe.
Solar System its planets and satellites.
Meteorites, Asteroids and Comets.
Earth in the Solar system, origin, size, shape, mass, density, rotational and revolution parameters and its age.
Earth and Moon System: Origin and Characteristics.
Initiation of plate tectonics movements and origin of Earth's early atmosphere.
Artificial satellites – Polar orbiting and geostationary satellites.

Unit II: Atmospheric Sciences

Thermal structure of the atmosphere and its composition.
Insolation, solar constant, albedo, radiation windows, radiative transfer, Greenhouse effect, net radiation budget, Rayleigh and Mie scattering, multiple scattering.
Latitudinal and seasonal variation of insolation, and different meteorological parameters.
Thermodynamics of dry and moist air: specific gas constant.
Adiabatic and isoentropic processes, Vertical stability of the atmosphere.

Unit III: Climatology

Classification of Cloud, Condensation and Precipitation.
Air masses, monsoon, Jet streams, tropical cyclones, and ENSO.
Classification of climates – Koppen's and Thornthwaite's scheme of classification.
Basic equations and fundamental forces: Pressure, gravity, centripetal and Corolis forces, continuity equation in Cartesian and isobaric coordinates.

Geostrophic, gradient winds and thermal wind.

Unit IV: Oceanic Sciences
Introduction to Oceanography.
Major Oceans of the world. Major physical divisions of the ocean basin
Properties of Sea Water
Temperature and salinity distribution in surface of the ocean.
Dissolved gases in seawater. Carbon dioxide and carbonate cycle.
Major currents of the world's ocean.
The Ocean Conveyor belt and its role in controlling world's climate.
Surface circulation, concept of mixed layer, thermocline and pycnocline, Coriolis Force and Ekman Spiral and Upwelling.
Deep-sea sediments and Calcite and Aragonite Compensation depth and significance.
Mineral resources of the ocean including polymetallic nodules. Marine Gas Hydrates and their economic potential.

Suggested Readings:
Fischer, G. and Wefer, G., 1999. Use of Proxies in Paleoceanography: Examples from the South Atlantic, Springer.
Gross, M.G., 1977. Oceanography: A view of the Earth, Prentice Hall.
Haq and Boersma, 1978. Introduction to Marine Micropaleontology, Elsevier.
Tolmazin, D., 1985. Elements of Dynamic Oceanography, Allen and Unwin.

GEOL-UG-E202: Physical Sciences III

Unit I: Atomic Structure
Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Wave mechanics: de Broglie equation, Heisenberg's uncertainty principle and its significance, Schrodinger's wave equation, significance of ψ and ψ2. Quantum numbers and their significance. Radial and angular wave functions. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Pauli's exclusion principle, Hund's rule of maximum multiplicity, Aufbau's principle and its limitations, Variation of orbital energy with atomic number.
Periodicity of Elements: s, p, d, f block elements and it general physical properties e.g Effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table.Atomic radii (van der Waals), Ionic and crystal radii, Covalent radii (octahedral and tetrahedral), Ionization enthalpy, Successive ionization enthalpies and factors affecting ionization energy. Applications of ionization enthalpy, Electron gain enthalpy, trends of electron gain enthalpy. Electronegativity.
Pauling's and Mulliken's electronegativity scales. Introduction of chemical bonding.

Unit II: Chemical Thermodynamics
State of a system, state variables, intensive and extensive variables, concept of heat and work, thermodynamic equilibrium, thermodynamic properties, various types of systems and processes.
First Law of thermodynamics. Calculation of work (w), heat (q), changes in internal energy (NU) and enthalpy (NH) for expansion or compression of ideal gases under isothermal and adiabatic conditions for both reversible and irreversible processes. Calculation of w, q, NU and NH for processes involving changes in physical states.
Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data.
Various statements of Second Law of thermodynamics, concept of entropy, Gibbs free energy and Helmholtz energy, Calculations of entropy change and free energy change for reversible and

irreversible processes under isothermal and adiabatic conditions. Criteria of spontaneity. Gibbs – Helmholtz equation. Maxwell's relations.
Introduction to Chemical kinetics Ist order, IInd order reactions. Rate law, molecularity & order. Arrhenius Equation.

Unit III: Chemical Equilibrium
Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium, Le Chatelier's principle. Relationships between Kp, Kc and Kx for reactions involving ideal gases.
Ionic Equilibrium: Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and 31 bases, pH scale, common ion effect, Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.
Phase Equilibrium: Ehrenapst classification of Phases, Solid –Liquid, Soild-Solid and Liquid-Liquid Mixtures. One Component and Two Component System, Eutectic and Peritectic system, classical Nucleation Theory.

Unit IV: Practical
Physical & Chemical parameters of Water
Estimation of Fe content in Haematite.
Mg & Ca ions Hard water
Estimation of Cu in Chalcopyrite
Estimation of Ca & Mg in Dolomite
Estimation of Fe in cement
Estimation of Fe using UV-VIS spectrophotometer.
Preparation of solutions of different Molarity/Normality of titrants
Estimation of carbonate and hydroxide present together in mixture.
Estimation of carbonate and bicarbonate present together in a mixture.
Estimation of oxalic acid and sodium oxalate in a given mixture.
Determination of heat capacity of calorimeter for different volumes.
Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
Determination of enthalpy of ionization of acetic acid.
Determination of integral enthalpy of solution of salts (KNO3, NH4Cl).
Determination of enthalpy of hydration of copper sulphate.
Study of the solubility of benzoic acid in water and determination of pH
Introduction to different analytical Instruments like UV-VIS, FTIR and P-XRD.

Suggested Readings:
Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970
Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006.
Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications 1962.
Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS.
Barrow, G. M. Physical Chemistry Tata McGraw-Hill (2007).
Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
Mahan, B. H. University Chemistry 3rd Ed. Narosa (1998).

GEOL-UG-E203: Computation-I

Unit I: Variables, Functions and Mapping

Variables and functions, Inverse functions, Common functions, Curves and Parameters, Exponential, Hyperbolic and Logarithmic Functions.

Functions and their graphs: polynomial, sine, cosine, exponential and logarithmic functions.

Motivation and illustration for these functions through projectile motion and simple pendulum, Simple observations about these functions like increasing, decreasing and, periodicity.

Sequences, Limits and Continuity: Sequences, Limits of sequences and functions, Functions of several variables – limits, continuity.

Unit II: Differentiation of Functions

The derivative, rules of differentiation, Higher derivatives, Parital differentiation, change of variable, implicit functions, higher order partial derivatives. Use of methods of differentiation like Chain rule, Product rule and Quotient rule. Second order derivatives of above functions

Integration as reverse process of differentiation. Integrals of the functions introduced above. Fundamental theorem of integral calculus, mean value theorems, evaluation of definite integrals, Convergence of improper integrals, tests of convergence, Differentiation of an integral containing a parameter, differentiation of integrals with variable limits - Leibnitz rule. Rectification, double and triple integrals, computations of area, surfaces and volumes. Integration by substitution, Integration by parts, Reduction formulae.

Unit III: Differential Equations

Classification of differential equations, Arbitrary constants and the order of differential equations, Ordinary first order differential equations, Ordinary differential equations of the second and higher orders, Transforms of basic functions, Inversion, Solution of differential equations, Partial differential equations.

Matrices and Linear Algebra: Algebra of matrices, Determinants, linear transformations, rank and inverse of a matrix, solution of algebraic equations, Eigenvalues and eigenvectors, Tensors.

Points in plane and space and coordinate form.

Unit IV: Elementary understanding of data

Measures of central tendency and dispersion. Curve fitting and method of least-squares, regression analysis, Correlation theory, simple linear regression, multiple regression, Co-variance and correlation co-efficient.

Introduction to set theory, Permutations and combinations, Elementary probability theory, Conditional probability, Expectation.

Random variables, probability distribution of finite random variables, discrete and continuous random variables, Normal distribution, Central limit theorem, Binomial distribution, Poisson distribution, t-Distribution, Chi-square distribution.

Suggested Readings:

H. S. Bear: Understanding Calculus, John Wiley and Sons (Second Edition); 2003.

E. Batschelet: Introduction to Mathematics for Life Scientists,Springer Verlag, International Student Edition, Narosa Publishing House, New Delhi (1971, 1975).

Introduction to probability and statistics. Schumm's Outlines.

Davis, JC Statistics and data analysis in geology. John Wiley & Sons. 2002.

H. S. Bear: Understanding Calculus, John Wiley and Sons (Second Edition); 2003.

E. Batschelet: Introduction to Mathematics for Life Scientists,Springer Verlag, International Student Edition, Narosa Publishing House, New Delhi (1971, 1975)

GEOL-UG-E302: Computation-II

Unit I: Computer Applications in Geosciences

Introduction to computer applications in geosciences.
Geological Data compilation, processing and presentation.
Introduction to Computer programming. Basic programming codes.
Statistical analysis using various statistical softwares including Excel, Origin and SPSS.
Introduction to MATLAB.
Introduction to Rockworks, Slope Stability and hydrological modeling softwares.

Unit II: Computer Applications in Hazard Assessment

Concept of Disaster and Hazard.
Types, Causes, Factors and Consequences of i. Geological ii. Hydro-meteorological iii. Biological, iv Technological and v. Man-made Hazards. Global and National distribution of different Hazards
Computer Applications in Disaster Risk Management.
Pre-disaster phase – Hazard, Vulnerability and Risk Zonation; Monitoring, Warning and Alert System; Awareness, Preparedness, Planning and Capacity Development.
During Disaster phase – Incident Command System (ICS) and Emergency Operations Centre (EOC), Emergency communication, transportation, rescue, relief, damage and needs assessment, rehabilitation, and restoration of basic facilities and infrastructure.
Post-disaster phase – Reconstruction, Relocation, Recovery and Redevelopment.

Unit III: Geohazards and risk assessment

Lithospheric Hazards: Earthquakes and Faults, Measures of an Earthquake, Earthquake Hazards, Earthquake Control and Prediction. Seismic zonation map of India.
Landslides, Types of slope failure, Slope Mass Rating (SMR) classification, Causative factors, Landslide Hazard Zonation, Factor of Safety analysis, Slope stabilization measures.
Volcanic Hazard: Origin and Types, Products and Hazards, Monitoring, Risk Evaluation, Prediciton, Tectonics and Climate, Meteorite Impacts.
Atmospheric Hazards: Cyclones and Anticyclones, Thunderstorms and Lightning, Hail, Flash Flooding GLOF. Drought.
Hydrospheric Hazards: Fluvial hazards: Flooding, channel migration, bank erosion, catchment erosion. Snow avalanches – snow packages and density, avalanche types, characteristics of avalanche, avalanche prone areas and their mitigation
Coastal Hazards: Tsunamis, Sea Level fluctuation

Unit IV: Practical

Application of listed softwares for Hazard assessment and Risk Management.
Case Studies related various Disasters.

Suggested Readings:

Bell, F.G., 1999. Geological Hazards, Routledge, London.
Bryant, E., 1985. Natural Hazards, Cambridge University Press.
Patwardhan, A.M., 1999. The Dynamic Earth System. Prentice Hall.
Smith, K., 1992. Environmental Hazards. Routledge, London.
Subramaniam, V., 2001. Textbook in Environmental Science, Narosa International
Merriam D.F., (Ed.) 2000. Computer methods in the Geosciences, Elsevier.

Chapman, S.J., 2008 Fortran for Scientists and Engineers (3rd Edn.) McGraw-Hill.

GEOL-UG-E303: Computation-III

Unit I: Concept and Foundation of Remote Sensing & Photogrammetry:
Electromagnetic radiations, Radiation Principles.
Interaction of energy with Atmosphere and Earth Surface features.
Different component of Remote sensing (Source of Energy, Data acquisition, Data interpretation and Reference Data).
An Ideal Remote Sensing System.
Characteristics of Real Remote sensing System.
Introduction to Global Positioning System and DGPS.
Application of Remote Sensing.
Characteristics and applications of imageries of LANDSAT1 to 7, SPOT missions,
Indian Remote Sensing Satellite mission.
Basic idea of hyperspectral image.
Elements of photo interpretation,
Basic characteristics of aerial photographs and camera.
Photographic scales, ground coverage of aerial photographs. Area Measurements, Relief displacement, vertical exaggeration and, distortion of aerial photographs, Image parallax.

Unit II: Visual image interpretation and Digital Image processing
Fundamental of visual image interpretation,
Land use land cover mapping,
Geologic and soil mapping
Introduction to Digital Image processing.
Image rectification and restoration
Image Enhancement
Contrast manipulation
Spatial Feature Manipulation
Multi Image Manipulation
Image Classification

Unit III: GIS and Surveying
Introduction to GIS, Spatial data types
Principles and use of the vocabulary of GIS,
Nature of geographic phenomena and their representation in the context of geo-informatics; Principal data models for spatial and non-spatial data used in GIS databases;
Basic data preparation
Geo-referencing and Data entry into a GIS.
Significance and Principles of Surveying,
Geodetic survey, Datum, Projection and Coordinate System.
Different type of maps: base maps, thematic maps.
Main categories of thematic maps used in earth sciences;
Techniques for legend and symbols in the maps;
Scale & Representative Fraction of maps, Classification of maps according to the scale, effect of the scale on the level of details of the information;
Introduction to Survey methods and application of Compass, Tape, Chain, Plain Table, Theodolite, Electronic Distance Meter, Total Station.
Contouring and Plotting, Measurement of slope heights, aspects and gradients; Use of abney level, pedometer,

Unit IV: Practical

Application of RS & GIS softwares: i. ArcGIS, ii. ERDAS, iii. ILWIS, iv. ENVIS

Hand on Practice on Remote Sensing and GIS softwares as mentioned in different Modules

Field Survey by using: Compass and Tape Survey, Plain Table Survey, and Total Station

Suggested Readings:

Avery, T.U. and Berlin, G.L. 1992 Fundamentals of remote sensing and air photo interpretation, McMillion Publishing Co., New York.

Campbell, J. B. (1996) Introduction to Remote Sensing.

Drury, S.A. 1987. Image interpretation in Geology. Chapman and Hall.

Gupta, R.P. (1991) Remote Sensing Geology. Springer-Verlag. 356pp.

Miller, V.C. & Miller, C.F. 1961. Photogeology. McGraw Hill, New York.

Pandey, S.N. 1987. Principles and applications of photogeology. Wiley Eastern, New Delhi.

Ray, R.G. 1969 Aerial photographs in geologic interpretation. USGS Professional Paper 373.

Punmia, b. C. , Jain, A.K. & Jain, A.K., Surveying (Volume - 1), 2005, Laxmi Publication Ltd.

Basak N N., Surveying and Levelling , 2001 (1st Edition) Tata McGraw Hill Education Private Limited

Bannister, A., Raymond, S. & Baker, R. Surveying 7th Edition, 2006, Pearson Education Singapore Pte Ltd.