

GEOLOGY

UG - Syllabus

Paper	Papertitle	Credit	Marks
Semester I			
GEO-UG-E101	EarthSystemScience, Petrologyand Mineralogy	4	100
GEO-UG-E102	PhysicalSciencesI	4	100
GEO-UG-E103	PhysicalSciencesII	4	100
Total		12	
Semester II			
GEO-UG-E201	Physical Geologyand Sedimentology	4	100
GEO-UG-E202	PhysicalSciencesIII	4	100
GEO-UG-E203	ComputationI	4	100
Total		12	
Semester III			
GEO-UG-E301	PalaeontologyandStratigraphy	4	100
GEO-UG-E302	ComputationII	4	100
GEO-UG-E303	ComputationIII	4	100
Total		12	
Semester IV			
GEO-UG-C401	Igneousand Metamorphic Petrology	4	100
GEO-UG-C402	Geologyof India	4	100
GEO-UG-F403	Communicative English (GFC)	4	100
Total		12	
Semester V			
GEO-UG-C501	Structural and EngineeringGeology	4	100
GEO-UG-C502	GeochemistryandHydrology	4	100
GEO-UG-F503	EasternHimalayanStudies (GFC)	4	100
Total		12	
Semester VI			
GEO-UG-C601	Economic GeologyandCoal&Petroleum Geology	4	100
GEO-UG-C602	Mini Project/IndustrialTraining	4	100
GEO-UG-F603	EnvironmentalStudies (GFC)	4	100
Total		12	

Semester I

GEOL-UG-E101:Earth SystemScience,Petrologyand Mineralogy

UnitI:Concept ofEarthSystemSciencesConcept ofearth systemsciencesand its branchesFormation ofvarious spheres ofearth. Introductionto various branches ofEarth Sciences. SolarSystem, Age ofthe earth,origin ofsolarsystem.meteorsand meteorites.Introductionto GeologicalTimeScale. Internalstructure ofEarth.Concept ofPlateTectonics and its elements.WilsonCycle,Orogeny,Earthquakes. Volcanoes, TsunamiIntroduct ionto Hydrology:Hydrologiccycle.

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: Orthosilicates, Ring & Disilicates, Chain silicates, Sheet silicates and Framework silicates. Non silicates: 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 siliciclastic 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, V.S. and Gupta, A. 2001. Introduction to Geomorphology. Orient

Longman Ltd. Easterbrook, D.J. 1992. Surface processes and landforms. McMillan Publ.

Prothoro and Schwab, 2004, Sedimentary Geology, Freeman and Co. New York,

Sam Boggs, 1995, Principles of Sedimentology and Stratigraphy, Prentice 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 sedimentology, 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. Introduction 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, Addison Wesley 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
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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. McGraw Hill, New York
Cox, K. G. Bel, J. D. and Pankhurst, R. J. 2002. The interpretation of igneous rocks. Allen and Unwin, London
Pankhurst, 2000. Igneous and Metamorphic rocks. Prentice Hall.
Phillips, 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, high ways 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, G.R. 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, S.K. 1993. Structural geology: fundamentals and modern developments, Pergamon Press, London

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. John 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-

Harkn'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,
Seawater 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. Groundwater 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-Sand 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 Gondwan coal fields 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; geological 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 borehole data; Construction of Panel and Fence diagram. Preparation of structure contour and isopach maps of reservoir facies and drawing oil/water contact from borehole 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 ScL Publ. 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: its composition, analysis, utilisation and valuation: E. E. Somermier 2008, McGraw Hill 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 as GSI, NHPC, CGWB etc and submit a report and make presentations.

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, Kepler's 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, Fraunhofer 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

nd half-wave plates, Production and analysis of circularly and elliptically polarized light.
Photoelectric Effect, Wave particle Duality.

Unit III: Electromagnetism and Electronics

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

Conductors and insulators, Electric current, ohm's law, resistivity and resistance.

Magnetic Field, Biot-

Savart's law, magnetic force on a current, Lorentz force, electromagnetic induction, Lenz' 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 NX

OR. 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 Pendulum.

Determination of g by Kater's pendulum or

Bar pendulum. Measurement of Resistance by Meter Bridge.

Series 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 Young's 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
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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 isentropic 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 Coriolis 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 ψ^2 . 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 their general physical properties. Effective nuclear charge, shielding or screening effect, Slater's 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 formation, 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 I st order, II nd 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 K_p , K_c and K_x 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 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: Ehrenfest classification of Phases, Solid–Liquid, Solid–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

(KNO_3 , NH_4Cl). 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, Partial 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, computation 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 coefficient.

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-squared 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, Prediction, 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.

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 components 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 LANDSAT 1 to 7, SPOT missions, Indian Remote Sensing Satellite mission.

Basic ideas 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

Fundamentals of visual image interpretation, Land use and 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 geoinformatics; 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 types 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 a bubble 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, McMillan 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.