

M.Sc. (Applied Geology)

| M.Sc. Previous – First Semester | | Maximum Marks |
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| EPS101 | Introduction to Earth & Planetary Sciences | 70 |
| EPS102 | Sedimentology | 70 |
| EPS103 | Mineralogy & Crystallography | 70 |
| EPS104 | Stratigraphy | 70 |
| EPS105 | Igneous & Metamorphic Petrology | 70 |
| Practical I | | 50 |
| Practical II | | 50 |
| M.Sc. Previous- Second Semester | | |
| EPS201 | Structural Geology | 70 |
| EPS202 | Engineering Geology | 70 |
| EPS203 | Geomorphology, Remote Sensing & GIS | 70 |
| EPS204 | Environmental Geology & Natural Hazards | 70 |
| EPS205 | Palaeontology | 70 |
| Practical I | | 50 |
| Practical II | | 50 |
| M.Sc. Final- Third Semester | | Maximum Marks |
| EPS301 | Economic & Mining Geology | 70 |
| EPS302 | Exploration Geophysics | 70 |
| EPS303 | Geochemistry | 70 |
| EPS304 | Coal & Petroleum Geology | 70 |
| EPS305 | Geohydrology | 70 |
| Practical I | | 50 |
| Practical II | | 50 |

M.Sc. Final- Fourth Semester

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| EPS401 | Geological Fieldwork | 100 |
| EPS402 | Term paper | 100 |
| EPS403 | Dissertation | 150 |
| EPS404 | Seminar | 50 |
| EPS405 | Comprehensive Viva-voice | 50 |

M.SC. PREVIOUS- I SEMESTER

EPS101: Introduction to Earth & Planetary Sciences

Unit I:

Origin of Solar system; Characteristic of planets in detail; Kepler's Laws of Planetary Motion; Bode's Law.

Unit II:

Evolution of the Earth; Earth's internal structure; Earthquakes and Volcanoes; Rock cycle.

Unit III:

Principles of geodesy, Isostasy, Plate tectonics, Continental drift, Geomagnetism, Sea-floor spreading, Features of ocean floor: Continental shelf, slope and rise.

Unit IV:

Composition of the atmosphere and its structure; Study of atmosphere on the basis of lapse rate: Prevailing and adiabatic lapse rates, Isothermal constant lapse rate, dry adiabatic lapse rate, Homogeneous lapse rate; Humidity: definition derivation of relative and absolute humidity; Potential temperature dew point temperature, Instability of dry and moist air; Geopotential; Condensation nuclei; Precipitation.

Unit V:

Fundamental forces in the atmosphere; Coriolis force and the Geostrophic wind, Gradient wind pressure Gradient wind basic structure and mechanism of atmospheric general circulation; Cyclones, Anticyclones. Climate change, Greenhouse warming.

Suggested Readings:

- Gass I.G. et al 1982: Understanding the Earth. Artemis Press (Pvt.) Ltd. U.K.
- Holmes, A. 1992: Holmes Principles of Physical Geology Edited by P. McL. D. Duff. Chapman and Hall, London, 791p.
- Byers, H.R. 1974: General Meteorology, McGraw Hill.
- William Lowrie, 1997: Fundamentals of Geophysics, Cambridge University Press.
- Holton, J. R. and Hakim G. J., An introduction to Dynamic Meteorology, Academic Press, ISBN: 9780123848666, 552p.

EPS102: Sedimentology

Unit I:

Sedimentary rock: definition and its scope; Classification of sedimentary rocks: Conglomerates, Sandstones, Shales, and Carbonate rocks, Provenance of Clastic sediments, Biogenic and Volcanogenic sediments, Diagenesis of Siliciclastic and Carbonate rocks.

Unit II:

Sedimentary textures- Grain size, Roundness, Sphericity, Shape and Fabric; quantitative grain size analysis, Elements of hydraulics, Flow regimes and processes of sediment transport, Different type of sedimentary structures-their genesis and Stratigraphic significance, Penecontemporaneous deformation structure; Biogenic structures; Principles and application of Paleocurrent analysis.

Unit III:

Composition and significance of different types of Sandstone, Limestone, Banded iron formation, Mudstone, Conglomerate; Carbonate Diagenesis and Dolomitization.

Unit IV:

Sedimentary facies and environments, Facies modelling for marine, non-marine and mixed sediments, Carbonate platforms- types and facies models; Reconstruction of Paleoenvironments,

Unit V:

Tectonics and sedimentation, Formation and evolution of sedimentary basins: Geo-synclinal and plate tectonic models, Basin analysis. Principles of sequence Stratigraphy- concepts and factors controlling Base level changes, Parasequence, Clinoform, Systems tract, Unconformity and Sequence boundary.

Suggested Readings:

- Sengupta, S. M. 2007, Introduction to sedimentology. CBS Publication, New Delhi, ISBN 81-239-1491-1, 339 pages.
- Prothero D. R. and Schwab, F. 2004, Sedimentary Geology. Freeman, 600 pages, ISBN (10)-716739054.
- Mc Lane, M. 1995, Sedimentology, Oxford University press, USA (April 27, 1995) ,448 pages, ISBN-10: 0195078683.
- Blatt, H., Middleton, G.V. and Murray, R.C. (1980): Origin of Sedimentary Rocks, Prentice-Hall Inc, New Jersey, 782 pages, ISBN 0-13-642710.
- Collinson, J. D., and Thompson, D.B., 1982: Sedimentary Structures, George Allen and Unwin, London.194 pages.
- Lindholm, R. C., 1987 A Practical Approach to Sedimentology, Allen and Unwin, London, 276 pages.
- Miall, A. D. (2000): Principles of Sedimentary Basin Analysis, Springer-Verlag, 628 pages, ISBN-10: 3540657908.

- Petti john, F. J. (1975): Sedimentary Rocks (3rd Ed.), Harper and Row Publ., New Delhi, 628 pages.
- Reading, H. G. (1997): Sedimentary Environments and facies, Blackwell Scientific Publication, ISBN 0-632-03627-3.
- Reineck, H. E. and Singh, I.B. (1973): Depositional Sedimentary Environments, Springer-Verlag, ISBN 3-540-07377-9.
- Selley, R. C. (2000) Applied Sedimentology, Academic Press, 523 pages, ISBN 0-12 6-36375-7.
- Tucker, M.E. (1981): Sedimentary Petrology: An Introduction, Wiley and Sons, New York, 272 pages, ISBN 0-632-05735-1.
- Tucker, M.E. (1990): Carbonate Sedimentology, Blackwell Scientific Publication, 482 pages, ISBN 0-632-01472-5.

EPS103: Mineralogy and Crystallography

Unit I:

Mineral: definition, physical properties of minerals; Structure and Classification of rock-forming minerals- Olivine, Garnet, Aluminosilicates, Pyroxene, Amphibole, Mica, Feldspar, Clay, Silica and Spinel group.

Unit II:

Study of Gem and Gemstones, Optical properties of minerals.

Unit III:

Twinning and Twin Laws: common types of Twins and their examples in minerals, Zoning, Polymorphism, Pseudomorphism, Isomorphism and Solid solution; Uniaxial and Biaxial crystals, Indicatrix, Pleochroism, Interference figures.

Unit IV:

Symmetry, Miller indices; Concept of unit cell and Bravais lattices; 32 Crystal classes, Types of bonding, Pauling's rules and Co-ordination number.

Unit V:

Introduction to Instrumental Techniques involved in mineral characterization (Powder X-Ray diffraction Analysis, Electron Microprobe Analysis, FTIR and Laser Raman Spectroscopy).

Suggested Readings:

- Dana, E. S. and Ford, W. E.: A Textbook of Mineralogy. Wiley Eastern Limited, New Delhi, 351 pages.
- Deer, W. A., Howie, R. A. and Zussman, J. (2013) An Introduction to the Rock-Forming Minerals (3rd Edition) The Mineralogical Society, London, 498 pages ISBN-978-0903056-33-5.

- Berry, L. G., Mason, B. and Dietrich, R. V.: Mineralogy, CBS Publishers, 550 pages, San Francisco.
- Phillips, F. C., Introduction to Crystallography, ELBS, Longman, Glasgow, 349 pages.
- Kerr, P. F., Optical Mineralogy. McGraw Hill Book Company. ISBN-13: 9780070342187 ISBN: 0070342180.
- Klein, C. and Hurlbut, C. S., Jr. (1977) Manual of Mineralogy (21st Revised Edition), John Wiley Sons, Inc., New York, 681 pages. ISBN 0-471-31266-5.
- Winchell, E. N.: Elements of Optical Mineralogy, 551 pages, John Willey & Sons Inc, ISBN 0471952710.

EPS104: Stratigraphy

Unit I:

Basic principles and definitions; Stratigraphic classification and Nomenclature; Brief account on Magnetostratigraphy, Stable Isotope Stratigraphy, Tephrochronology and Event Stratigraphy; Stratigraphic correlation, Palaeontological and non-Palaeontological criteria of correlation; Graphic correlation; Facies concept in stratigraphy; Lateral migration of facies, Physiographic divisions, Structure and tectonic history of Indian subcontinent; Precambrian basement of Indian Peninsula.

Unit II:

Introduction to Sequence stratigraphy depositional sequence, Sequence architecture types and Boundaries, Conformity and types of Sequence Unconformities; Flooding surface, maximum flooding surface, marine flooding surface; Bed, Bedset, Parasequence, Parasequence boundary, Parasequence set; System tracts - Lowstand system tract, Transgressive system tract, Highstand system tract, Overlap, off lap, Top lap and On lap, Aggradation, Progradation, Retrogradation, Transgression and Regression; Eustatic sea level changes, sediment supply, Basin subsidence rate, and Accommodation.

Unit III:

Archaean rocks: distribution, Classification and Economic importance; Precambrian basement of Extra-peninsula- Tethyan basement, Lesser Himalaya; Basement-cover transition; Proterozoic formations of Indian Peninsula- Cuddapah, Delhi, Bijawar and Gwalior Group and their equivalents. Vindhyan Supergroup and its equivalents; Correlation of equivalent Proterozoic formations in Extra-peninsular India. Chronology of Orogenies.

Unit IV:

Paleozoic Era- Paleogeographic, Paleoclimatic and tectonic set up, A detailed study of succession, lithology, Age, Depositional environments, Economic importance and fossil contents of various formations of Salt Range, Tethys Himalaya and Lesser Himalaya Ranges; Gondwana sequences. Mesozoic Era- Paleogeographic, Paleoclimatic and tectonic set up formations of Extra-peninsular and Peninsular India.

Unit V:

Cenozoic Era- Paleogeographic, Paleoclimatic and tectonic set up along with Himalayan Orogeny. A detailed study of succession, Lithology, Age, Depositional environments, Economic importance and fossil contents of various Paleogene and Neogene formations of Extra-peninsular and Peninsular India; Siwalik Supergroup. Deccan Traps: distribution, Petrology and age. Lameta beds, Bagh beds, Inter-trappeans and Infra-trappeans.

Suggested Readings:

- Krishnan, M.S. 1982 Geology of India and Burma, CBS Publ, Delhi, 536 pages, ISBN 81-239-0012-0, John Wiley and Sons, New York. 356 pages.
- Nichols, G. 1999, Sedimentology and stratigraphy, Blackwell Science, Oxford, 355 pages, ISBN 0-632-03578-1.
- Ramakrishnan, M and Vaidyanadhan, R. 2008, Geology of India(In 2 Volumes), Geological Soc. of India, Bangalore, ISBN 9788185867779.
- Kumar, R. 1996, Fundamentals of Historical geology and stratigraphy of India, publisher: New Delhi: New Age International Publishers, 254 pages, ISBN 0852267452.
- Schoch, R.M. 1989, Stratigraphy: principles and methods, Van Nostrand Reinhold, 375 pages, ISBN 0442280211.
- Coe, Angela, Dan Bosence, Kevin Church, Steve Flint, John Howell and Chris Wilson (2002): The Sedimentary Record of Sea Level Change, Cambridge Univ. Press.
- Emery, D, (1996): Sequence Stratigraphy, Blackwell Scientific Publ.
- Miall, A.D. (1997): The Geology of Stratigraphic Sequence, Springer-Verlag.
- Reineck, H.E., and Singh, I.B. (1980): Depositional Sedimentary Environments, Springer-Verlag.

EPS105: Igneous and Metamorphic Petrology

Unit I:

Igneous Petrology: Definition of important rock types, Structural and tectonic control and mode of emplacement of different igneous rocks, Classification of igneous rocks.

Unit II:

Elements of Thermodynamics, Enthalpy, Entropy, Gibb's free energy, Phase equilibria studies on different rock types at variable temperature and pressure, different systems of binary, ternary diagram, Solid solution series.

Unit III:

Detail studies on rocks of Basalt family, Granites family, Kimberlites, Peridotites, Komatites, Ophiolites, Feldspathoid-bearing volcanic rocks, Lamprophyres and Anorthosites.

Unit IV:

Metamorphic Petrology: Concepts of metamorphic facies, Different facies and sub-facies assemblages in a P-T grid, Graphic representation of typical facies assemblages.

Unit V:

Schreinemaker principle in relation to invariant, invariant and singular point assemblages, Contact, Burial and Regional metamorphism, (Green Schist facies and Almandine Amphibolite facies), Granulite facies migmatization and Shock Metamorphism.

Suggested Readings:

- Bose, M.K. (1997): Igneous Petrology, World Press, Kolkata, 568 pages.
- Best, Myron G. (2002): Igneous and Metamorphic Petrology, Blackwell Science, CBS publ., Delhi, 729pages, ISBN 1-40510-558-7.
- Cox, K.G., Bell, J.D. and Pankhurst, R.J. (1993): The Interpretation of Igneous Rocks, Chapman and Hall, London, 450 pages, Allen &Unwin, ISBN 041253410X.
- Faure, G. (2001): Origin of Igneous Rocks, Springer, ISBN 3 540 67772 0 Hall, A. (1997): Igneous Petrology, Longman,
- LeMaitre R.W. (2002): Igneous Rocks: A Classification and Glossary of Terms, Cambridge University Press, 252 pages, ISBN (10) 052166215, ISBN (13) 978 0521662154.
- McBirney (1994): Igneous Petrology, CBS Publ., Delhi, ISBN 0-87735-323-9, 509 pages.
- Phillipotts, A.R. (1994): Principles of Igneous and Metamorphic Petrology, Prentice Hall of India, 498 pages.
- Sood, M.K. (1982): Modern Igneous Petrology, Wiley-Interscience Publ., New York.
- Wilson, M. (1993): Igneous Petrogenesis, Chapman and Hall, London, 466 pages, ISBN 0-04-552025-9.
- Winter, J.D. (2001): An Introduction to Igneous and Metamorphic Petrology, Prentice Hall, New Jersey.
- Bucher, K. and Martin, F. (2002): Petrogenesis of Metamorphic Rocks (7th Rev. Ed.), Springer-Verlag, ISBN 3-582-30096-7.
- Yardley, B.W.D., Mackenzie, W.S. and Guilford, C. (1995): Atlas of Metamorphic Rocks and their textures, Longman Scientific and Technical, England.
- Yardlley, B.W.D. (1989): An Introduction to Metamorphic Petrology, Longman Scientific and Technical, New York, ISBN 0-582-30096-7.

Practical papers:

Practical-I

Crystallography & Mineralogy:

Identification of rock-forming minerals in hand specimens. Study of the optical properties of rock forming minerals in thin sections. Megascopic and microscopic study of important igneous rocks.

Atomic structure models. Characterization and identification of gems and gem stones. Representation of symmetry elements of crystals belonging to 32 classes of symmetry.

Practical-II

a) *Igneous and Metamorphic Petrology:*

Plotting of important igneous rock suits on the map of India. Preparation of tables and charts of textures and structures. Study of igneous rocks in hand specimen and under microscope. Plotting of Important metamorphic rock suited on the map of India. Preparation of tables and charts of textures and structures. Study of metamorphic rocks in hand specimen and under microscope.

b) *Sedimentology:*

Study of sedimentary rocks in hand specimen and under microscope. Grain-size analysis, Identification of clay minerals, Roundness and shape analyses of clastic grains, Heavy mineral analysis, Study of sedimentary structures and Paleocurrent analysis, Megascopic and microscopic study of sedimentary rocks, Staining techniques for identification of carbonate minerals, Study of profile sections of some selected sedimentary environment.

M.Sc. PREVIOUS- II SEMESTER

EPS201: Structural Geology

Unit I:

Definition, Primary and Secondary structures, Methods and application of structural geology. Fold elements and terminology, Classification: Geometrical, Morphological and Genetic, Origin and Development of folds, Superposed Folds. Determination of top and bottom of beds. Recognition and Representation of folds.

Unit II:

Classification, and origin of joints, relation to other structures. Faults, terminology and Classification, Structures associated with faults. Gravity, Thrust and Strike-slip faults classification and description. Mechanics of fracturing. Block, Rifted and Wrench-faulted regions, Thrusts and Nappe structures, Tectonic mélanges, Dome and Basin structures, Metamorphic terrains, Mylonite zone and Pseudotachylytes.

Unit III:

Different types of unconformities, Meteoritic Impact structures and Impactites, Collapse compaction, Diapers, Salt domes. Salient structural features of the Himalayan Arc. Indo-Gangetic Plains, Peninsular India and Indian Ocean.

Unit IV:

Fundamental concept of Geo-tectonics, its practical and Theoretical importance. Organic and Epeirogenic Phases; Concept and theories of Isostasy; Origin and significance of Mid-Oceanic Ridges

and Trenches; Island arcs and Mountain chains, Their global distribution and evolution. Concept of Sea floor spreading; Evidence of continental drift, Concept of Plate Tectonics, Nature and types of Plate Margins, Geometry and Mechanism of Plate Motion. Tectonic and Economic significance of Plate Tectonics.

Unit V:

Impact Cratering and Impact Tectonics, Stress and Strain, Orogenic Belts of India and the World.

Suggested Readings:

- George H. Davis and Stephen J. Reynolds, 1996, Structural Geology of Rocks and Regions, John Wiley & Sons, Inc., 492p. ISBN- 047152621-5
- Robert D. Hatcher, 1995, Structural Geology, principles, Concepts, and Problems, Prentice Hall, 525p. ISBN-0023557133.
- S. K. Ghosh, 1993, Structural Geology, Fundamentals and Modern Developments, Pergamon Press, 598p. ISBN-0080418791.
- Subip Kumar Ghosh and Sudipta Sengupta and S. Sengupta, 1997, Evolution of geological structures in Micro- to Macro-scales, Springer, Berlin.446p. ISBN-0412750309.
- John G. Ramsay and Martin I. Huber, 2003, The Techniques of Modern Structural Geology, Volume 1: Strain Analyses, Academic Press, 305p. ISBN-0-12-576921-0.
- John G. Ramsay and Martin I. Huber, 2003, The Techniques of Modern Structural Geology, Volume 2: Folds and Fracture, Academic Press, 697p. ISBN-0-12-576902-4
- Stephen Marshak and Gautum Mitra, 1988, Methods of Structural Geology, Prentice Hall, 446p. ISBN- 0130651788
- Richard J. Lisle, 2003, Geological Structures and Maps: A Practical Guide, Butterworthheinemann, 124p. ISBN-0750657804
- R. G. Park, 2004, Foundation of Structural Geology, Routledge, 202p. ISBN-074875802X.
- Haakon Fossen, 2010, Structural Geology, Cambridge University Press, 463p. ISBN-9780521516648.
- David D. Pollard and Raymond C. Fletcher, 2005, Fundamentals of Structural Geology, Cambridge University Press, NewYork, 500p. ISBN-10 0-521-83927-3.
- Donal M. Ragan, 2009, Structural Geology: An Introduction to Geometrical Techniques, Cambridge University Press, 602 p. ISBN-0521897580.
- Windley B. 1973: The Evolving continents. John Wiley & Sons, New York.
- Condie, Kent. C. 1982. Plate Tectonics and Crystal Evolution Pergamon Press Inc., New York, 310 p.

EPS202: Engineering Geology

Unit I:

Engineering geology- Importance of earth sciences in engineering. Mechanical Properties of Rocks and Soils: Elastic, An-elastic and Plastic behaviour of material, Stress and Strain state in rocks, Longitudinal

strain, Shear strain, Young's modulus, Rigidity modulus, Bulk modulus, Compressibility, Poisson's ratio.

Unit II:

Earth Movements Types Causes and Remedial Measures: Landslides in clayey rocks. Sliding movement in hard rocks. Stabilization of slopes in slide areas and other preventive measures. Construction Materials: Geological criteria for selection of construction material for various uses, viz. Concrete aggregate rip-rap, Rigid and Flexible Pavements, Facing, Roofing and Raving. Environmental impact on materials.

Unit III:

Foundation of Building, Industrial Structures and Bridges: Mechanical behaviour of foundation rocks and soils. Geological investigation of the building or bridge sites. Tunnels and Underground Power Plants: Types of tunnels, Tunnelling methods, Geological investigations along tunnel alignments. Potential geological hazards and Suggested remedial measures.

Unit V:

Hydraulic Structures: Types of Dams. Basic considerations of forces on dams, Geological and geomorphological criteria for selection of dam sites. Dam sites on igneous, Metamorphic and Siltation of reservoirs.

Suggested Readings:

- Krynine, D.H. & Judd, W.R. (1998) Principles of Engineering Geology, CBS Edition, 730 pages, ISBN 81-239-0603-X.
- Schultz, J.R. & Cleaves, A.B. (1951) Geology in Engineering, John Willey & Sons, New York.
- Prabin Singh, (2013) Engineering and General Geology. S.K. Kataria & Sons.

EPS203: Geomorphology, Remote Sensing & GIS

Unit I:

Basic concepts and significance of Geomorphology, Concept of erosion cycles. Geomorphology of Fluvial tracts, Arid zones, coastal regions, Karst landscapes and Glaciated ranges. Rock weathering and soils, Mass wasting. Influence of climate on processes.

Unit II:

Morphometric analysis of river basin, applications of geomorphology in mineral prospecting, Civil engineering, Hydrology and Environmental studies.

Unit III:

Topographical maps- projections, scale. Geomorphology of India: Peninsular, Extra-peninsular and Indo-Gangetic Plains.

Unit IV:

Basics of Remote Sensing, Electromagnetic spectrum; Electromagnetic bands in remote sensing; Spectra of common natural objects– soil, rock, water and vegetation. Aerial photos – types, scale, resolution; properties of aerial photos, stereoscopic parallax, Relief displacement; General Orbital characteristics of remote sensing satellites; General sensor characteristics of remote sensing satellites: LANDSAT, IRS, SPOT.

Unit V:

Digital Image Processing, Elements of Photo and Imagery pattern and Interpretation– drainage, erosion, details, Grey tones; Principles and components of GIS, applications of GIS in various geological aspects.

Suggested Readings:

- Thornbury, W.D. 1980: Principles of Geomorphology. Wiley Eastern Ltd., New York.
- Holmes, A. 1992: Holmes Principles of Physical Geology Edited by P. McL. D. Duff. Chapman and Hall, London.
- Halis, J.R. 1983: Applied Geomorphology.
- Sharma, H.S. 1990: Indian Geomorphology. Concept Publishing Co. New Delhi.
- Drury, S.A. (1987) Image Interpretation in Geology. Allen and Unwin ,290 pages, ISBN 0-632-054085.
- Lillesand, T.M. and Kiefer, R.W. (1987) Remote Sensing and Image Interpretation. John Wiley, New York, 610 pages.
- Siegal, B.S. and Gillespie, A.R. (1980) Remote Sensing in Geology. John Wiley
- Gupta, R.P. (1991) Remote Sensing Geology, Springer, Berlin, ISBN 81-8128-283-3, 655 pages.
- Sabins, F.F. 2007, Remote Sensing: Principles and Interpretation, Waveland Pr Inc., New York, 432 pages, ISBN 0716724421.

EPS204: Environmental Geology and Natural Hazards

Unit I:

Time scales of global changes in the ecosystems and climate. Concepts and principles of environmental geology, Environmental hazards- prevention and precautions.

Unit II:

Earthquakes: seismic waves, Ray-path geometry in layered ground, loss of seismic energy, seismic energy sources, detection and recording of seismic waves, applied seismology. Distribution, magnitude and intensity of earthquakes.

Precaution and prevention measures of following hazards: Floods: their causes and control. Landslides: Landslide hazards: causes and investigations; Coastal erosion: causes and related engineering structures.

Unit III:

Global warming: caused by CO₂ increase in present atmosphere due to indiscrete exploitation of fossil fuels, deforestation. Water: Impact assessment of degradation and contamination of surface water and groundwater quality due to industrialization and urbanization. Soil: Soil profiles and soil quality degradation due to irrigation, use of fertilizers and pesticides. Population increase: Urbanization and land use changes and related hazards.

Unit IV:

Disaster management: Evaluating hazards, past history, linkages between hazardous events, precursor events, prediction, probability of occurrence, risk determination, acceptable risk, problems and opportunities in risk assessment, human response to hazard and disaster, artificial control of natural processes.

Unit V:

Milankovitch cycle, Sea level rise, Eutrophication and Acid rain, Biogeochemical cycle of carbon; Geological investigations of nuclear waste disposal sites; Application of remote sensing and geographic information systems (GIS) in environmental geology.

Suggested Readings:

- Valdiya, K.S. (1987) Environmental Geology – Indian Context. Tata McGraw Hill. ISBN: 0074519719 9780074519714.
- Keller, E.A. (1978) Environmental Geology, Bell and Howell, USA, 562 pages, ISBN: 0-13-022466-9.
- Bryant, E. (1985) Natural Hazards, Cambridge University Press.
- Patwardhan, A.M. (1999) The Dynamic Earth System. Prentice Hall, ISBN: 81203149649788120314962.
- Subramaniam, V. (2001) Textbook in Environmental Science, Narosa International, 238 pages, ISBN: 0849324084 9780849324086.
- Bell, F.G. (1999) Geological Hazards, Routledge, London, ISBN: 0-419-16970-9, 324 pages, ISBN 0 415 01217 1
- Reynolds J. M. (1998) An introduction to Applied and Environmental Geophysics, John Wiley & sons, England, ISBN: 0-471-96802, pp. 796.

EPS205: Palaeontology

Unit I:

Definition, objectives and scope. Conditions and modes of fossilization. Organic evolution and classification. Concept of species. Habit and habitats. Dispersal, migration and extinction. Paleoecology, concepts and approaches. Taphonomy.

Unit II:

Detailed shell morphology, classification, composition and structure of the shell and geological description of the following invertebrate fossil groups; Brachiopoda, Bivalvia, Gastropoda and Cephalopoda.

Unit III:

Morphology, classification and geological description of Echinoidea, Trilobita, Graptoloidea and Corals. Evolutionary trends in Graptoloidea and Ammonoidea. Functional morphology of bivalvia. Buoyancy of cephalopod shells. Heteromorphs and extinction in ammonites.

Unit IV:

Elements of micropaleontology and its applications. Collection and preparation of microfossils. Types of microfossils. Brief morphological study of the following types of microfossils and their paleoceanographic and paleoenvironmental significance; Calcareous (Foraminifera, Ostracoda, Pteropods and Calpionellids), Siliceous (Radiolaria, Diatoms).

Unit V:

Brief morphological study of Phosphatic (Conodonts) and Organic-walled (Acritarchs, Tasmanitids and Dinoflagellates) microfossils. Introduction to paleobotany with special reference to Gondwana plant fossils. Introduction to vertebrate paleontology. Vertebrate life through geological time. Study of Siwalik vertebrate fauna. Brief study about evolution of dinosaur, horse, elephant and primate.

Suggested Readings:

- Clarkson, E.N.K. (1998) Invertebrate Palaeontology and Evolution, ELBS/Allen & Unwin, London,382, ISBN 0-04-560010-4.
- Prothero, D.R. (1998) Bringing Fossil to Life – An Introduction to Palaeontology (McGraw Hill),457 pages, ISBN 0070521972, 9780070521971.
- Raup, D.M. and Stanley, S.M. (1985) Principles of Palaeontology (CBS Publications), W.H. Freeman and Company, New York, 481 pages.
- Colbert, E.H. (1984): Evolution of Vertebrates. Wiley Eastern Ltd., ISBN 085556 125 X, New Delhi, 535 pages.
- Benton, M.J. (1990): Vertebrate Paleontology. Unwin Hyman, London, 452 pages, ISBN 0-632-05614-2.
- Haq, B. U. and Boersma, A., (1998) Introduction to Marine Micropaleontology, Elsevier, 376pages, ISBN 0444826726.

Practical-I

Structural Geology:

Determination of true dip from apparent dip measured in different directions, determination of angle of pitch, plunge, etc. from the knowledge of attitude of folds, interpretation of geological structures from maps, solution of various structural geological problems by graphical and stereographic projection. Introduction to Clinometer, Brunton, Hammer and field instruments.

Practical-II

Palaeontology:

Study of specimens illustrating various nature and modes of occurrence of fossils. Study of morphological characters of some important Invertebrate fossils. Study of functional morphology of Bivalvia shells. Study of morphological characters of some important Gondwana plant fossils. Microscopic study of various types of microfossils.

M.Sc. FINAL- III SEMESTER

EPS301: Economic and Mining Geology

Unit I:

Mode of occurrence, origin, classification of economic deposits (magmatic, metamorphic, contact metasomatic, sublimation, hydrothermal, oxidation and supergene enrichment and sedimentary), Porphyry and skarn mineralisation. Fluid inclusion studies.

Unit II:

Mineralisation associated with (i) Ultramafic, mafic and Acidic rocks, (ii) Greenstone belts, (iii) Komatiites, Anorthosites and Kimberlites and (iv) Submarine volcanism, Stratiform and Strata bound ores. Ores and metamorphism cause and effect relations, Forms of ore deposits,

Unit III:

Methods of ore microscopy, Geothermometry, Metallogenic epochs and provinces of India, Strategic, essential and Critical minerals with examples. Origin and distribution of important metallic (base metals, iron, manganese, aluminium, chromium, nickel, gold, silver, molybdenum) and Non-metallic mineral deposits (asbestos, barytes, gypsum, graphite, apatite and beryl), Phosphorite deposits, Rare earth mineral deposits, Raw material for ceramic, refractory, cement, paint, fertilizer, and glass industries and building stones, Gemstones. Distribution of mineral deposits in India.

Unit IV:

Introduction: Classification of mining methods. Mining Methods: Placer mining methods, open pit methods, Underground mining methods, Coal Mining methods and Ocean bottom mining methods; their advantages and disadvantages. Ventilation in underground mining: Purpose, types and arrangements of ventilation in underground mining. Mining hazards and safety measures.

Unit V:

India's status in mineral production; co-products and by-products, consumption, substitution and conservation of minerals; National Mineral Policy, Mineral Concession Rules, Marine mineral resources and Laws of the sea.

Suggested Readings:

- McKinstry, H. E. (1976) Mining Geology, Prentice Hall, Englewood Cliffs, N.J. 680 pages.
- McKinstry, H.E. Mining Geology, Prentice Hall, Englewood Cliffs, N.J.
- Clark, G.B. (1967) Elements of Mining, III ed. John Wiley, 780 pages, ISBN-10: 0471533319.
- Arogyaswami, R.P.N. (1996) Courses in Mining Geology, IV Ed. Oxford IBH.
- Gaudin, A.M. Principles of Mineral Dressing. McGraw Hill Pub. Co. Ltd. Bombay.
- Prasad, U. 2003, Economic geology, CBS Publ, Delhi, 319 pages, ISBN 81-239-0460-6.
- Bateman, A.M. 1959, Economic mineral deposits. Asia Publ. House, 916p.
- Evans, A.M. 1993, Ore geology and Industrial minerals, Blackwell, 389pages, ISBN 0-632-02953-6.
- Mookherjee, A. 2000, Ore genesis-A holistic approach, allied Publ, New Delhi, 657 pages, ISBN81-7032-576-6.
- Stanton, R.L. (1972): Ore Petrology, McGraw Hill, New York,713 pages, ISBN 10: 0070608431.

EPS302: Exploration Geophysics

Unit I:

Basic principles of geophysical exploration. Gravity Method: Gravity force and potential, Stable and unstable gravimeters, field procedure and reduction of gravity data. Various types of corrections applied to gravity data, preparation of gravity anomaly maps. Gravity effect of spherical body.

Unit II:

Magnetic Method: Basic Theory, inverse square law, concept of potential, magnetism on atomic scale, Dia- para- ferro magnetic materials, susceptibilities and densities of various rocks and minerals, magnetic properties of rocks. Basics of Magnetometer.

Unit III:

Electrical methods: Electrical resistivity, current distribution in homogeneous ground due to single electrode and dipoles. Resistivity method: Basic principles, various types of electrode configurations, Wenner, and Schlumberger configurations, Elements of SP and IP method.

Unit IV:

Seismic Method: Elementary principle of reflection and refraction methods. Ray parameter. Geometry for seismic wave paths: Reflection from single-horizontal interface, normal-move-out. Different methods for velocity estimation. Dipping reflector, Dip-move-out.

Unit V:

Geometry of Seismic refraction paths. Head waves, single-horizontal refractor, method of estimation of velocity of layers and depth of the interface. Estimation of velocity and thickness of layers. Intercept time, delay time. Geophones, Electromagnetic geophones. Hydrophones.

Suggested Readings:

- Telford, Geldart, Sheri and Keys, (2004); Applied Geophysics, Cambridge University Press, 792pages, ISBN-10: 0521339383.
- Milton B. Dobrin, (1988); Introduction to Geophysical Prospecting, 3rd Ed., McGraw Hill, 630pages, ISBN: 0070171955.
- William Lowrie, (1997); Fundamentals of Geophysics, Cambridge University Press, 354 pages, ISBN: 0-52-63454 7.
- Edwin S. Robinson, (1988); Basic Exploration Geophysics, John Wiley & Sons, 562 pages, ISBN: 0-471-87941-x.
- Gadallah, M.R., Fisher, R., Fisher, R.L., (2008); Exploration Geophysics, ISBN 978-3-540-85159-2, Springer.

EPS303: Geochemistry

Unit I:

Introduction of Geochemistry and Cosmochemistry. Chemical composition and properties of Earth's layers. Atmosphere: its layers, chemical composition and evolution of Atmosphere. Meteorites, classification, mineralogy, origin, significance and phenomena of fall.

Unit II:

Geochemical cycle; Minor cycle and Major cycle. Geochemical classification of elements. Periodic table with special reference to rare earth elements and transition elements.

Unit III:

Stable isotope geochemistry of Carbon, Hydrogen, Oxygen and Nitrogen and its application in Geology, Cosmogenic radionuclides.

Unit IV:

Radiogenic isotopes. Decay scheme and methods of dating by K-Ar, Ar-Ar, Sm-Nd, Re-Os, Lu-Hf, U-Pb and Rb-Sr. Isotope systematics in two component mixtures, Sr and Nd isotope geology in meteorites, igneous rocks, sedimentary rocks, fission track dating.

Unit V:

Various sample preparation techniques in geochemical analyses; Historical development of Mass Spectrometers, principle, application and their utility in geochemistry.

Suggested Readings:

- Rankama, K. and Sahama, Th. G. (1950) Geochemistry. Univ. Chicago Press.
- Mason, B. and Moore, C.B. (1991) Introduction to Geochemistry, Wiley Eastern.
- Krauskopf, K.B. (1967): Introduction to Geochemistry. McGraw Hill, 616 pages, ISBN 0-07-035447-2.
- Fyfe, W. S. (1964): Geochemistry of Solids. McGraw Hill, New York, ISBN 10: 0070226458
- Evans, R. C. (1964): Introduction to Crystal Chemistry. Cambridge Univ. Press, Cambridge, 410pages.
- Bloss, F. D. (1971): Crystallography and Crystal Chemistry. Holt, Rinehart, and Winston, New York, 545 pages, ISBN 1878907026.
- Klein, C. and Hurlbut, C. S.(1993): Manual of Mineralogy, John Wiley & Sons, New York, 682pages, ISBN 0-471-31266-5.
- G. Faure, Principles of Isotope Geology, John Wiley & Sons.
- Das H. A., A. Faanhof and H. A. Van Der Sloot, Radioanalysis in Geochemistry, Elsevier Publishers.
- Allan P. Dickin, Radiogenic isotope geology.

EPS304: Coal and Petroleum Geology

Unit I:

Definition and origin of coal. Sedimentology of coal bearing strata, types of seam discontinuities and structures associated with coal seams. Chemical analysis of coal (proximate and ultimate analysis).

Unit II:

Coal Petrology – concept of ‘Lithotype’, ‘Maceral’ and ‘Micro-lithotype’. Classification and optical properties of macerals and micro-lithotypes. Application of coal petrology. Classification of coal in terms of Rank, Grade and types. Elementary Idea about coal preparation, Coal carbonization, Coal gasification, Coal hydrogenation, coal Combustion and fertilizer form coal.

Unit III:

Coalbed methane – a new energy resource. Elementary idea about generation of methane in coalbeds, coal as a reservoir and coalbed methane exploration. Coal as a source rock in petroleum generation. Geological and geographical distribution of coal and lignite deposits in India. Indian coal reserves and production of coal in India. Coal exploration and estimation of coal reserves.

Unit IV:

Petroleum – its composition. Origin (Formation of source rocks-kerogen, organic maturation and thermal cracking of kerogen) and migration of petroleum. Reservoir rocks-porosity and permeability.

Reservoir traps – structural, Stratigraphic and combination traps. Oilfield fluids –water, oil and gas. Oil shale.

Unit V:

Methods of prospecting for oil and gas (geological modelling). Elementary knowledge of drilling and logging procedures. An outline of oil belts of the world. Onshore and offshore petroliferous basins of India. Geology of productive oilfields of India.

Suggested Readings:

- Chandra, D., Singh, R. M. Singh, M. P. (2000): Textbook of Coal (Indian context). Tara Book Agency, Varanasi.
- Singh, M. P. (Ed.) (1998): Coal and organic Petrology. Hindustan Publishing Corporation, New Delhi.
- Scott, A. C. (1987): Coal and Coal-bearing strata: Recent Advances. The geological Society of London, Publication no. 32, Blackwell scientific Publications.
- Stach R. (1982): Textbook of Coal petrology. Gebruder Borntraeger, Stuttgart.
- Stach, E., Mackowsky, M-Th., Taylor, G. H., Chandra, D., Teichmuller, M. and Teichmuller. Holson, G. D. and Tiratso, E. N. (1985): Introduction to Petroleum Geology. Gulf Publishing, Houston, Texas.
- Tissot, B. P. and Welte, D. H. (1984): Petroleum Formation and Occurrence, Springer – Verlag. ISBN: 3540086986.
- North, F. K., (1985): Petroleum Geology. Allen Unwin, ISBN: 0045530033 9780045530038 0045530041 9780045530045.

EPS305: Geohydrology

Unit I:

Hydrology cycle, Precipitation, Evaporation, Evapotranspiration, Seepage, Infiltration and runoff, Availability of water in the world, Origin of groundwater, Subsurface distribution of water, Springs. Hydrology Properties of Water Bearing Materials: Porosity, Types of porosity, Permeability, Transmissivity, Storativity, Specific yield, Specific retention.

Unit II:

Mode of occurrence of groundwater. Classification of rock with respect to their water bearing characteristics, Aquifers, Aquicludes, Aquifuge, Aquitards, Classification of aquifers and groundwater provinces.

Unit III:

Movement of groundwater: Darcy's law, Reynolds number, and range of validity of Darcy's law, theory of groundwater flow under steady and unsteady conditions, Hydraulic conductivity and Intrinsic

permeability, Determination of permeability, Transmissivity and Storativity by discharging pump tests. General flow equation.

Unit IV:

Hydro-geochemistry: Physical and Chemical characteristics of groundwater, Classification of groundwater in respect to domestic, irrigation and industrial use, Pollution of groundwater.

Unit V:

Ground Water Exploration and Management: Natural and Artificial recharge of groundwater, Water balance, Analysis of hydrograph, Conjunctive and Consumptive use of groundwater.

Suggested Readings:

- David Keith Todd (2005): Groundwater Hydrology, 3rd edition, Wiley; 537 pages, ISBN: 978-047105937.
- Roy Ward and Mark Robinson (1999): Principles of Hydrology, (4th edition), McGraw-Hill. ISBN-13:978-0077095024.
- Chow, (1964): Handbook of Applied Hydrology, McGraw-Hill. ISBN: 0070107742 9780070107748.
- Raghunath H. M. (2002): Hydrology: Principles, Analysis and Design, Publisher: New Age International, ISBN: 8122418255.
- Karanth K. R. (1987): Ground Water Assessment, Development and Management of Water Resources, McGraw-Hill, ISBN: 9780074517123.

Practical Papers

Practical-I

a) Economic and Mining Geology: Study of ore minerals in hand specimen and under microscope. Preparation of mineral map of India.

b) Remote sensing & GIS: Determination of scale in aerial photos. Measurement of heights of objects from aerial photos, Study and interpretation of single and stereopair aerial photos, Basic application of ArcGIS SOFTWARE.

Practical-II

a) Geo-exploration:

1. Determination of velocities and depth of the interface by refraction method.
2. To estimate the overburden and vertical depth of horizontal layer.
3. To apply the corrections to gravity data.
4. Delineate the ore body using gravity and magnetic data.
5. Computation of gravity effect of a sphere.

b) Geohydrology:

Determination of average rainfall. Determination of maximum intensity of rainfall for different time durations. Determination of Hydraulic conductivity and Radius of influence of the Well for different types of aquifers. Classification of irrigation water on the basis of SAR and Conductivity.

B) Field Geology: Students will be required to carry out fieldwork for 1 week in suitable geological areas to study various aspects of field geology and submit a report thereon.

M.Sc. FINAL- IV SEMESTER

EPS401: Field Geology

Geological field work in some appropriate areas. Submission of report thereon.

EPS402: Term paper

Student has to select any topic of his/her choice from any one branch of Geology for detail study of the recent developments based on research papers published on that topic and to prepare a write up.

EPS403: Dissertation

Student has the choice to select a topic of interest from any branch of geology to do the project-oriented dissertation thesis under the supervision of a faculty member. This includes field study, lab work, data generation and thesis writing.

EPS404: Seminar

Student has to give seminar on a suitable topic.

EPS405: Viva-voce

A viva-voce examination will be conducted based on the complete course of M.Sc. (Applied Geology).