Course Scheme of M.Sc. (Applied Geology)
Department of Earth Science: Assam University, Silchar

First Semester

Course No.	Course Title	Mark Distribution			Credit	Contact Hours
		Semester	Sessional	Total		
ES 101	Geomorphology, GIS and Remote Sensing	75	25	100	5	50
ES 102	Palaeontology	75	25	100	5	50
ES 103	Mineralogy	75	25	100	5	50
ES 104	Geochemistry and Isotope Geology	75	25	100	5	50
ES 105	Practical on ES 101 and ES 102	37.5	12.5	50	2.5	50
ES 106	Practical on ES 103 and ES 104	37.5	12.5	50	2.5	50
	Total	375	125	500	25	300

Second Semester

Course No.	Course Title	Mark Distribution			Credit	Contact Hours
		Semester	Sessional	Total		
ES 201	Igneous and Metamorphic Petrology	75	25	100	5	50
ES 202	Sedimentology	75	25	100	5	50
ES 203	Open Course (Physics and Dynamics of Earth)	75	25	100	5	50
ES 204	Hydrogeology	75	25	100	5	50
ES 205	Practical on ES 201 and ES 202	37.5	12.5	50	2.5	50
ES 206	Field Work and Practical on ES 204	37.5	12.5	50	2.5	90
	Total	375	125	500	25	340

Third Semester

Course No.	Course Title	Mark Distribution			Credit	Contact Hours
		Semester	Sessional	Total		
ES 301	Structural Geology and Tectonics	75	25	100	5	50
ES 302	Petroleum Geology	75	25	100	5	50
ES 303	Open Course (Earth's Physical Processes and Geoinformatics)	75	25	100	5	50
ES 304	Elective Course (I. Oceanography II. Seismology)	75	25	100	5	50
ES 305	Practical on ES 301 and ES 302	37.5	12.5	50	2.5	50
ES 306	Field Work and Practical on ES 304	37.5	12.5	50	2.5	90
	Total	375	125	500	25	340

Fourth Semester

Course No.	Course Title	Mark Distribution			Credit	Contact Hours
		Semester	Sessional	Total		
ES 401	Ore Geology and Mining Geology	75	25	100	5	50
ES 402	Environmental Geology and Geo-Engineering	75	25	100	5	50
ES 403	Principles of Stratigraphy and Indian Stratigraphy	75	25	100	5	50
ES 404	Elective Paper (Project Oriented Dissertation)	75	25	100	5	150
ES 405	Practical on ES 401 and ES 402	37.5	12.5	50	2.5	50
ES 406	Industrial/Laboratory Training and Practical on ES 403	37.5	12.5	50	2.5	60
	Total	375	125	500	25	410

M.Sc. (Applied Geology) Course Curriculum

Preamble:

Candidates who have passed Three Years Degree Course (Science) examination (Honours and Pass) with Geology/having Geology as one of the pass subjects will be considered eligible for admission to the M.Sc. (Applied Geology). Students admitted to the M. Sc. (Applied Geology) Program shall be required to pursue their studies for two consecutive academic sessions involving four semesters; each of six months duration. They will be examined and evaluated on grade basis at the end of each semester in respective courses of theory and practical as per credits assigned. The M.Sc. (Applied Geology) shall consist of (a) Core Courses, (b) Elective Courses (c) Open courses (d) Geological Field Training (e) Industrial / Laboratory Training and (f) Project Oriented Dissertation involving a total of 100 credits distributed equally over the four semesters (25 credits per semester) as detailed below:

(a) The Core courses will be compulsory for all the students admitted to M.Sc. (Applied Geology). There will be twelve core Theory courses, each of 5 credits and eight core Practical courses each of 2.5 credits covering major branches of Geology.

(b) There shall be two Open Courses (Theory) each of 5 credits, one each in 2nd and 3rd semester.

(c) There are two Elective Courses, each of 5 credits one each in 3rd and 4th semester.

(d) Two compulsory geological field trainings (2.5 credits in total); one each in 2nd and 3rd semester as part of the practical courses and involve two to three weeks of each field work (2nd Semester: within Northeast India, 3rd Semester: Rest of India), submission of Field report, corresponding sessional and viva-voce examination at the end of respective semester.

(e) Students admitted to the M.Sc. (Applied Geology) program are to compulsorily undergo industrial / laboratory training (1.25 credits) of at least one week duration as part of the practical course in 4th semester. It involves submission of a training report, seminar presentation, corresponding sessional and viva-voce examination at the end of the semester.

(f) Along with the above courses, there shall be a compulsory Project Oriented Dissertation of 5 credits in 4th semester. The area of Dissertation shall be assigned to the students in the beginning of the 3rd semester based on the preference & merit of the student as well as expertise available with the Department. The project oriented dissertation thesis must be submitted a week ahead of the date of final presentation as announced by the Department for the purpose of evaluation before the faculty members and the board of examiners at the end of the semester.

FIRST SEMESTER

ES 101: Geomorphology, GIS and Remote Sensing
Total Credit: 5
Contact hours: 50
Full Marks: 100 (Semester End Exam 75 + Int. 25)

UNIT I: Introduction to Geomorphology; Geomorphic processes; Fluvial, Glacial, Coastal landforms; Models of Landform evolution, Davis' Model, Penk's Model, King's Model; Tectonic Geomorphology; geomorphic markers; Geomorphic indices of active tectonics

UNIT II: Components of remote sensing, energy sources, Electromagnetic spectrum, energy interaction in the atmosphere, Atmospheric windows, Spectral reflectance, Types of satellites and sensors, Photogrammetry: introduction, types of Aerial photographs; Stereoscopic models; Stereoscopes; Pocket and Mirror.

UNIT III: Digital image processing; Introduction to digital image; Image rectification and restoration; Image enhancement; Image classification; Data margin and GIS integration, Remote sensing data interpretation: Manual and Digital; Application of Remote sensing in Geosciences: Hydrology, Mineral exploration, Natural Diasastar management.

UNIT IV: Satellite programmes: Indian remote sensing satellite (IRS) series, Landsat Series: Microwave Remote sensing: Introduction, Radar development, Radar image interpretation, Application; Hyperspectral Remotesensing: Principles Data interpretations, Applications, Thermal Infra Red Remotesensing: Principles, data interpretations, Applications.

UNIT V: Introduction to Geographic Information System: History of GIS development; GIS techniques and technology: relating information from different sources; GIS uncertainties, GIS data representations, data capture, vector to rastar transformation, Map projection, coordinate systems.

Books Recommended:

Drury, S.A. 1987: Image Interpretation in Geology. Allen & Unwin.
Gupta, R.P. 1990: Remote Sensing Geology. Springer Verlag
Lillesand, T.M. and Kieffer, R.W. 1987: Remote Sensing and Image Interpretation. John Wiley
Miller, V.C. 1961: Photogeology. McGraw Hill.
Moffitt, F.H. and Mikhail, E.M. 1980: Photogrammetry. Harper and Row.
Moffitt, F.H. and Mikhail, E.M., 1980: Photogrammetry, Harper and Row
Paine, D.P. 1981: Aerial Photography and Image Interpretation for Resource Management. John Wiley
Pandey, S.N. 1987: Principles and Applications of Photogeology. Wiley Eastern, New Delhi.
Ray, R.G. 1969: Aerial Photographs in Geologic Interpretations. USGS Prof. Paper, 373.
Sabbins, F.F. 1985: Remote Sensing Principles and Applications. Freeman.
Sharma: Indian Geomorphology, Concept
Singh, S., 2001: Geomorphology, Pustakalaya Bhawan, Allahabad.
Thornbury, 2nd Edition: Principles of Geomorphology, CBS

ES 102: Palaeontology
Total Credit: 5
Contact hours: 50
Full Marks: 100 (Semester End Exam. 75 + Int. 25)

UNIT- I: Principles of paleontology vis-à-vis paleobiology; Species concept and speciation. Origin and diversity of life; Adaptation and functional morphology; Mechanism of evolution; Palaeobiogeography, Major Mass Extinction Events of Earth's history.

UNIT-II: Functional morphology and evolutionary history of Brachiopoda, Mollusks and echinoids. Trace fossils: kinds, classification and their significance in palaeoenvironmental analysis.Variations in pedicle opening in brachiopods, variation in occulogenital system and ambulacralplates in echinoids.Evolution and ecology of corals.

UNIT- III: Foraminifera: Brief morphology, classification, Morphology and classification of Ostracoda,Radiolaria, Conodonts and their significance; Introduction to calcareous algae, dinoflaggellates and their significance.

UNIT- IV: Morphology of plant fossil, use of plant fossil, major subdivisions of plant fossil, Evolution of land floras, Palynology including spore/pollen morphology and their application.

UNIT- V: Major subdivisions of vertebrates, Morphology of different diagonostic element of vertebrates: skull, jaw, vertebral column, ribs, teeth, General Evolution of vertebrates, Evolution of Horses; elephants; primates and man.

Books Recommended:

Alfred R. Loeblich, Jr. and Helen Tappan(1998):Foraminiferal Genera and their classification: Van Nostrand Reinhold Company, New York
Arnold (2002): Quaternary Environmental Micropaleontology (Ed. Simon K. Haslett), Oxford niversity Press, New York.
B.K.Sengupta: Modern Foraminifera
Benton, M.J. (1990): Vertebrate Paleontology. Unwin Hyman, Lindon.
Bignot, G., Grahm and Trottman (1985): Elements of Micropaleontology, London.
Boardman, R.S., Cheethan, A.M. and Rowell, A.J. (1988): Fossil Invertebrates, Blackwell.
Clarksons, E.N.K. (1998): Invertebrate Paleontology and Evolution, Allen and Unwin, London.
Colbert, E.H. (1984): Evolution of Vertebrates. Willey Eeastern Ltd.
Glaessner. N. (1944): Principles of Micropaleontology, Melbourne
Haynes,J.R; 1981: Foraminifera, John Wiley
Jones, D..J. Introduction to Microfossils:,Cambrigde University press
Jones, Robert Wynn. (1996): Micropaleontology in Petroleum Exploration,Clarendon Press
M. Brasier: Micropaleontology, Blackwell
Prothero, D.R. (2004): Bringing Fossil to Life An Introduction to Paleontology (2nd Ed.), McGraw Hill.
Raup, D.M. and Stanley, S.M (2008): Earth System History, Blackwell Publ.
Raup, D.M. and Stanley, S.M. (1985): Principles of Paleontology ,CBS Publ..
Romer, A.S. (1966): Vertebrate Paleontology (3rd Edn.) Chicago University Press.
Strean, C.W. and Carroll, R.L. (1989): Paleontology the record of life, John Wiley.
Swnnerton, H.H. (1950): An outline of paleontology, Edward Arnold and Co.
Vladimir Pokorny(1963):Principles of Zoological Micropaleontology,Vol.1,Pergasmon press, Oxford, London, New York,pp.91

ES 103: Mineralogy
Total Credit: 5
Contact hours: 50
Full Marks: 100 (Semester End Exam. 75 + Int. 25)

UNIT I: Introduction to crystal chemistry: bonding in minerals, solid solution, exsolution, polymorphism, isomorphism, pseudomorphism, polytipism, polysomatism; Atomic and Ionic radii, Pauling's rules governing the ionic structures; Spheres in closest packing: Cubic closest packing, Hexagonal closest packing, Body centered cubic packing. Voids in closest packing.

UNIT II: Structure & Classification of Silicate minerals. Detailed study of following mineral groups with reference to their general formulae, classification, atomic structure, chemistry, diagnostic physical and optical properties, P-T stability, alteration and occurrences: a. Nesosilicates: Olivine Group, Garnet Group, Aluminosilicate Group (Kyanite, Andalusite, and Sillimanite) b. Cyclosicates: Beryl.

UNIT III: Detailed study of following mineral groups with reference to their general formulae, classification, atomic structure, chemistry, diagnostic physical and optical properties, P-T stability, alteration and occurrences: a. Inosilicates: Pyroxene Group; Amphibole Group, b. Phyllosilicates: Kaolinite Group; Serpentine Group; Mica Group; Chlorite Group, c. Tectosilicates: Feldspar Group; Cordierite.

UNIT IV: Twinning and twin laws; common types of twins and their examples in minerals. Concept of Crystal Field Theory and mineralogical spectroscopy; Liquid crystals and their applications. Detailed study of the Oxide, Sulphide and Sulphate Minerals.

UNIT V: Light – mineral interactions, Refractive index determinations; Pleochroism; Isotropism vs Anisotropism, Interference color; Birefringence; Extinction - types and determination. Optical Indicatrix-Uniaxial and Biaxial Interference Figures and Optic sign determination, 2V and 2E.

Books Recommended:

Azaraoff: Elements of X-ray Crystallography.
Berry, L.G., Mason, B. and Dietrich, R.V.: Mineralogy, CBS Publishers
Buerger: Elementary Crystallogaphy
Dana, E.S. and Ford, W.E.: A textbook of Mineralogy. Wiley Eastern Limited.
Dana: Elements of Mineralogy
Deer, Howie and Zusmann: Rock forming minerals
Deer, W.A., Howie, R.A. & Zussman, J. : An Introduction to the rock forming minerals, Longman
Guillman: Art and Science of Crystal Growth
Kerr,P.F. Optical Mineralogy. McGraw Hill Book Company
Klein, C. and Huburt, Jr., C.S., 1993: Manual of Mineralogy. John Wiley.
Moorhouse, W.W.: Optical Mineralogy.
Nesse, D.W.: Optical Mineralogy, McGraw Hill.
Philips, Wm, R. and Griffen, D.T. 1986: Optical Mineralogy, CBS Edition
Philips,F.C. Introduction to crystallography.
Putnis, Andrew. 1992: Introduction to Mineral Sciences. Cambridge Univ. Press.
Spear, F. S. (1993) : Mineralogical phase equilibria and Pressure- Temperature- Time paths
Winchell: Elements of Optical Mineralogy part I and II

ES 104: Geochemistry and Isotope Geology
Total Credit: 5
Contact hours: 50
Full Marks: 100 (Semester End Exam. 75 + Int. 25)

UNIT I: Meteorites: classification, mineralogy, origin, significance; Primary Chemical Differentiation of the earth. Geochemical composition of the crust, mantle and core. Principles of ionic substitution in minerals; Element partitioning in mineral/ rock and concept of distribution coefficients. Distribution characteristics of trace elements and rare earth elements (REE) in minerals and selected rock types: basalt, granite and komatiite.

UNIT II: Chemical weathering and rock decomposition. Differential loss of elements during weathering; Factors affecting element distribution in sedimentary rocks: ionic potentials, hydrogen ion concentration, oxidation-reduction potentials. Uses and applications of major, trace and REE to sedimentological problems.

UNIT III: Methods and techniques of geochemical analyses of major trace and REE. Principles involved in analyzing the geological materials by Atomic Absorption Spectrophotometer (AAS), X-ray Fluorescence Spectrometry (XRF), Inductively Coupled Plasma Atomic Emission Spectrometry (ICP AES), and Inductively Coupled Plasma mass spectrometry (MS)

UNIT IV: General characteristics of isotopes. Stable isotope Geology: fundamentals and principles; nature, abundance and fractionation of stable isotopes. Isotopes of Oxygen, Hydrogen, Carbon and Sulphur, Application of stable isotopes in geological studies.

UNIT V: Radiogenic isotopes: Criteria for useful radioactive nuclides, Radioactive decay mechanisms. Srontium, Lead and Neodymium isotopes. Radioactive decay schemes, growth of daughter isotopes and radiometric dating. Geochronology: K-Ar, Rb-Sr, U-Pb and Sm-Nd isotope systematics

Books Recommended:
Cox, K. G., Bell, J. D. and Pankhurst, R. J., 1979. The Interpretation of Igneous Rocks. Allen & Unwin.
Faura, G. 1986: Principles of Isotope Geology.
Govett, G.J.S. (Ed) 1983: Handbook of exploration Geochemistry
Henderson,P.1987: Inorganic Geochemistry
Hoets, J. 1980: Stable Isotope Geochemistry. Springer Verlag.
Krauskopf, K.B. 1967: Introduction to Geochemistry.
Marshal, C.P. & Faibridge, R.W. 1999: Encyclopaedia of Geochemistry.
Mason, B. and Moore, C.B. 1991: Introduction to Geochemistry
Nordstorm, D.K. and Munoz, J.L. 1986: Geochemical Thermodynamics.
Rollinson, H. 1993: Using geochemical data: evaluation, presentation and interpretation. Longman.

ES 105: Practical on ES 101 and ES 102
Total Credit: 2.5
Contact hours: 50
Full Marks: 50 (Semester End Exam. 37.5 + Int. 12.5)

Study of nature of aerial photographs: resolution, mosaics, symbols, gully pattern, drainage analysis, and image parallax. Determination of scale, height, dip, slope, vertical exaggeration, and image distortion. Interpretation from imageries. Making false color composites and study of multispectral scans and spectral patterns. Exercises on digital image processing. Study of environmental hazard maps. Morphometric analysis in different river basins.

Study of vertebrate fossils, pollens, foraminifers, ostracods and Trace fossils of India. Coiling geometry in Gastropoda, cephalopoda. Application and interpretation in sedimentary depositional environment. Techniques of separation of microfossils from matrix; SEM applications in micropaleontology; Study of surface ultrastructures of foraminifera; Study of larger benthic foraminifera useful in Indian stratigraphy with special reference to Cenozoic petrolliferous basins of India; Important palynomorphs of Cretaceous and Paleogene age.

ES 106: Practical on ES 103 and ES 104
Total Credit: 2.5
Total contact hours: 50
Full Marks: 50 (Semester End Exam. 37.5 + Int. 12.5)

Handspecimen study of minerals. Thin section study of minerals.

Uses and applications of major and trace element composition of igneous rocks as a means to understand the petrogenesis and to determine their paleotectonic setting. The use of geochemical data on sedimentary rocks as a guide to source rock composition, weathering condition and environment of deposition. Exercises on Geochronology.

SECOND SEMESTER

ES 201: Igneous Petrology and Metamorphic Petrology
Total Credit: 5
Contact hours: 50
Full Marks: 100 (Semester End Exam. 75 + Int. 25)

UNIT I: Phase rule and phase diagrams. Phase relations in Binary and Ternary systems, Application of phase rule in the study of silicate systems Binary: Diopside-Anorthite; Albite-Anorthite; Leucite-Quartz and Ternary: Nepheline-Kalsilite-Silica, Diopside-Forsterite-Anorthite, Forsterite-Anorthite-Silica.

UNIT II: Upper mantle mineral assemblages and its chemical composition. Partial melting processes in the upper mantle. Basaltic magma spectrum in relation to partial melting processes. MORB and evolution of depleted mantle, OIB and enriched mantle; Concept of hot spots and mantle Plumes.

UNIT III: Magmatism in relation to global tectonic processes. Characteristic magma series associated with specific tectonic settings. Magmatism at constructive plate margins: Mid-oceanic ridges. Magmatism at destructive plate margins: island arcs, active continental margins. Within plate magmatism: Oceanic islands, flood basalts, continental rift systems.

UNIT IV: Kinetics of metamorphism. Metamorphic textures and structures. Concept of iso-grads and iso-reaction grads. Types of metamorphic equilibrium reactions. Graphical representation of mineral assemblages in composition diagrams (ACF AKF and AFM diagrams). Progressive metamorphism of pelites, basic rocks and carbonates. Metasomatism Mass transfer mechanism, Metasomatic reactions.

UNIT V: Metamorphism in relation to plate tectonics. High Pressure - Low Temparature metamorphism and subduction and obduction; Low Pressure metamorphism and Paired Metamorphic Belts; Metamorphism in extension zones and ocean ridge metamorphism; High Temparature Low Pressure gradients and continental shear zones.

Books Recommended:

Best, Myron G., 2002. Igneous and Metamorphic Petrology, Blackwell Science.
Bose, M.K., 1997. Igneous Petrology, World Press, Kolkata.
Bucher, K. and Martin, F. 2002: Petrogenesis of Metamorphic Rocks, Springer-Verlag
Carmichel, Turner and Verhoogen : Igneous Petrology, Mc.Graw Hill.
Cox, K.G., Bell, J.D. and Pankhurst, R.J., 1993: The Interpretation of Igneous Rocks.
Faure, G.: Origin of Igneous Rocks, Springer.
Mc Berney, 1993: Igneous Petrology
Middlemost. E.A.K.: Igneous Petrology
Philpotts, A.R. 1994: Principles of Igneous and Metamorphic Petrology, Prentice Hall.
Roger Powell: Equilibrium Themodynamics in Petrology
Sood, M.K., 1982: Modern Igneous Petrology. Wiley-Interscience Publ., New York.
Turner, F. J., 1980: Metamorphic Petrology, Mc Graw Hill.
Wilson, M., 1993: Igneous Petrogenesis. Chapman & Hall, London.
Winkler: Metamorphic Petrology
Yoder, H.S.: Modern Igneous Petrology

ES 202: Sedimentology
Total Credit: 5
Contact hours: 50
Full Marks: 100 (Semester End Exam. 75 + Int. 25)

UNIT I: Earth Surface System: liberation of flux of sediments. Sedimentary structures: classification, significance and field recording. Fluid flow mechanics and formation of sedimentary bedforms, Concept of Flow Regime.

UNIT II: Sedimentary Environments and Facies; Walther's law of facies succession, Processes and characteristics of fluvial, estuarine, deltaic, lagoonal, barrier beach, tidal flats and deep-sea environments.

UNIT III: Marine and continental evaporate. Shallow water carbonates. Volcanoclastic: on-land and marine. Palaeocurrent properties and indicators, Palaeocurrent analysis. Significance of ichnofossils in sedimentological studies, Cyclic sedimentation.

UNIT IV; Petro genesis of sandstones, Graywacke and graywacke problem; plate - tectonics and sandstones composition, Sedimentary basins in relation to Plate tectonics, Clastic petrofacies, Palaeoclimate indicators.

UNIT V: Diagenesis and fluid flow. Diagenesis of mudstones, sandstones and carbonate rocks: changes in mineralogy, fabric and chemistry. Heavy minerals and their uses in provenance studies.

Books Recommended:

Allen, J.R.L. 1985: Principles of Physical Sedimentation. George Allen & Unwin.
Allen, P. 1997: Earth Surface Processes. Blackwell.
Bhattacharya, A. and Chakraborti, C. 2000: Analyses of Sedimentary Successions. Oxford -IBH.
Blatt, H., Murray, G.V., and Middleton, R.C. 1980: Origin of Sedimentary Rocks.
Boggs, Sam Jr. 1995: Principles of Sedimentology and Stratigraphy. Prentice Hall.
Collins, J.D., and Thompson, D.B. (1982): Sedimentary Structures, George Allen and Unwin, London.
Davis, R.A. Jr. 1992: Depositional Systems. Prentice Hall.
Einsele, G. 1992: Sedimentary Basins. Springer Verlag.
Lindholm, R.C. (1987) A Practical Approach to Sedimentology, Allen and Unwin, London.
Miall, A.D. 2000: Principles of Sedimentary Basin Analysis. Springer Verlag.
Nichols, G. 1999: Sedimentology and Stratigraphy. Blackwell.
Pettijohn, F.J., Potter, P.E., and Siever, R. 1990: Sand and Sandstone. Springer Verlag.
Prothero, D.R. and Schwab, F. 1996: Sedimentary Geology. Freeman.
Reading, H.G. 1996: Sedimentary Environments. Blackwell.
Reineck, H.E. and Singh, I.B. 1980: Depositional Sedimentary Environments. Springer Verlag.
Selley, R. C. (2000) Applied Sedimentology, Academic Press.
Sengupta, S. 1997: Introduction to Sedimentology. Oxford - IBH.
Tucker, M.E. (1981): Sedimentary Petrology: An Introduction, Wiley and Sons, New York.
Tucker, M.E. (1990): Carbonate Sedimentolgy, Blackwell Scientific Publication.

ES 203: Open Course

The Department offers "Physics and Dynamics of Earth" as open course. Subject to the availability of the infrastructure/specialization with the Department and approval by the statutory bodies, more open courses may offered.

ES 203: Physics and Dynamics of Earth

Total Credit: 5
Contact hours: 50
Full Marks: 100 (Semester End Exam. 75 + Int. 25)

UNIT- I: Density distribution, shape and mass of the earth, density vs. depth profile; Gravity and gravitational mechanics, gravity anomalies and isostatic equilibrium. The mantle: Seismological methods of investigating mantle structure; Electrical conductivity of mantle. Temperature-depth distribution composition of mantle. Density and elastic properties. Thermal properties of rocks. Earth's heat budget.

UNIT- II: Seismic waves and their velocities; The continental crust: Structure based on seismological data. Fundamentals of current flow in the earth. Electrode arrangements and field procedures. Instruments. Processing and interpretation of resistivity data. Field procedure, data acquisition and interpretation of self-potential, Induced polarization and electromagnetic methods

UNIT- III: Plate tectonics: Processes and structures associated with different types of plate boundaries. Tectonism along continental margins and continental rifts. Driving forces of plate tectonics. Mantle plumes. The oceanic crust: Structure based on seismic data; velocity depth distribution. Oceanic magnetic anomalies. Ocean floor spreading. Oceanic ridges and continental margins.

UNIT- IV: The earth as a magnet, earth s magnetic field, changes in magnetic field, origin of geomagnetic field, magnetic properties of rocks. Palaeomagnetism Paleomagnetic sampling. Measurement of NRM. Magnetic cleaning techniques and field tests of Paleomagnetic stability Palaeomagnatism and its applications.

UNIT- V: Radiometric methods: Physical principles and basic theory. Radioactivity of rocks. Ratioactive dating methods. Field surveys and instruments. Data processing and interpretation. Applications of radiometric dating.

Books Recommended:

Bott, M.H.P., 1982: The interior of the earth its structure, constitution and evaluation.
Condie, K. C. : Plate tectonics and crustal evolution
Kearey, P. & Brooks, M., 1991: Introduction to Geophysical Prospecting, Osney Mead, Oxford.
Nagata, T.: Rock Magnetism, Maruzen Co., Ltd., Tokyo
Parkinson, W.D., 1983: Introduction to Geomagnetism, Scottish Acad., Press, Edinburgh
Pick, M., Picha, J. & Vyskocil, V. 1973: Theory of the Earth s Gravity Field, Elsevier.
Tarling, D.H. 1983: Palaeomagnatism, Chapman and Hall, London
Telford, W. M., Geldart, C.P., Sheriff, R.E. & Keys, D.A., 1976: Applied Geophysics, Cambridge University Press, London.

ES 204: Hydrogeology
Total Credit: 5
Contact hours: 50
Full Marks: 100 (Semester End Exam. 75 + Int. 25)

UNIT-I: Scope of hydrogeology; Groundwater in hydrogeological cycle; Types of aquifers; Properties of aquifers: water table, porosity, permeability, hydraulic conductivity, transmissivity, storativity.

UNIT II: Principles of groundwater flow: Darcy's law, hydraulic head, flow nets, flow in relation to groundwater contours, flow across a water table, regional flow pattern; Determination of hydraulic conductivity: formulas, laboratory methods, field methods: tracer tests, pumping tests of wells.

UNIT III: Groundwater exploration: remote sensing & GIS, electrical resistivity method, Seismic refraction method; Subsurface investigation of groundwater: test drilling, water level measurement; Groundwater occurrence in different rock types: sedimentary, igneous and metamorphic.

UNIT IV: Groundwater chemistry: units of measurement, major ion chemistry, isotope hydrology, presentation of result of chemical analyses, hydrochemical facies and their evaluation; Saline and fresh water interaction; Surface and groundwater interaction.

UNIT V: Drilling methods of shallow water wells: dug wells, bored wells, driven wells; Drilling methods of deep water wells: cable tool method, rotary method; Management of groundwater: natural groundwater recharge methods, artificial groundwater recharge methods.

Books Recommended:
Alley, W.M. 1993: Regional Groundwater Quality. VNR, New York.
Black, W. et al (Eds), 1989: Hydrogeology. Geol. Soc. Am. Publications.
Chow, V.T. 1988: Advances of Hydroscience. McGraw Hill.
Davies, S.N. and Dewiest, R.J.M. 1966: Hydrogeology. John Wiley.
Fetter, C.W. 1990: Applied Hydrogeology. Merrill Publishing.
Freeze, R.A. and Cherry, J.A. 1979: Groundwater. Prentice Hall.
James L. Drever, 2nd Edition: The Geochemistry of Natural Water.
Karanth, K.R. 1987: Groundwater Assessment - Development and Management. Tata McGraw Hill.
Mahajan, G. 1990: Evaluation and Development of Ground Water. D.K. Publishers.
Raghunath, N.M. 1982: Groundwater. Wiley Eastern.
Subramaniam. V. 2000: Water. Kingston Publications, London.
Todd, D.K. 1980: Groundwater Hydrology. John Wiley.
Walton, W.C. 1988: Ground Water Resource Evaluation. McGraw Hill.

ES 205: Practical on ES 201 and ES 202
Total Credit: 2. 5
Contact hours: 50
Full Marks: 50 (Semester End Exam. 37.5 + Int. 12.5)

Megascopic and microscopic study of different igneous rocks. Calculation of Modal mineralogy, Calculation of CIPW Norms, preparation of variation and discrminant diagrams. Megascopic and microscopic study of metamorphic rocks of different facies. Graphic construction of ACF, AKF and AFM diagrams.

Megascopic study of clastic and non-clastic rocks. Study of primary, secondary, and biogenic sedimentary structures in hand specimens, in photographic atlases, field photographs, and wherever possible on outcrops. Exercises related to palaeocurrent analysis and interpretation of depositional sedimentary environments. Microscopic examination of important rock-types. Heavy mineral separation and microscopic examination. Grain-size analysis by sieving method; Plotting of size-distribution data as frequency and cumulative curves, computation of statistical parameters and interpretation.

ES 206: Field work and Practical on 204
Total Credit: 2.5
Contact hours: 90
Full Marks: 50 (Semester End Exam. 37.5 + Int. 12.5)

In addition to the requisite number of lectures and practicals; students are compulsorily required to undertake field work of two weeks duration on various components of Field Geology. Each student is required to submit a report duly certified by the Teachers in-Charge of the Field tour and the Head of Department and has to take a viva- voce examination on that field work.

Delineation of hydrological boundaries on water table contour maps and estimation of permeability; Hydrogeomorphic mapping. Analysis of hydrochemical facies and its evolution on Trilinear and Durov diagrams. Pumping test: time-drawdown and time recovery tests and evaluation of aquifer parameters. Vertical electrical resistivity.

THIRD SEMESTER

ES 301: Structural Geology and Tectonics
Total Credit: 5
Contact hours: 50
Full Marks: 100 (Semester End Exam. 75 + Int. 25)

UNIT I: Mechanical principles and properties of rocks and their controlling factors, Concept of stress; Theories of rock failure; Two-dimensional stress analyses; Concept of strain, two dimensional strain analysis; Types of strain ellipses and ellipsoids, their properties and geological significance;

UNIT II: Mechanics of folding and buckling. Fold development and distribution of strain in folds. Morphological & Geometrical classification of folds. Causes and dynamics of faulting with special reference to stress and strain, strike-slip faults, normal faults, over thrust and nappe and their characteristics.

UNIT III: Brittle and ductile shear zones, geometry and products of shear zones; Mylonites and cataclasites; Planar and linear fabrics in deformed rocks, their origin and significance. Concept of petrofabrics, Planar and linear fabrics in deformed rocks, graphic treatment, Types of fabrics, fabric elements and interpretation of fabric data on microscopic and mesoscopic scale.

UNIT IV: Plate Tectonics: recent advances, pros and cons. Dynamic evolution of continental and oceanic crust. Tectonic features of extensional-, compressional-, and strike-slip-terrains and relevance to plate boundaries. mantle plumes.

UNIT V: Study of large scale tectonic features of the Earth. Tectonics of Precambrian Orogenic Belts of India. Formation of mountain roots. Anatomy of orogenic belt. Structure and origin of the Alpine-Himalayan belt, the Appalachian-Caledonian belt and the Andes. Plate tectonic evolution of India.

Books Recommended:

Condie, Kent. C. (1982): Plate Tectonics and Crustal Evolution, Pergamon Press Inc.
Gass I.G. (1982): Understanding the Earth. Artemis Press (Pvt) Ltd. U.K.
Ghosh, S.K. (1993): Structural Geology: Fundamental and Modern Developments. Pergamon Press.
Hobbs, B.E., Means, W.D. and Williams, P.F. (1976): An outline of Structural Geology, John Wiley and Sons, New York.
Ramsay, J.G. (1967): Folding and fracturing of rocks, McGraw Hill.
Ramsay, J.G. and Huber, M.I. (1983): Techniques of Modern Structural Geology, Vol. I, Strain Analysis,Academic Press.
Ramsay, J.G. and Huber, M.I. (1987): Techniques of Modern Structural Geology, Vol. II, Folds and Fractures, Academic Press.
Ramsay, J.G. and Huber, M.I. (2000): Techniques of Modern Structural Geology, Vol. III (Application of continuum mechanics), Academic Press.
Turner, F.J. and Weiss, L.E. (1963): Structural analysis of Metamorphic Tectonites, McGraw Hill.
Windley B. (1973): The Evolving continents, John Wiley and Sons, New York.

ES 302: Petroleum Geology
Total Credit: 5
Total Lectures: 50
Full Marks: 100 (Semester End Exam. 75 + Int. 25)

UNIT I: Petroleum its composition and origin. Migration of petroleum and natural gas. Reservoir properties: porosity and permeability, fluid saturation, relative permeability and fluid flow. Characteristics of reservoir rocks and traps (structural, stratigraphic and combination). Pressure condition in the reservoir. Identification and characterisation of Source rock.

UNIT II: Geophysical exploration for hydrocarbon: Gravimetric surveys and gravity anomaly maps; Seismic surveys-principles and interpretation. Oil well drilling and drilling fluid. Estimation of oil and gas reserve.

UNIT III: Wireline logging: principles and interpretations of Spontaneous Potential log, Natural gamma ray log, Porosity logs-sonic, density, neutron logs, Resistivity log, Conventional electric log, Induction logging, Resistivity and water saturation.

UNIT IV: Development of oil fields-aims, methods and stages, Primary and enhanced oil recovery-stimulation of initial recovery, water flooding, thermal recovery method, miscible flood method, polymer flooding, MEOR.

UNIT V: Onshore and offshore petroliferous basins of India; Geology of productive oil and gasfields of India with special reference to NE India; Elements of unconventional petroleum systems; Basin-centered gas, fractured-shale gas system, shallow biogenic gas and natural gas hydrates.

Books Recommended:
Leverson: Geology of Petroleum
North F. K., 1985: Petroleum Geology.
Shelly, R.C., 1998: Elements of Petroleum Geology
Tissot, B.P. and Welte, D. H., 1984: Petroleum Formation and occurrences.

ES 303: Open Course

The Department offers the following course as open course at present. Subject to the availability of the Infrastructure and increase in the faculty strength within the Department and due approval by the statutory bodies, more open courses may also be added to the list.

ES 303: Earth's Physical Processes and Geoinformatics

Total Credit: 5
Contact hours: 50
Full Marks: 100 (Semester End Exam. 75 + Int. 25)

UNIT I: Overview of the earth: lithosphere, plate tectonics, atmosphere, earth's rotational effect on atmospheric and oceanic circulation, hydrosphere; Development of geomorphic thoughts: catastrophism, uniformitarianism, geographical cycle, Treppen concept, pediplanation cycle; Principles of geomorphic processes.

UNIT II: Fluvial geomorphic system: channel geometry, processes of transport, concept of grade, drainage basin morphometry: stream ordering system, bifurcation ratio, drainage density, Hack's profile; Fluvial landforms: erosional and depositional.

UNIT III: Coastal geomorphology: shore zone processes, wind generated waves and tsunamis, coastal erosional and depositional landforms. Glacial geomorphology: formation and characteristics of ice, mass balance of glacier, glacial surface features, glacial types, alpine and continental glacial landforms.

UNIT IV: Principles of remote sensing; evolution and growth of remote sensing technology; fundamentals of digital image processing; Concept of coordinate system; Types of satellites: polar and equatorial; application of remote sensing in geoscience.

UNIT- V: Fundamentals of Geographic Information System; Types of data: spatial data, non-spatial data; Data representation: raster and vector; Global Positioning System (GPS); Digital elevation model (DEM); GIS and remote sensing data integration; application of GIS.

Books Recommended:

Arthur L. Bloom, A systemic analysis of late Cenozoic landforms, Pearson Edition.
Drury, S.A. 1987: Image Interpretation in Geology. Allen & Unwin.
Gupta, R.P. 1990: Remote Sensing Geology. Springer Verlag
Halis, J.R., 1983: Applied Geomorphology.
Lillesand, T.M. and Kieffer, R.W. 1987: Remote Sensing and Image Interpretation. John Wiley
Miller, V.C. 1961: Photogeology. McGraw Hill.
Moffitt, F.H. and Mikhail, E.M. 1980: Photogrammetry. Harper and Row.
Moffitt, F.H. and Mikhail, E.M., 1980: Photogrammetry, Harper and Row
Paine, D.P. 1981: Aerial Photography and Image Interpretation for Resource Management. John Wiley
Pandey, S.N. 1987: Principles and Applications of Photogeology. Wiley Eastern, New Delhi.
Peter Burrough and Rachael M. Medwell, Principles of Geographic information System
Ray, R.G. 1969: Aerial Photographs in Geologic Interpretations. USGS Prof. Paper, 373.
Sabbins, F.F. 1985: Remote Sensing Principles and Applications. Freeman.
Sharma: Indian Geomorphology, Concept
Singh, S., 2001: Geomorphology, Pustakalaya Bhawan, Allahabad.
Thornbury: Principles of Geomorphology, 2nd Edition, CBS

ES 304: Elective Course

A list of elective courses is offered below. Students will have the option to choose any one of the following courses. Subject to the availability of the infrastructure/ specialization with the Department and approval by the statutory bodies, other Elective courses may also be added to the list.

ES 304 (I): Oceanography
Total Credit: 5
Contact hours: 50
Full Marks: 100 (Semester End Exam. 75 + Int. 25)

UNIT I: Physiography of ocean floors, Ocean morphology, deep ocean basins, mid oceanic ridges, ridges, sea mounts. Coral reefs, continental shelf, continental slope, trenches and canyons and bathymetric provinces. The origin of ocean basins; continental drifts, sea floor spreading and global plate tectonics.

UNIT II: Ocean currents, waves and tides, important current systems, Deep Ocean Circulation, concept of thermohaline circulation, formation of bottom waters; oceanic conveyor belt and its role in controlling world's climate. Major water masses of the world s oceans.

UNIT III: Physical properties of sea water, salinity, temperature, density, Major and minor constituents of seawater; Processes controlling composition of seawater; Dissolved gases in seawater; The carbon, phosphorous and nitrogen cycle; Trace metals in seawater; Marine pollution.

UNIT IV: Surface circulation; concept of mixed layer, thermocline and pycnocline, Coriolis Force and Ekman Spiral, Upwelling, El nino. Major currents of the world's ocean. Processes affecting biological productivity of ocean margin waters.

UNIT V: Mineral resources of the ocean including polymetalic nodules. Marine Gas Hydrates and their economic potential. Diagenetic changes in oxic and anoxic environments. Deep Sea Drilling Project (DSDP); Ocean Drilling Program (ODP) and their major accomplishments. Integrated Ocean Drilling Program (IODP) and its aims and objectives. Evolution of Oceans in the Cenozoic.

Books Recommended:

Kennett, J.P., 1982: Marine Geology. Prentice Hall.
Pipkin, B.W., Gorsline, D.S., Casey, R.E., and Hammond, D.E., 1972: Laboratory Exercises in Oceanography. Freeman.
Seibold, E. and Berger, W.H., 1982: The Sea Floor. Springer Verlag.

Practical on ES 304 (I)

Preparing and Interpreting T-S Diagram; Exercises on Ocean morphology, Surface and Deep water Circulation, Thermihaline circulations and Water masses; El-Nino. Exercises on Waves and Tides.

ES 304 (II): Seismology
Total Credit: 5
Contact hours: 50
Full Marks: 100 (Semester End Exam 75 + Int. 25)

UNIT-I: Types of Seismic waves, characteristics of seismic waves, seismic wave attenuation and their types, seismic phases, classification of earthquakes based on epicentral distances and depth of focus; Concept of Microseisms, Aftershock, Foreshock, Multiplets, Swarms, Vp/ Vs ratio and its implications, Shear Modulus, Young s Modulus, Bulk Modulus, Poisson s ratio, Force, Stress Tensor, Strain Tensor, Snell s Law, Fermat s Principle, Huygens Principle, Ray Parameter. Magnitude and intensity. Concept of isoseismal, isoseist, meizoseismal.

UNIT-II: Source Mechanism: Concept of fault, classification of fault, criteria of fracture, Dynamics of faulting, Elastic Rebound Theory: Single Couple and Double Couple Hypothesis, Source Parameters, Plotting of P-wave first motion Data and fault plane solution, Focal Mechanism solution through waveform inversion , Earthquake mechanism and plate tectonics. Seismotectonic with special reference to NE India.

UNIT-III: Earthquake Location Parameters. Earthquake Location Methods: Manual method, single station method, Multi-station method. Computer Programs for earthquake Location: HYPO 71 Program, HYPOELLIPSE Program, SEISAN Program

UNIT-IV: Introduction to Mathematical and Statistical concepts in Seismology: Fourier transform, Linear Alzebra, Real Analysis, Green s Function, Finite,Element Method (FEM), Stochastic Process, Interpolation and Extrapolation of Data.

UNIT-V: Seismograph and its principle, Types of Seismograph: Short Period, Long Period and Broadband; Strong Motion Accelerograph(SMA) .Seismic risk zones of India. Earthquake Disaster Management and Mitigation: Probabilistic Seismic Hazard Assessment(PSHA)

Books Recommended:
OTA KULHA NEK: Anatomy of Seismograms
Peter M. Shearer: Introduction to Seismology, Cambridge University Press
Thorne Lay & Terry C. :Wallace Modern Global Seismology, Academic Press

Practical on ES 304 (II)
Fault plane solution: determination of dip angle, plunge rake etc. Determination of Hypocentral location by triangulation method. Use of seismometer and determination of damping ratio etc.

ES 305: Practical on ES 301 and ES 302
Total Credit: 2.5
Total contact hours: 50
Full Marks: 50 (Semester End Exam. 37.5 + Int. 12.5)

Preparation and interpretation of geological maps and sections; Structural problems concerning economic deposit based on orthographic and stereographic projections; Recording and plotting of the field data; Study of deformed structures in hand specimens; Strain estimation from the data already collected from the field; Study of dip-isogons from the fold profiles; Preparation of geotectonic maps.

Preparation of lithostratigraphic sections from geophysical well logs and well data, study of wireline logs (SP, IEL, Porosity, Neutron, Gamma ray, CBL), Determination of Porosity and water saturation (for clean sand) from well log data, structure contour, isopay and isopach maps, estimation of Oil and gas reserves, preparation of geotechnical order for exploratory and development wells.

ES 306: Field work and Practical on ES 304*
Total Credit: 2.5
Contact hours: 90
Full Marks: 50 (Semester End Exam. 37.5 + Int. 12.5)

In addition to the requisite number of lectures and practical the students are compulsorily required to undertake field work of two weeks duration on applied aspects of geology. Each student is required to submit a report duly certified by the Teachers in-Charge of the Field tour and the Head of Department and has to take a viva- voce test on that field trip.

*contents of the practicals for the Elective courses are mentioned along with the respective Elective theory papers.

FOURTH SEMESTER

ES 401: Ore Geology and Mining Geology
Total Credit: 5
Contact hours: 50
Full Marks: 100 (Semester End Exam. 75 + Int. 25)

UNIT I: concept of ore genesis; Spatial and temporal distribution of ore deposits; Metallogenic epochs and Metallogenic Provinces. Nature and morphology of principles types of ore deposits; Classification of ore deposits. Textures, paragenesis and zoning of ores and their significance

UNIT II: Concept of ore bearing fluids, their origin and migration. Wall rock alteration; Structural, physicochemical and stratigraphic controls of ore localization; Ore deposits in relation to Plate tectonics; Fluid inclusions in ore – principles and applications.

UNIT III: Mineralogy, classification and genesis of ore deposits associated with orthomagmatic ores of ultramafic-mafic rocks; Ores of felsic-silicic igneous rocks; Ores of sedimentary affiliation - biochemical, chemical and clastic sedimentation, placers and residual concentration deposits; Ores of metamorphic affiliations.

UNIT IV: Study of ore minerals related to the following metals with special reference to their mineralogy, genesis, specification (if any), uses and distribution in India: Fe, Mn, Cr, Cu, Pb, Zn. Al, Mg, Sn, and W.

UNIT V: Classification and description of mining methods. Planning, exploration and exploratory mining of surface and underground mineral deposits. Exploration for placer deposits; Ocean bottom mining; Mining hazards: mine inundation, fire and rock burst.

Books Recommended:

Arrogyaswami, R.N.P. 1996: Courses in Mining Geology (IV ed). Oxford IBH.
Barnes, H.L. 1979: Geochemistry of Hydrothermal Ore Deposits. John Wiley.
Clark, G.B. 1967: Elements of Mining (3rd ed). John Wiley.
Craig, J.M. and Vaughan, D.J. 1981: Ore Petrography and Mineralogy. John Wiley.
Dahlkamp, F.J. 1993: Uranium Ore Deposits. Springer Verlag.
Evans, A.M. 1993: Ore Geology and Industrial Minerals. Blackwell.
Guilbert, J.M. and Park, C.F. Jr. 1986: The Geology of Ore Deposits. Freeman.
Klemm, D.D. and Schneider, H.J. 1977: Time and Strata Bound Ore Deposits. Springer Verlag.
McKinstry, H.E. 1962: Mining Geology (2nd ed). Asia Publishing House.
Mookherjee, A. 2000: Ore Genesis A Holistic Approach. Allied Publishers.
Peters, W.C. 1978: Exploration and Mining Geology. John Willey and Sons.
Sawkins, F.J. 1984: Metal deposits in Relation to Plate Tectonics. Springer Verlag.
Stanton, R.L. 1972: Ore Petrology. McGraw Hill.
Torling, D.H. 1981: Economic Geology and Geotectonics. Blackwell.

ES 402: Environmental Geology and Geo-Engineering
Total Credit: 5
Contact hours: 50
Full Marks: 100 (Semester End Exam. 75 + Int. 25)

UNIT I: Principles of environmental geology, orientation to environmental studies, global environmental issues in Environmental Geology. Time scales of global changes in the ecosystems and climate. Earth resources – Conservation, management, concept of sustainable development.

UNIT II Natural hazards: Seismic hazards, earthquake prediction; Landslides: Identification of landslide prone areas; Flood hazard: Management. Zoning and risk assessment: Hazard Zonation maps.

Unit III Environmental geologic mapping. Environmental change- natural and man-made; Prediction of environmental changes and areas of human concern and impact indicators. Environment impact analysis of dams, building, highways and tunnels. EIA methods. Scales of interest in EIA and EIA models. – Steady state and time dependant.

UNIT IV: Role of engineering geology in civil construction and mining industry. Various stages of engineering geological investigation for civil engineering projects. Engineering properties of rocks. Physical characters of building stones. Metal and concrete aggregates.

UNIT V: Geological considerations for evaluation of dams and reservoir sites. Geotechnical evaluation of tunnel alignments, transportation routes and bridges. Mass movements with special emphasis on landslides and causes of hill slope instability. Influence of geological conditions on foundation and design of buildings. Aseismic designs of building.

Books Recommended:
Bell, F.G. 199: Geological Hazards. Routledge.
Bryant, E. 1985: Natural Hazards. Cambridge University Press.
Keller, E.A. 1978: Environmental Geology. Bell and Howell.
Krynine, D.H. and Judd, W.R. 1998: Principles of Engineering Geology. CBS Edition.
Smith, K. 1992: Environmental Hazards. Routledge.
Subramaniam, V. 2001: Textbook in Environmental Science. Narosa International.
Valdiya, K.S. 1987: Environmental Geology Indian Context. Tata McGraw Hill.

ES 403: Principles of Stratigraphy and Indian Stratigraphy

Total Credit: 5

Contact hours: 50

Full Marks: 100 (Semester End Exam. 75 + Int. 25)

UNIT I: Controls on the development of stratigraphic records. Completeness/ incompleteness of stratigraphic records. Lithostratigraphy: correlation and stratigraphic code. Biostratigraphy: controlling factors, zonation, time significance, quantitative stratigraphy.Geochronology and chronostratigraphy, Sequence stratigraphy. Brief ideas of magneto- seismic- chemo- and event stratigraphy; Stratigraphic correlations.

UNIT II: Classification and correlation of Precambrian crystalline rocks of India with particular reference to Dharwar, Singbhum, Bundelkhand, Aravalli; Mobile belts: eastern Ghats and Satpura. Stratigraphic classification and correlation of the Proterozoic rocks of India; Precambrian – Cambrian boundary problem.

UNIT III: Classification, lithology, correlation and fossils of Palaeozoic rocks of India with particular reference to Tethyan basins, Jammu and Kashmir, Himachal Pradesh, Uttaranchal and Peninsular India.

UNIT IV: Classification, lithology, correlation and fossils of Gondwana Super Group; Classification and correlation of Mesozoic rocks of India with particular reference to Jammu and Kashmir, Himachal Pradesh; Kutch, Rajsthan, Tamilnadu, Narmada and Assam- Meghalaya.

UNIT V: Classification, lithology, correlation and fossils of Tertiary rocks of India with particular reference to Rajasthan, Jammu and Kashmir, Kerala, Maharashtra, Kutch, Uttaranchal, Assam-Meghalaya and Tamilnadu; Quaternary stratigraphy of India; Neogene-Quaternary boundary problem.

Books Recommended:

Brenner, R.E. and McHargue, T.R. 1988: Integrative Stratigraphy: Concepts and Applications. Prentice Hall.

Doyle, P. and Bennet, M.R. 1996: Unlocking the Stratigraphic Record. John Wiley.

Goodwin, A.M. 1991: Precambrian Geology: The Dynamic Evolution of Continental Crust. Academic Press.

Naqvi, S.M. and Rogers, J.J.W. 1987: Precambrian Geology of India. Oxford University Press.

Pomerol, C. 1982: The Cenozoic Era: Tertiary and Quaternary. Ellis Harwood Ltd.

ES 404: Project Oriented Dissertation
Total Credit: 5
Contact hours: 150
Total Marks: 100

Candidates admitted to the M.Sc. Programme in Applied Geology will be required to undergo a project oriented dissertation on the problems assigned by the department. The dissertation will be field/laboratory/data based and will be carried out under the guidance of a faculty member. Candidates may avail the laboratory facilities at the Department/University as well as outside within the country.

The dissertation findings shall be compiled and submitted in the form of a thesis for evaluation. In addition, candidates are also required to present their dissertation findings in the form of seminar followed by viva-voce before a duly constituted committee.

A certificate duly signed by the candidate and the supervisor has to be enclosed stating the genuineness of the work and it has NOT been submitted elsewhere for any degree.

Examiners and scheme of evaluation shall be as follows:

1. Board of Examiners:
    i. Chairman: Head of Department
    ii. Expert: External Examiner
    iii. Member: Supervisor/ Internal Examiner

2. Evaluation Scheme:
    i. Evaluation jointly by External and Internal Examiners : 75 Marks
    ii. Seminar/Viva-Voce : 25 Marks

ES 405: Practical on ES 401 and ES 402
Total Credit: 2.5
Contact hours: 50
Full Marks: 50 (Semester End Exam. 37.5 + Internal 12.5)

Megascopic study of metallic ores and industrial minerals in hand specimens; Study of ore structures in hand specimens; Study of optical properties and identification of important ore minerals under ore microscope; Preparation of maps showing distribution of metallic and industrial minerals in India and also classical world mineral deposits.

Exercises on calculation of Clarke Concentration. Diagrammatic representation of open cast and underground mining. Exercises on mine sampling and determination of tenor, cutoff grades, and ore reserves.

Laboratory exercises on properties of common rocks with reference to their utility in engineering projects. Laboratory exercises on maps and models of important engineering structures e.g. dam sites and tunnels. Landslide hazard zonation.

ES 406: Industrial/Laboratory Training and Practical on ES 403
Total Credit: 2.5
Contact hours: 60
Full Marks: 50 (Semester End Exam. 37.5 + Internal 12.5)

This programme will focus on training a candidate at an industry based on geological resources in all aspects of mining and mineral processing, equipments being used, products, operation and process control, waste disposal and managing the environment. The department will facilitate the students in getting trained at Geological Industries at the first hand, however, in a constrained situation, few or all the students will be trained in sophisticated instruments used in geological studies in various laboratories in all aspects of the instrumentation including analysis. In either case the students shall have to obtain a certificate of appreciation from the manager of the Industry or in-charge of the laboratory. Each student is required to submit a report on their training and present his/her training in a seminar.

The scheme of evaluation for the Industrial/Laboratory training shall be as follows:

i) Report (will be evaluated jointly by External and Internal supervisors)
ii) Seminar (will be evaluated by a constituted committee)

Study of rocks in hand specimens from known Indian stratigraphic horizons and type localities; Exercises on stratigraphic classification and correlation, sequence-, magneto- and seismic stratigraphic interpretations; Study and understanding of plate-movements through important periods during Phanerozoic eon; Study of palaeogeographic maps of various geological periods.

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