Bachelor of Science- Earth Science (Honors)

Syllabus - First Semester

EARTH SURFACE FEATURES & PROCESSES

Course Code: ESC2102 **Credit Units: 03**

Course objective: The objective of the course is to make the students acquainted with the various processes operating on the earth and how the interactions leads to the evolution of different geomorphological features and landscape. This course gives an idea of natural process in line with human approach of growth and development and how a mutual balancecaters the human need in best possible ways.

Module I:
Introduction to earth surface processes and historical development in concepts;Basic concepts of geomorphology; Terrestrial relief and scales in geomorphology; nature and scope; Overview of landscape evolution models; weathering and erosional processes; Normal cycle of Erosion.

Module II:
Geological work by geological agents; Fluvial, glacial, Aeolian, Coastal and Karst landforms, with special reference to Indian context; Slopes: Stability and failures; River basin and drainage network; River erosion and sediment transport.

Module III:
Overview of Indian geomorphology; Aeolian, Coastal, River valley etc. and their significance.

Examination Scheme:

Components	**A**	**CT**	**HA**	**EE**
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings

- Bloom, A.L. 1998. Geomorphology: A systematic Analysis of Late Cenozoic Landforms (3rd Edition), Pearson Education, Inc.
- Singh, S. 1998. Geomorphology. PrayagPustakBhavan, Allahabad.
- Kale, VS. and Gupta, A. 2001. Introduction to Geomorphology. Orient Longman Ltd.
- Easterbrook, D.J. 1992. Surface processes and landforms. McMillan Publ.

PHYSICS FOR EARTH SCIENCES-I

Course Code: ESC2103 **Credit Units: 02**

Course Objective: The course is designed to develop an understanding of basics of physics which is intricately related to various sub-branches of earth sciences. This course will provide theoretical foundations of different geological processes including structural geology, stratigraphy, geo-tectonics, mass wasting, petrology, crystallography and mineralogy.

Module I:
Elasticity: Hooke's Law, elastic constants, bending of beam,bending moment, Cantilever depression at the loaded end of a cantilever, determination of Young's modulus by non-uniform bending; Viscosity: viscosity of a liquid, viscous force, co-efficient of viscosity of a liquid, Poiseuille's formula, comparison of viscosities of two liquids by graduated burette method; Surface Tension: surface tension, excess of pressure inside a curved surface, Synclatic system, Surface Tension and interfacial surface tension by the method of drops.
Heat:Specific heat, Newton's law of cooling, determination of specific heat of a liquid using Newton's law of cooling; Emissivity and Emissive Power; J.K. Effect, Positive &Negative Effect, Temperature of Inversion; Super conductors, Type I and II, Meisner Effect, Helium I & II

Module II:
Electricity and magnetism: Potentiometer, Principle, Calibration of low range voltmeter, Measurement of internal resistance of cell, measurement of an unknown resistance.
Magnetism: Moment and pole strength of a magnet, Deflection magnetometer, Tan C position, Vibration magnetometer, Theory, Period of Oscillation, Determination of M and BH using the deflection magnetometer in Tan C position and the vibration magnetometer.
Sound and acoustics of building: Transverse vibration of strings, Velocity and frequency of vibrations of a stretched string, laws, sonometer, A.C. Frequency, Steel Wire, Brass wire.
Ultrasonics: Production by Piezo, electric method, properties and uses.
Acoustics of buildings: Reverberation, Reverberation time, Sabine's formula (definition only), Sound absorption co-efficient of surface, conditions for the perfect acoustics.

ModuleIII:
Geometrical optics:Defects of Images (Lens): Spherical aberration; minimizing spherical aberration by using two thin lenses in contact; Chromatic aberration; Achromatic combination of two thin lenses in contact;
Physical optics:Interference; Air Wedge, Description Test for optical flatness of glass plate, determination of diameter of a thin wire by air wedge;Diffraction;Theory of transmission grating, Normal Incidence, Determination of Wavelength of monochromatic source and Wavelength of mercury line using a grating by normal Incidence; Polarisation; Optical activity, Specific rotatory power; Polarimeter.

Examination Scheme:

Components	**A**	**CT**	**HA**	**EE**
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings

- Allied Physics – R. Murugesan S. Chand & Co. First Edition (2005).
- Allied Physics – Dr. K. Thangaraj, Dr. D. Jayaraman Popular Book Department, Chennai.
- Allied Physics – Prof. Dhanalakshmi and others.
- Elements of Properties of Matter – D.S. Mathur, S. Chand & Co. (1999).
- Heat and Thermodynamics – N. Brijlal and Subramaniam S. Chand & Co.
- A text book of Sound – by M. Narayanamoorthy and other National Publishing Companies (1986).
- Modern Physics – R. Murugesan S. Chand & Co. (2004).

CHEMISTRY FOR EARTH SCIENCES-I

Course Code: ESC2104 **Credit Units: 02**

Course Objective: To develop the ability to predict the structures, certain properties and reactivity of the elements and their simpler ionic and covalent compounds. The students would also enhance their understanding of atomic structure and periodicity which would be beneficial in various branches of earth sciences.

Module I:
Atomic Structure: Bohr's theory, wave mechanics: de Broglie equation; Heisenberg's uncertainty principle; Basic idea of Quantum Mechanics Schrodinger's wave equation, quantum numbers and their significance; Pauli's exclusion principle; Hund's rule of maximum multiplicity; Aufbau's principle and its limitations; variation of orbital energy with atomic number.

Module II
Structure and Bonding: Hybridization Ionic Bonding : lattice energy and solvation energy, stability and solubility of ionic compounds, Derivation of Born-Lande equation, Born-Haber cycle and its applications, polarizing power and polarizability, Fajan'srules,ionic character in covalent compounds, bond moment, dipole moment, percentage ionic character.Van-der Waals interactions, hydrogen bonding.

Module III
Chemical Thermodynamics: Objectives and limitations, state and types of system, thermodynamic properties and equilibrium; Laws of Thermodynamics: Concepts of internal energy and enthalpy;entropy, Gibbs free energy and Helmoltz free energy; Concepts in Thermochemistry. Ionic Equilibria: Strong, moderate and weak electrolytes, ionization constant and ionic product of water, pH, ionization of weak acids and bases.

Examination Scheme:

Components	**A**	**CT**	**HA**	**EE**
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings

- Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
- Douglas, B.E. and Mc Daniel, D.H., *Concepts & Models of Inorganic Chemistry*, Oxford, 1970
- Atkins, P.W. & Paula, J. *Physical Chemistry*, Oxford Press, 2006.
- Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry,* ACS Publications 1962.

MATHEMATICS-I

Course Code: ESC2105 **Credit Units: 02**

Course Objective: To make the students well versed with the fundamental concepts in mathematics, which will be essential to understand different physical, mechanical process of earth process with respect to space and time

Module I

Algebra:Partial Fractions; Binomial, Exponential and logarithmic Series (without Proof); Summation; Simple problems.

Theory of equations:Polynomial Equations with real Coefficients; Irrational roots and Complex roots; Transformation of equation by increasing or decreasing roots by a constant; Reciprocal equations; Newton's method to find a root approximately; Simple problems.

Module II

Matrices:Symmetric; Skew-Symmetric; Orthogonal and moduleary matrices; Rank of a matrix; Consistency of equations; Eigen roots and eigen vectors; Cayley-Hamilton theorem (without proof); Verification and computation of inverse matrix.

Trigonometry:Expansions of sinn θ, cosn θ, sinnθ, cosnθ, tannθ; Expansions of sinθ, cosθ, tanθ in terms of θ; Hyperbolic and inverse hyperbolic functions; Logarithms of complex numbers.

Module III

Differential calculus:n-th derivatives; Leibnitz theorem (without proof) and applications; Jacobians; Concepts of polar co-ordinates; Curvature and radius of curvature in Cartesian co-ordinates.

Examination Scheme:

Components	**A**	**CT**	**HA**	**EE**
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings

- P.Duraipandian and S.Udayabaskaran,(1997) Allied Mathematics,Vol. I &II.Muhil Publishers, Chennai.
- P.Balasubramanian and K.G.Subramanian,(1997) Ancillary Mathematics. Vol.I& II. Tata McGraw Hill,
- S.P.Rajagopalan and R.Sattanathan, (2005) Allied Mathematics.Vol. I &II.Vikas Publications, New Delhi.
- P.R.Vittal (2003) Allied Mathematics. Marghan Publications, Chennai
- P.Kandasamy, K.Thilagavathy (2003) Allied Mathematics Vol-I, II S.Chand& company Ltd., New Delhi-55.

BIOLOGY FOR EARTH SCIENCES

Course Code: ESC2106 **Credit Units: 02**

Course Objective: Biology is essential to understand geological processes as it provides several vital clues about tracking process in past. This course is meant to provide basic understanding of different forms of life and their organization which is pre-requisite for paleontology. The major thrust will be on the taxonomical classification of the plant and animal kingdom.

Module I:
Introduction: Origin of life; Their adaptation to various kinds of environments; Theories of evolution: Darwinism, Neo-Darwinism, Lamarckism and Neo-Lamarckism; Mode of speciation; Fossils and their significance; Zoogeographical &Phytogeographical outline only.

Module II:
Taxonomic Hierarchy: Taxonomic category and groups; Concepts of species, genus and family; Nomenclature: Principles and rules, Ranks and names; Type method; Principle of priority and its limitations; Biological classification: Five Kingdom system; Plant & Animal Kingdom basics

Module III:
Structural Organization in Plants and Animals: Structuralorganization in animals; Salient features and classification of Non-chordates, Classification of Mammal outline; Salient features and classification of plants.

Examination Scheme:

Components	A	CT	HA	EE
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings

- Ganguly,H.CandKar,A.K.:*College Botany,* Vol.II, (New Central Book Agency)
- Mayr and Ashlok: *Principles of Systematic Zoology*
- Minkoff: *Evolutionary Biology*
- Ayala: *Population and Evolutionary Genetics*
- Jones,S.B.&Luchsinger, A.B: *Plant Systematics,* (McGrawHill)
- Datta,S.C.: *Systematic Botany,*(Wiley Eastern)

CHEMISTRY LABORATORY

Course Code: ESC2107 **Credit Units: 01**

Course Content:

1.Titrimetric Analysis
(i) Calibration and use of apparatus
(ii) Preparation of solutions of different Molarity/Normality of titrants

2. Acid- Base Titrations
(i) Estimation of carbonate and hydroxide present together in mixture.
(ii) Estimation of carbonate and bicarbonate present together in a mixture.
(iii) Estimation of free alkali present in different soaps/detergents

3. Oxidation- Reduction Titrimetry
(i) Estimation of Fe(II) and oxalic acid using standardized $KMnO_4$ solution.
(ii) Estimation of oxalic acid and sodium oxalate in a given mixture.
(iii) Estimation of Fe (II) with $K_2Cr_2O_7$ using internal (diphenylamine, anthranilic acid) and external indicator.

Examination Scheme:

IA				EE	
A	**PR**	**LR**	**V**	**PR**	**V**
5	10	10	5	35	35

Note: IA –Internal Assessment, EE- External Exam, PR- Performance, LR – Lab Record, V – Viva.

FIELD SURVEY-I

Course Code: ESC2108 **Credit Units: 02**

Course Content:

1. To make the students acquainted with toposheets and working on GPS
2. Identification of geomorphological features in a terrain

Examination Scheme:

IA				EE	
FV	**PR**	**LR**	**V**	**PR**	**V**
20	10	10	10	25	25

Note: IA –Internal Assessment, EE- External Exam, FV-Field Visit, PR- Presentatione, LR – Lab Record, V – Viva.

Syllabus - Second Semester

CRYSTALLOGRAPHY & MINERALOGY

Course Code: ESC2201 **Credit Units: 03**

Course Objective: The course will develop an understanding of the science behind the fundamental chemical, geometrical and physical relationship of matter. This course highlights the chemical and optical fundamentals to decipher structural symmetry of minerals and their optical properties.

Module I:
Crystallography: Definition and morphology of crystal and crystal notation; Symmetry elements; Parameter, indices and symbols, Laws of Crystallography; Stereographic Projection; Derivation of 32 classes of crystal; Study of following crystal systems: Isometric System, Tetragonal System, Hexagonal System, Orthogonal System, Monoclinic System, Triclinic System.

Module II:
Mineralogy: Definition and physical properties of Minerals; ions, bonds and their types, coordination number, Isomorphism, Polymorphism and Pseudomorphism; Structure of silicates; A detailed study of importantrock forming mineral groups with reference to their composition, structure, physical and optical properties and paragenesis.

Module III:
Optical Mineralogy: Elementary concepts of light; Propagation of light through minerals, Principles of optical mineralogy; Brief idea of space lattice;Crystal habits and twinning, laws of twinning, polarization, double refraction; construction of Nicol Prism, Petrological Microscope and its functions;Isotropism and Anisotropism; Important optical properties: R.L, Relief, Pleochroism, Pleochroic, Haloes, Extinction and Extinction angle, Birefringence, Interference colours; behavior of convergent polarized light in Uniaxial and Biaxial Minerals.

Examination Scheme:

Components	A	CT	HA	EE
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings

- W. D. Nesse, (2000), Introduction to Mineralogy, Oxford University Press, ISBN 0-19-510691-1
- Cornelis Klein and Barbara Dutrow, The manual of Mineral Science, Wiley Publication 2007.
- P. F. Kerr Optical Mineralogy,1959
- P. K. Verma , Optical mineralogy, CRC press 2009
- NesseW.D. , Introduction to Optical mineralogy, 2008
- Deer, W. A. , Howie, R. A. and Zussman, J., An introduction to the rock forming minerals, ELBS publication,1962-1963.

PHYSICS FOR EARTH SCIENCES-II

Course Code: ESC2204 **Credit Units: 02**

Course Objective: This course is designed to develop an understanding of physics at successively deeper levels with a greater insight into the topics such as wave mechanics, nuclear and energy physics alongwith crystallography and fibre optics.

Module I:
Mechanics:Galilean invariance and Newton's Laws of motion; Dynamics of a system of particles; Conservation of momentum and energy; work energy theorem; Conservation of angular momentum, torque, Motion of a particle in central force field;Kepler's Laws, Satellite in circular orbit and applications; Wave mechanics:Wave mechanics, De Broglie Waves, dual nature, experimental study of Matter Waves, Davission and Germer's Experiment, G. P. Thomson's Experiment, Heisenberg's uncertainty Principle, the position and moment of a particle.

ModuleII
Fluid Mechanics: Fluid Flow,Archimedes' Principle, Ideal fluid in motion, Equation of continuity, Darcy's Law, Bernoulli's Theorem, The flow of real fluids;Waves and Oscillations: Simple harmonic motion, damped and driven harmonic oscillator, coupled oscillator, energy; Wave equation: Travelling waves, superposition principle, pulses; Doppler effect,physics of hearing, heartbeat; Electromagnetic Waves, Maxwell's equation;

Module III
Magentism: Magnetic field; The magnetic dipole; Current and the magnetic field; Magnetism, Gauss's law; Paramagnetism, Diamagnetism and Ferromagnetism; The magnetism of the Earth, and its causes; Gravity; Earth's Gravitational field, Gravity and its measurement; Gravity anomaly, Free-air Correction; Bougyer Correction;

Examination Scheme:

Components	**A**	**CT**	**HA**	**EE**
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings

- Allied Physics – R. Murugesan S. Chand & Co. First Edition (2005).
- Allied Physics – Dr. K. Thangaraj, Dr. D. Jayaraman Popular Book Department, Chennai.
- Allied Physics – Prof. Dhanalakshmi and others.
- Modern Physics – R. Murugesan S. Chand & Co. (2004).

CHEMISTRY FOR EARTH SCIENCES-II

Course Code: ESC2205 **Credit Units: 02**

Course objective:
To develop the ability to predict the structures, certain properties and reactivity of the elements with emphasis on inorganic compounds and complexes which would be beneficial in various branches of earth sciences.

Module I
Complexes of s- and p- block elements; Hydrides and their classification (ionic, covalent and interstitial);Structure and variations in properties with respect to stability; Bio-Inorganic Chemistry: A brief introduction to bio-inorganic chemistry; Role of metal ions present in biological systems with special reference to Na^+, K^+,Mg^{2+} ions: Na/K pump; role of Mg^{2+} ions in energy production transmission of impulses along nerve fibers and chlorophyll; Role of Ca^{2+}ions in blood clotting, muscle contraction, stabilization of protein structures and structural role.

Module II
Kinetic Theory of Gases: Collision and mean free path of molecules; Effects of temperature and pressure; Viscosity, relation between mean free path and coefficient of viscosity; Temperature and pressure dependence of coefficient of viscosity; Degrees of freedom of motion, Principle of equipartition of energy.
Chemical Toxicity: Toxicity of As, Cd, Pb. Hg, CO, NOx, SOx, H_2S;Sources of contamination; Causes of toxicity.

Module III
Liquids: Surface tension and Viscosity and their determination; Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only); Systems of Variable Composition and Solutions Partial molar quantities and their physical significance; Chemical potential,Free Energy and entropy of mixing of ideal gases; Thermodynamics of Ideal Solutions.

Examination Scheme:

Components	**A**	**CT**	**HA**	**EE**
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings

- Atkins, P.W. & Paula, J. *Physical Chemistry*, Oxford Press, 2006.
- Day, M.C. and Selbin, J. *Theoretical Inorganic Chemistry*, ACS Publications 1962.

MATHEMATICS-II

Course Code: ESC2206 **Credit Units: 02**

Course objective: To make the students explore the basic concepts of mathematics and statistics which are relevant for branches of earth sciences.

Module-I

Introduction, integration of few standard functions, integration by parts, partial fractions, integration by parts, Definite integrals and their properties, applications of integrals such as area of curves. Evaluation of double, triple integrals; Simple applications to area and volume

Module-II

Statistics: Frequency and distribution; Arithmetic mean, Median, Partition values, Mode, Variance and standard deviation; Curve fitting; Principle of least square; Linear regression.

Module-III

Probability: Introduction to Probability; Addition and multiplication theorem of Probability; Random variables and Probability distribution; Expected values; Binomial distribution; Poisson distribution & Normal distribution and their application.

Examination Scheme:

Components	**A**	**CT**	**HA**	**EE**
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings

- P. Duraipandian and S.Udayabaskaran,(1997) *Allied Mathematics*, Vol. I &II.Muhil Publishers, Chennai
- Shaum's Series outlines of Statistics

STRUCTURAL GEOLOGY

Course Code: ESC2210 **Credit Units: 03**

Course Objective: This course deals with the study of the three dimensional distribution of rock Modules with respect to their deformational history. The study will make the students understand the structural evolution of a particular region and the important events which occurred in the regional geological past.

Module I:
Definition and objectives; Effects of topography on structural features; Topographic and structural maps; scale of the map; Survey methods; Contouring and Plotting, Measurement of slope heights, aspects and gradients; Global Position System.Exercise of localization of points, estimation of slope and real distance in the map, isolines, elevation points; Landform identification and construction of elevation profiles from maps

Module II:
Idea of stress in rocks, factors controlling rock deformations;Stratification and bedding; Attitude of beds; Outcrops and outcrop patterns, Outliers and inliers; Dip & strike: Clinometers compass and its uses;Significance of top-bottom criteria in structural geology;

Module III:
Definitions, classifications, causes, recognition and economic importance and geologic significance of Folds, Faults, Unconformities, Joints.Lineation, Foliation, Rock cleavage:definition and types.

Examination Scheme:

Components	**A**	**CT**	**HA**	**EE**
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings

- Davis, GR. 1984. Structural Geology of Rocks and Region. John Wiley
- Weijermars, R. 1997. Structural Geology and Map Interpretation, Alboran Science Publishing.
- Billings, M.P. 1987. Structural Geology, 4th edition, Prentice-Hall.
- Hatcher, Jr., R.D. 1995. Structural Geology - Principles, Concepts and Problems, Merrill Publishing Company.
- Ghosh, SK. 1993. Structural geology: fundamentals and modern developments, Pergamon Press, London

EARTH SCIENCES LABORATORY-I

Course Code: ESC2208 **Credit Units: 02**

Course Content:

Crystallography:

1. Study of elements of symmetry of normal classes of six crystal systems.
2. Study of Clinographic Projection
3. Stereographic projection of face poles of crystals.

Mineralogy:

4. Study of physical properties of various common and important minerals in hand specimen –i.e. Silicates, Sulfides, Oxides, Hydroxides, Halides, Carbonates, Phosphates etc.

Optical Mineralogy:

5. Optical identification of common rock forming minerals - Quartz, Plagioclase, Microcline, Muscovite, Biotite, Fluorite, Olivine, Garnet. Tourmaline, Staurolite, Andalusite, Kyanite, Sillimanite, Cordierite. Hypersthene, Augite, Diopside, Hornblende, Tremolite-Actinolite. Corundum, Beryl, Calcite, Barite.

Structural Geology

6. Drawing profile sections and interpretation of geological maps of different complexities.
7. Exercises of stereographic projections of mesoscopic structural data (planar, linear, folded etc.).
8. Solving problems related to stress and strain measurements.

Examination Scheme:

IA				EE	
A	**PR**	**LR**	**V**	**PR**	**V**
5	10	10	5	35	35

Note: IA –Internal Assessment, EE- External Exam, PR- Performance, LR – Lab Record, V – Viva.

FIELD SURVEY-II

Course Code: ESC2209 **Credit Units: 02**

Course Content:

- To identify the mineral assemblage on an outcrop through hand lens and physical properties habit, color, luster, tarnish, cleavage, and hardness, relative to a knife.
- To identify and relate the various structural features found in the field and prepare a geological map.

Examination Scheme:

IA				EE	
FV	**PR**	**LR**	**V**	**PR**	**V**
20	10	10	10	25	25

Note: IA –Internal Assessment, EE- External Exam, FV-Field Visit, PR- Presentatione, LR – Lab Record, V – Viva.

Syllabus - Third Semester

IGNEOUS PETROLOGY

Course Code: ESC2301 **Credit Units: 03**

Course Objective: A basic course in earth sciences which deals with the origin, composition, distribution and structure of the rocks that have an origin from magma. The study of igneous rocks is important because they make up the bulk of the earth's crust in the geological time period.

Module I
Introduction to petrology; its significance, distinguishing features of three types of rocks; Magma: Definition, generation and crystallization of magma, elementary idea of magma generation & tectonic setting; Origin of primary and basic magma, Bowen's reaction principle and its petrological significance; Diversity of igneous rocks, concept of intrusion and extrusion.

Module II
Structure, textures and classification of igneous rocks; Concept of mode and norm; Phase rule and phase diagrams – binary and ternary systems.

Module III
Petrogenesis of granite, alkaline rocks; Basalt, Anorthosite and Ultramafic rocks; Petrographic description of the following rock types: Granite, Rhyolite, Syenite, Nepheline-syenite, Monzonite, Granodiorite, Diorite, Pegmatite, Anorthosite, Gabbro, Dolerite, Basalt, Peridotite, Pyroxenite, Norite, Dunite, Trachyte and Andesite.

Examination Scheme:

Components	**A**	**CT**	**HA**	**EE**
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings:

- John D. Winter 2001. An Introduction to Igneous and Metamorphic Petrology. Prentice Hall Inc
- Loren A. Raymond 2002. Petrology: The study of Igneous, Sedimentary and Metamorphic rocks. McGraw Hill .New York
- Bose M.K. 1997. Igneous Petrology. World Press
- Cox, K.G. Bel, J.D. and Pankthrust, R.J. 2002. The interpretation of Igneous rocks. Allen and Unwin, London
- Pankthrust, 2000. Igneous and Metamorphic rocks. Prentice Hall.
- Phillpots, A.R., and Ague, S.J., 2009. Principles of igneous and metamorphic petrology (2^{nd}Edn.) Cambridge.

SEDIMENTOLOGY

Course Code: ESC2302 **Credit Units: 02**

Course Objective: This course is a branch of petrology, dealing with the study of modern sediments and the processes resulting in their deposition. Sedimentary rocks are particularly significant because of the vast extent on the earth's surface and their close linkages to the geological past.

Module I

Introduction to basic concepts: Definition, difference between sedimentary petrology and sedimentology; Description and classification of sedimentary rocks, sedimentary environments and facies, Weathering and sedimentary flux: physical and chemical weathering, submarine weathering, soils and paleosols; Fluid flow and its types, sediment transport and deposition.

Module II

Textures of clastic and non-clastic sedimentary rocks; Structures of sedimentary rocks;Lithification and Diagenesis; Provenance; Siliciclastic rocks: Conglomerates, Sandstones, Mudrocks (texture, composition, classification, origin and occurrence); Introduction to coal and petroleum.

Module III

Non-siliciclastic rocks: Carbonate rocks, controls of carbonate deposition, limestone, dolomite and dolomitisation; Chert and siliceous sediments; Phosphorites, carbonaceous sediments, iron rich sediments and evaporates; Petrographic description of the major rock types: Conglomerate, Breccia, Sandstones - orthoquartzite, Arkose, Greywacke, Limestone, Dolomite, Shale.

Examination Scheme:

Components	**A**	**CT**	**HA**	**EE**
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings:

- Prothoreo and Schwab, 2004, Sedimentary Geology, Freeman and Co. New York, 557p
- Sam Boggs, 1995, Principles of Sedimentology and Statigraphy, Printice Hall, New Jersey, 765p .
- Maurice E. Tucker, 2006, Sedimenary Petrology, Blackwell Publishing, 262p.
- Collinson, J.D. and Thompson, D.B. 1988, Sedimentary structures, Unwin-Hyman, London, 207p.
- Lindholm, R.C., 1987, A practical approach to sedimenmtology, Allen and Unwin, London
- Pettijohn, F.J. 1975, Sedimentary rocks, Harper and Row Publ. New Delhi

METAMORPHIC PETROLOGY

Course Code: ESC2303 **Credit Units: 02**

Course Objective: This course would highlight the relationship of rocks with the field relations and local tectonic environment, especially how the impact of heat and pressure causes profound physical and chemical change in a rock to change their form.

Module I

Definitions and scope, factors controlling metamorphism; Types of metamorphism: contact, regional, fault zone metamorphism, impact metamorphism; Metamorphic zones and isograds; Limitations of metamorphism; Diagenesis, Metamorphism, Anataxis, Palingenesis

Module II

Concept of zones, facies, grades andisograds; Metamorphic differentiation, prograde, retrograde, and poly-metamorphism;Paired metamorphic belts, Index minerals; Thermal and Regional metamorphism of argillaceous, calcareous and basic igneous rocks.

Module III

Metamorphism and melting, origin of migmatities; Metasomatism, role of fluids in metamorphism; Petrographic notes on the following metamorphic rocks: Slate, Phyllite, Schists, Gneisses, Amphibolites, Marble, Quartzites, Hornfels, Charnockite, Khondalite, Eclogite, Kodurite and Skarns.

Examination Scheme:

Components	**A**	**CT**	**HA**	**EE**
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings:

- Yardley, B W D. 1990. An introduction to metamorphic petrology. ELBS publication.
- Bucher K. and Martin F. 2002. Petrogenesis of Metamorphic rocks. Springer-Verlag Publication.
- Best, M.G. 2002. Igneous and metamorphic petrology. Wiley publication.
- Vernon R. H. and Clarke G. L. 2008. Principles of metamorphic Petrology. Cambridge publication.
- Spears F. 1993. Metamorphic Phase Equilibria and Pressure-Temperature-Time Paths. AGU publication
- John D. Winter 2001. An Introduction to Igneous and Metamorphic Petrology. Prentice Hall Inc

ATMOSPHERIC SCIENCES

Course Code: ESC2304 **Credit Units: 02**

Course Objective: The purpose of the course is to give a holistic understanding of the various processes and effects of the atmosphere on the other systems and vice versa. This will make the students aware with the fundamental concepts of the climate system and the changes taking place therein.

Module I

Atmosphere: Structure and composition, vertical profile of temperature and pressure, microphysical processes in the atmosphere;Atmospheric physics: radiation balance, radiative forcing;Fundamental forces: Pressure gradient force, centrifugal force, gravity force, coriolis force;

Module II

Introduction to components of climate science**:** Climate System and interaction among components of climate system and feedback mechanisms; Atmospheric thermodynamics, radiation in the atmosphere, Earth's heat budget, greenhouse gases and climate forcing; Heat transfer in ocean

Module III

Paleoclimatology: Introduction and measurement techniques; Aerosol in atmosphere, properties; carbonaceous aerosols; radioactive effects of Atmospheric aerosols; direct and indirect effects of aerosol particles. Indian monsoon and its variability, western disturbances, Indian Ocean Dipole; El Niño-Southern Oscillation;

Examination Scheme:

Components	**A**	**CT**	**HA**	**EE**
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings:

- Barbara J., Pitts F. and Pitts J.N., Jr (2000) Chemistry of the Upper and Lower Atmosphere-Theory, Experiments and Applications Academic Press, San Diego.
- Marshall J. and Plumb R.A. (2001) Atmosphere, Ocean and Climate, *Elsevier*, Amsterdam.
- Oliver J.E. and HidoreJ.J. (2008) *Climatology: An Atmospheric Science*, Prentice Hall.
- Seinfeld J.H. and PandisS.N. (2006) Atmospheric Chemistry and Physics-from Air Pollution to Climate Change, John Wiley and Sons, INC.
- Barry, R. G., 2003. Atmosphere, weather and climate. Routledge Press, UK

MARINE SCIENCES

Course Code: ESC2309 **Credit Units: 02**

Course Objective: The aim of this course is to make the students aware of the various factors that play an important role in determining the physical and chemical characteristics of the marine water and the associated marine biota.

Module I

Hydrological cycle; Origin and composition of sea water; geomorphology of Ocean; Relief of ocean floor; division of ocean floor; Chemical composition of sea water; Vertical and horizontal distribution of temperature and salinity

Module II

Oceanic current system and effect of coriolis forces; Concepts of Eustasy; Ekman rule; Land-Air-Sea interactions; Ocean currents, major ocean currents; Sea level changes and its impact on coastal areas, waves, climate change and ocean.

Module III

Coastal erosion and stabilization; Delta and estuaries; Coastal zone regulation and management; Basic ocean biology

Examination Scheme:

Components	A	CT	HA	EE
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings:

- Gross,M.G., 1977. *Oceanography: A view of the Earth*, Prentice Hall.
- Haq and Boersma, 1978. *Introduction to Marine Micropaleontology*, Elsevier.
- Tolmazin,D., 1985. *Elements of Dynamic Oceanography*, Allen and Unwin.

EARTH SCIENCES LABORATORY-II

Course Code: ESC2307 **Credit Units: 02**

Course Content:

Igneous Petrology:
Megascopic and microscopic (textural and mineralogical) study of major igneous rocks.

Metamorphic Petrology:
Megascopic and microscopic study (textural and mineralogical) of low grade metamorphic rocks (i.e.,serpentinites, schist, slate, talc-tremolite-calcite-quartz schist.)
Megascopic and microscopic study (textural and mineralogical) of medium to high grade metamorphic rocks: Gneisses, amphibolite, hornfels, sillimanite-kyanite-bearing rocks, Granulites, eclogite, diopside-forsterite marble.
Laboratory exercises in graphic plots for petrochemistry and interpretation of paragenetic diagrams.

Sedimentology:
Exercises on sedimentary structures and their palaeo-environmental significance,
Petrography of clastic and non-clastic rocks through handspecimens and thin sections.

Examination Scheme:

IA				EE	
A	**PR**	**LR**	**V**	**PR**	**V**
5	10	10	5	35	35

Note: IA –Internal Assessment, EE- External Exam, PR- Performance, LR – Lab Record, V – Viva.

FIELD SURVEY-III

Course Code: ESC2308 **Credit Units: 03**

Course Content:

- To identify rocks and mineral assemblages in an outcrop through rock hammer, pocket knife, a hand lens or a magnifying glass or dropper bottle of hydrochloric acid.
- To acquaint the students with the geomorphological features.
- Mapping and identification of structural features in the field.

Examination Scheme:

IA				EE	
FV	**PR**	**LR**	**V**	**PR**	**V**
20	10	10	10	25	25

Note: IA –Internal Assessment, EE- External Exam, FV-Field Visit, PR- Presentatione, LR – Lab Record, V – Viva.

SUMMER PROJECT EVALUATION-I

Course Code: ESC2335 **Credit Units: 03**

Objectives:
Practical and field training is based on the theoretical subjects studied by subjects. It can be arranged within the college, research organization, or any in any related industrial unit. The students are to learn various geological, mining, technical and administrative processes. In case of on campus training the students will be given specific tasks of testing / analysis / characterization of subject related domain of Earth and Environmental Science. On completion of the practical training the students are to present a report covering various aspects learnt by them and give a presentation of the same.

Chapter Scheme and distribution of marks:
Chapter 1: Introduction – 10 marks
Chapter 2: Conceptual Framework/ National/International Scenario – 25 marks
Chapter 3: Presentation, Analysis & Findings -- 25 marks
Chapter 4: Conclusion & Recommendations -- 10 marks
Chapter 5: Bibliography -- 05 marks

Project Report	Power Point Presentation & Viva
75 marks	25 marks

The Steps of a Project Report
Step I : Selection of the topic for the project by taking following points into consideration:

- Suitability of the topic.
- Relevance of the topic
- Time available at the disposal.
- Feasibility of data collection within the given time limit.
- Challenges involved in the data collection (time & cost involved in the data collection, possibility of getting responses, etc.)

Step II : Finalisation of the Topic and preparation of Project Proposal in consultation with the Supervisor.

Step III : Collection of information and data relating to the topic and analysis of the same.

Step IV : Writing the report dividing it into suitable chapters, viz.,
Chapter 1:Introduction,
Chapter 2: Conceptual Framework / National & International Scenario,
Chapter 3: Analysis & Findings
Chapter 4: Conclusion and Recommendations.

StepV: The following documents are to be attached with the Final Project Report.
1) Approval letter from the supervisor (Annexure-IA)
2) Student's declaration (Annexure-IB)
3) Certificate from the Competent Authority of the Organisation / Institution, if the student undertakes the Project Work in any Organisation / Institution.

Guidelines for Evaluation:

- Each of the students has to undertake a Project individually under the supervision of a teacher and to submit the same following the guidelines stated below.
- Language of Project Report and Viva-Voce Examination may be English. The Project Report must be typed and hard bound.
- Failure to submit the Project Report or failure to appear at the Viva-voce Examination will be treated as "Absent" in the Examination. He /she has to submit the Project Report and appear at the Viva-Voce Examination in the subsequent years (within the time period as per University Rules).
- No marks will be allotted on the Project Report unless a candidate appears at the Viva-Voce Examination. Similarly, no marks will be allotted on Viva-Voce Examination unless a candidate submits his/her Project Report.
- Evaluation of the Project Work to be done jointly by one internal expert and one external expert with equal weightage, i.e., average marks of the internal and external experts will be allotted to the candidate.

Syllabus - Fourth Semester

ECONOMIC GEOLOGY (INDIA)

Course Code: ESC2405 **Credit Units: 02**

Course Objective: This course will emphasize on the earth materials primarily used for economic and/or industrial purposes. This branch of earth sciences is extremely significant as it used ingeochemistry, mineralogy, geophysics, petrology, structural geology etc. Economic geology is of utmost concern for environmentalists, engineers and conservationists

Module I

Definition and types of ore and minerals and their deposition; Bateman's classification; Principles and processes of formation of ores: Endogenous processes: magmatic concentration, contact metasomatic, skarns, greisens, pegmatites and hydrothermal deposits. Exogenous processes: sedimentation as a process of ore formation. Chemical and bacterial precipitation.Colloidal deposition.

Module II

Weathering products and residual deposits:oxidation and supergene enrichment.Evaporation of brine and metamorphism as ore forming processes. Metallic ores: uses, geological occurrences, origin and geographical distribution of the mineral deposits of –Fe, Cr, W, Sn, Zn Pb, Au, Al, Mg and Co and atomic minerals, Nonmetallic and industrial rocks and minerals, their nature and distribution in space and time in India: refractory, chemical, fertilizer, cement, chemical and gemstone industry including building stones.

Module III

Economic importance of the following geological formations of India: Precambrians of Dharwars&Singhbhum, Cuddapah, Vindhyan, Gondwana, Jurassic of Kutch, Cretaceous of South India, Siwaliks and Tertiary of Assam.

Examination Scheme:

Components	A	CT	HA	EE
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Reading:

- Jensen and Bateman: Economic Mineral Deposits.
- Sen and Guha: A Handbook of Economic Geology.
- Banerjee: Mineral Resources of India.
- Sharma and Ram: Introduction to India's Economic Minerals.
- Deb: Industrial Minerals and Rocks of India.

GEOCHEMISTRY

Course Code: ESC2406 **Credit Units: 03**

Course Objective: This course would provide various aspects of chemistry, with major thrust on the relative abundance, distribution and cycling of earth's chemical elements and their isotopes. This will also lay a foundation for analytical and conceptual concepts which would further be helpful for research in specialized areas much significant of earth sciences.

Module I

States of matter and atomic environment of elements, geochemical classification of elements, the composition of different earth reservoirs and the nucleus and radioactivity.Conservation of mass, isotopic and elemental fractionation. Concept of radiogenic isotopes in geochronology and isotopic tracers: dating by radioactive nuclides, Carbon 14, Beryllium 10, K-Ar method, radiogenic

Module II

Introduction to properties of elements:. Element transport: advection, diffusion. Chromatography. Aqueous geochemistry: carbonate chemistry basic concepts, speciation in solutions; toxicity of heavy metals; precipitation and dissolution of minerals; the solubility of minerals: clays, hydroxides, carbonates, sulfides, the phase rule, elements of marine chemistry.

Module III

Mineral reactions- Diagenesis and hydrothermal reactions.The solid Earth – geochemical variability of magma, melting of the mantle and growth of continental crust.The Earth in the solar system, the formation of solar system, composition of the bulk silicate Earth.Meteorites.Geochemical behavior of selected elements like Si, Al, K, Na etc.

Examination Scheme:

Components	**A**	**CT**	**HA**	**EE**
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings:

- Mason, B (1986). Principles of Geochemistry. 3rd Edition, Wiley New York.
- Walther John, v., 2009 Essentials of geochemistry, student edition. Jones and Bartlett Publishers
- Albarede, F, 2003. An introduction to geochemistry. Cambridge University Press

REMOTE SENSING AND GIS

Course Code: ESC2410 **Credit Units: 02**

Course Objective: This course will develop the skills of students in the field of GIS and remote sensing. It will also give the basic concepts of remote sensing and principles associated with image acquisition and image processing. The role of GIS as a tool in environmental management and knowledge of GPS will be facilitated. This course will also look into the application of remote sensing/GIS in database generation and environmental management.

Module I

Map: Definition, types, scale and projections; Remote sensing: Introduction, scope and components; Electromagnetic spectrum, its characteristics and interaction with environment, spectral signature, albedo, atmospheric windows, platforms & sensors; Aerial photography, elements of visual image interpretation, multispectral remote sensing, microwave remote sensing;Photogrammetry: Introduction, stereoscopic vision;Digital image processing.

Module II

Geographic Information System:Introduction, definition and terminology; Components and fundamental operations of GIS; Data structure, raster and vector data structures;Data input methods;Accuracy, precision and resolution, Consistency, completeness; Global positioning systems (GPS):Basics, satellite generation, positioning services, GPS details and integration, coordinate systems, survey of India (SOI) topographical maps; GIS and image processing software.

Module III

Techniques and applications of remote sensing in forest cover/ type mapping, degradation, biomass estimation, habitat analysis, biodiversity characterization, environmental monitoring, geo-hazard assessment; Use of GIS and remote sensing to solve environmental problems and early warning system.

Examination Scheme:

Components	A	CT	HA	EE
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings:

- Lillisand, Thomas, Ralph W. Kiefer and Jonathan Chipman. 2007. Remote Sensingand Image Interpretation. Wiley India.
- Jensen, John R. 2004. Introductory Digital Image Processing: A Remote SensingPerspective.Prentice Hall.
- Burrough, P.A. and McDonnell, R.A. (1998) Principles of geographical information systems. Oxford University Press, Oxford, 327 pp.
- Jensen J.R. (2000) Remote Sensing of the Environment: An Earth Resource Perspective, Prentice Hall, ISBN 0-13-489733-1.

HYDROGEOLOGY

Course Code: ESC2411 **Credit Units: 02**

Course Objective: The course is designed to make the students aware about the peculiarities of the availability and movement of sub-surface and surface water. The various geological characteristics of ground water and surface water will be dealt with.

Module I:
Scope of hydrogeology and its societal relevance; Hydrologic cycle (Precipitation, evapo-transpiration, runoff, infiltration); Subsurface movement of water, flow in saturated and unsaturated zones; Vertical distribution of sub-surface water; Origin and age of groundwater.

Module II:
Groundwater - geological formations as aquifers, aquifer properties, types of aquifers, geological classification of aquifers, porous and fractured aquifers; Groundwater occurrence in igneous, metamorphic and sedimentary rocks; Groundwater in non-indurated sediments; Darcy's law; Groundwater provinces of India; Dynamics of groundwater flow; phreatic and piezometric level, analysis of piezometric surface, groundwater level fluctuations; aquifer's hydraulic parameters.

Module III:
Theory of groundwater flow, elementary well hydraulics, surface and subsurface exploration of groundwater, drilling and construction of wells, pumping tests and analysis of test data for evaluation of aquifer parameters; Groundwater level fluctuations; Physical and chemical properties of water and water quality; Water balance studies: basic concept, development and management of groundwater resources. Surface and subsurface water interaction, Sea water intrusion in coastal aquifers;

Examination Scheme:

Components	**A**	**CT**	**HA**	**EE**
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings

- Todd, D.K. 2006. Groundwater hydrology, 2nd Ed., John Wiley & Sons, N.Y.
- Davis, S.N. and De Weist, R.J.M. 1966. Hydrogeology, John Wiley & Sons Inc., N.Y.
- KaranthK.R., 1987, Groundwater: Assessment, Development and management, Tata McGraw-Hill Pub. Co. Ltd.
- Fetter, C.W. 2001. Applied Hydrogeology, Prentice Hall Inc., N.J

GEOPHYSICS

Course Code: ESC2412 **Credit Units: 02**

Course Objective: The course is developed to give an insight about the physics of earth and the study of earth using quantitative physical methods.

Module I
Interrelationship between geology and geophysics - Role of geological and geophysical data in explaining geodynamical features of the earth. General and Exploration geophysics- Different types of geophysical methods;

Module II
Geophysical Methods: Gravity, magnetic, Electrical, Seismic- their principles and applications. Concepts and Usage of corrections in geophysical data. Geophysical field operations - Different types of surveys, grid and route surveys, profiling and sounding techniques, scales of survey, presentation of geophysical data.

Module III
Application of Geophysical methods - Regional geophysics, oil and gas geophysics, ore geophysics, groundwater geophysics, engineering geophysics. Geophysical anomalies: correction to measured quantities, geophysical, anomaly, regional and residual (local) anomalies, factors controlling anomaly, depth of exploration. Integrated geophysical methods - Ambiguities in geophysical interpretation, Planning and execution of geophysical surveys.

Examination Scheme:

Components	**A**	**CT**	**HA**	**EE**
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings:

- The Solid Earth: An Introduction to Global Geophysics (2^{nd} ed. 2005) by CMR Fowler, Cambridge University Press.
- Applied Geophysics by Telford W.M., Geldart L.P. and Sheriff R.E., Cambridge University Press.

EARTH SCIENCE LABORATORY-III

Course Code: ESC2408 **Credit Units: 02**

Course Content:

- Study of Topographic Sheets, map sheets, thematic maps,
- Study of aerial photographs delineating geomorphic features, rock types and structural features
- Processing of satellite data and delineation of rock types and mapping of soil, vegetation, water and geologic structure.
- Preparation and interpretation of water table contour maps and depth to water level contour maps.
- Study, preparation and analysis of hydrographs for differing groundwater conditions.
- Water potential zones of India (map study) including saline water zones.

Examination Scheme:

IA				EE	
A	**PR**	**LR**	**V**	**PR**	**V**
5	10	10	5	35	35

Note: IA –Internal Assessment, EE- External Exam, PR- Performance, LR – Lab Record, V – Viva.

FIELD SURVEY-IV

Course Code: ESC2409 **Credit Units: 03**

Course Content:

- Detailed hand on exposure with GPS (Global Positioning System) and its working.
- Correlation of satellite image with toposheet and ground verification in a terrain and preparation of a geological map.
- Geological reporting of field including all major parameters and their important significance.

Examination Scheme:

IA				EE	
FV	**PR**	**LR**	**V**	**PR**	**V**
20	10	10	10	25	25

Note: IA –Internal Assessment, EE- External Exam, FV-Field Visit, PR- Presentatione, LR – Lab Record, V – Viva.

Syllabus - Fifth Semester

EXPLORATION GEOLOGY

Course Code: ESC2503 **Credit Units: 02**

Course Objective: Basic knowledge of the occurrence of the resources along with the techniques and statistical analysis associated with for mineral exploration.

Module I:
Resource reserve definitions; Mineral resources in industries:Historical and presentperspective; A brief overview of classification of mineral deposits with respect to processes of formation in relation to exploration strategies.

Module II:
Principles of mineral exploration;Prospecting and exploration- conceptualization; Methodology and stages; Sampling, subsurface sampling including pitting, trenching and drilling, core and non-core drilling, planning of bore holes and location of boreholes on ground; Core-logging; Geochemical exploration: Nature of samples; Anomaly, strength of anomaly and controlling factors; Coefficient of aqueous migration.

Module III:
Introduction to geophysical methods of exploration Principles of reserve estimation, density and bulk density, factors affecting reliability of reserve estimation, reserve estimation based on geometrical models (square, rectangular, triangular and polygon blocks);Regular and irregular grid patterns;Statistics and error estimation.

Examination Scheme:

Components	**A**	**CT**	**HA**	**EE**
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings:

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

PALEONTOLOGY

Course Code: ESC2505 **Credit Units: 02**

Course Objective: The students would develop an understanding of the origin and evolution of the past life which is a vital in giving information about Earth's organic and inorganic past.

Module I

Introduction to fossils and index fossils, fossilization processes (taphonomy), and modes of preservation; Species concept, species problem in palaeontology, Methods of description and naming of fossils, code of systematic nomenclature; Theory of organic evolution and the fossil record; Palaeoecology: Principles and methods;Palaeobiogeography and palaeoclimate.

Module II

Invertebrate Palaeontology: Morphology, classification and geological history of the following groups: Gastropoda, Lamellibranchia, Brachiopoda, Cephalopoda, Trilobita and Echinoidea;
Classification of trace fossils and their utility in palaeo-environmental reconstructions; Vertebrate Palaeontology:origin of vertebrates; Vertebrate fossil record from Gondwana formations, Deccan volcanic province, Palaeogene and Neogene sequences of India and their evolutionary and palaeobiogeographic significance.

Module III

Palaeobotany: Early plant life;Colonization of land; Carboniferous coal forests; Gondwana flora and role of climate in its evolution; Micropaleontology: Microfossils and their importance.

Examination Scheme:

Components	**A**	**CT**	**HA**	**EE**
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings:

- Clarkson, E.N.K.1998. Invertebrate Palaeontology and Evolution, George Allen &Unwin.
- Raup, D.M. and Stanley, S. M. 1971. Principles of Palaeontology, W.H. Freeman and Company.
- Benton, M. 1997. Basic Palaeontology: An introductory text, D.Harker, Addision Wisely Longman.
- Prothero, D.R. 1998. Bringing fossils to life – An introduction toPalaeobiology, McGraw Hill.
- Willis, K.J. &McElwain, J.C. 2002. The evolution of plants, Oxford University Press.
- Brenchley, P. J., and Harper, D. A. T. 1998. Palaeoecology: Ecosystems, Environments and Evolution. By Chapman and Hall.

STRATIGRAPHY OF INDIA

Course Code: ESC2509 **Credit Units: 03**

Course Objective: The students would explore study of strata (rock layers) and stratification (layering) in sedimentary and layered igneous rocks. This course further gives an elementary idea about the diverse arrangement and deposition of rocks and formations in Indian sub-continent with respect to the geological past. It would also elaborate regional geology and tectonic evolution of India.

Module I:
Stratigraphic principles and correlation; Steno, faunal succession, unconformities, stratigraphic nomenclature;Faciesconceptand Walther's Law.Principles and methods of lithostratigraphy, biostratigraphy and chronostratigraphy; magnetostratigaphy and chemostratigraphy,sequence stratigraphy.

Module II
Physiographic and tectonic subdivisions of India; regional geology and tectonic evolution of cratons; Geology of Proterozoic,Cuddapah and Vindhyan sedimentary basins; Precambrian / Cambrian boundary.

Module III
Palaeozoic succession of Kashmir and its correlatives from Spiti and Zanskar; Stratigraphy and structure of Gondwana basins; Himalayan region;Marinemesozoic formations with reference to the Triassic deposits; Jurassic rocks of Kutch and Jaisalmer basins; Distribution and age of mesozoic volcanic provinces of India; Deccan Traps, Panjal Traps, Rajmahal Traps, Sylhet Traps; Stratigraphic boundary problems with special reference to P / T and K / T boundaries in India.

Examination Scheme:

Components	**A**	**CT**	**HA**	**EE**
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings:

- Krishnan, M.S. 1982. Geology of India and Burma, CBS Publishers, Delhi
- Pascoe, E.H. 1968. A manual of the Geology of India and Burma (Vol.I-IV), Govt. Of India Press, Delhi.
- Doyle, P. & Bennett, M.R. 1996. Unlocking the Stratigraphic Record. John Wiley
- Ramakrishnan, M. &Vaidyanadhan, R. 2008. Geology of India Volumes 1 & 2, Geological society of India, Bangalore.
- Valdiya, K.S. 2010. The making of India, Macmillan India Pvt. Ltd.

ENGINEERING GEOLOGY

Course Code: ESC2510 **Credit Units: 02**

Course Objective: The course deals with the study of geological structures and their role in engineering structures and projects. Students are expected to develop an insight about the role of a geologist in such engineering projects.

Module I
Introduction to the concept of geology vis-à-vis engineering; Role of geology in planning, design and construction of major man-made structural features; Elementary concepts of rock and soil mechanics.

Module II
Site selection and investigation; Characterization and problems related to civil engineering projects: Types of structures and classification and their effect on civil engineering projects and Geological mapping; Geological and geotechnical investigations for dams, reservoirs and spillways, tunnels, underground caverns, bridges, highways, shorelines.

Module III
Environmental considerations related to civil engineering projects; Construction materials; Geological hazards (landslides and earthquakes), their significance, causes and preventive/remedial measures; Recent trends in engineering geology.

Examination Scheme:

Components	**A**	**CT**	**HA**	**EE**
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings:

- Krynin, D.P. and Judd W.R. 1957. Principles of Engineering Geology and Geotechnique, McGrawHill (CBS Publ).
- Johnson, R.B. and DeGraf, J.V. 1988. Principles of Engineering Geology, John Wiley & Sons, N.Y.
- Goodman, R.E., 1993. Engineering Geology: Rock in Engineering constructions. Jonh Wiley & Sons, N.Y.
- Waltham, T., 2009. Foundations of Engineering Geology (3rdEdn.) Taylor & Francis.

EARTH SCIENCES LABORATORY-IV

Course Code: ESC2507 **Credit Units: 02**

Course Content:

- Selection of sites using topographic maps for dams, tunnels, bridges, highways and similar civil structures.
- Index Tests for soil, rocks and debris.
- Evaluation of shear strength parameters.
- Study of fossils showing various modes of fossilization.
- Thin section study of fossils to understand important parameters.
- Study of diagnostic morphological characters through hand specimens of fossils.
- Study of distribution important metallic, non-metallic deposits in India.

Examination Scheme:

IA				EE	
A	**PR**	**LR**	**V**	**PR**	**V**
5	10	10	5	35	35

Note: IA –Internal Assessment, EE- External Exam, PR- Performance, LR – Lab Record, V – Viva.

FIELD SURVEY-V

Course Code: ESC2508 **Credit Units: 03**

Course Content:

- Detailed hand on exposure with GPS (Global Positioning System) and its working.
- Correlation of satellite image with toposheet and ground verification in a terrain and preparation of a geological map.
- Geological reporting of field including all major parameters and their important significance.

Examination Scheme:

IA				EE	
FV	**PR**	**LR**	**V**	**PR**	**V**
20	10	10	10	25	25

Note: IA –Internal Assessment, EE- External Exam, FV-Field Visit, PR- Presentatione, LR – Lab Record, V – Viva.

SUMMER PROJECT EVALUATION-II

Course Code: ESC2535 **Credit Units: 6**

Objectives:
Practical and field training is based on the theoretical subjects studied by subjects. It can be arranged within the college, research organization, or any in any related industrial unit. The students are to learn various geological, mining, technical and administrative processes. In case of on campus training the students will be given specific tasks of testing / analysis / characterization of subject related domain of Earth and Environmental Science. On completion of the practical training the students are to present a report covering various aspects learnt by them and give a presentation of the same.

Chapter Scheme and distribution of marks:
Chapter 1: Introduction – 10 marks
Chapter 2: Conceptual Framework/ National/International Scenario – 25 marks
Chapter 3: Presentation, Analysis & Findings -- 25 marks
Chapter 4: Conclusion & Recommendations -- 10 marks
Chapter 5: Bibliography -- 05 marks

Project Report	Power Point Presentation & Viva
75 marks	25 marks

The Steps of a Project Report
Step I : Selection of the topic for the project by taking following points into consideration:

- Suitability of the topic.
- Relevance of the topic
- Time available at the disposal.
- Feasibility of data collection within the given time limit.
- Challenges involved in the data collection (time & cost involved in the data collection, possibility of getting responses, etc.)

Step II : Finalisation of the Topic and preparation of Project Proposal in consultation with the Supervisor.

Step III : Collection of information and data relating to the topic and analysis of the same.

Step IV : Writing the report dividing it into suitable chapters, viz.,
Chapter 1:Introduction,
Chapter 2: Conceptual Framework / National & International Scenario,
Chapter 3: Analysis & Findings
Chapter 4: Conclusion and Recommendations.

StepV: The following documents are to be attached with the Final Project Report.
1) Approval letter from the supervisor (Annexure-IA)
2) Student's declaration (Annexure-IB)
3) Certificate from the Competent Authority of the Organisation / Institution, if the student undertakes the Project Work in any Organisation / Institution.

Guidelines for Evaluation:

- Each of the students has to undertake a Project individually under the supervision of a teacher and to submit the same following the guidelines stated below.
- Language of Project Report and Viva-Voce Examination may be English. The Project Report must be typed and hard bound.
- Failure to submit the Project Report or failure to appear at the Viva-voce Examination will be treated as "Absent" in the Examination. He /she has to submit the Project Report and appear at the Viva-Voce Examination in the subsequent years (within the time period as per University Rules).
- No marks will be allotted on the Project Report unless a candidate appears at the Viva-Voce Examination. Similarly, no marks will be allotted on Viva-Voce Examination unless a candidate submits his/her Project Report.
- Evaluation of the Project Work to be done jointly by one internal expert and one external expert with equal weightage, i.e., average marks of the internal and external experts will be allotted to the candidate.

Syllabus - Sixth Semester

COAL AND PETROLEUM GEOLOGY

Course Code: ESC2603 **Credit Units: 03**

Course Objective: This course will deal with the geological aspects related to coal and petroleum. This is of utmost significance keeping in view the high employability opportunities associated with this branch of earth science.

Module I:
Coal; types, ranks and uses;Origin; Coalification process; Lithotypes, microlithotypes and macerals: Physical, chemical and optical properties; Maceral analysis: Mineral and organic matter in coal; Petrographical methods and tools of examination; Applications of coal geology in hydrocarbon exploration; coal petrography of different coalfields of India;

Module II:
Natural occurrence, Chemical composition and physical properties of crudes in nature; Origin of petroleum, maturation of kerogen; Biogenic and thermal effect; Reservoir rocks: General attributes and petrophysical properties; Migration of oil and gas: Geologic framework and factors controlling hydrocarbon migration; migration routes and barriers.

Module III:
Hydrocarbon traps: Definition, theory and classification of hydrocarbon traps - structural, stratigraphic and combination; Time of trap formation and hydrocarbon accumulation; Cap rocks: Definition and general properties; Formation water characteristics as oil exploration leads; Plate tectonics and global distribution of hydrocarbon reserves; Classification of Indian basins and petroleum geology of Assam, Bengal, Cauvery, Krishna-Godavari, Cambay and Bombay offshore basins.

Examination Scheme:

Components	A	CT	HA	EE
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings:

- Coal Geology: Larry Thomas, 2002, Wiley and Sons.
- Coal: it's composition, analysis, utilisation and valuation.: E.E.Somermier 2008, McGrawHill
- Petroleum Geology: F.K.North, 1986, Allen and Unwin
- Petroleum Formation and Occurrence: B.P.Tissot and D.H.Welte 1978, Publisher: Springer-Verlag
- Elements of petroleum Geology: R.C.Shelley 1998, Academic press.

HAZARD ASSESSMENT AND RISK MANAGEMENT

Course Code: ESC2604 **Credit Units: 03**

Course Objective: This paper introduces the students to various environmental hazards, their causes, nature, preparedness and assessment of loss. It teaches them to model hazards and familiarizes them with methods of management of disasters and consequently risk zonation.

Module I

Disasters at global and national level: Trends and dimensions, impact on development and society, need for disaster risk management; Hazards and Disasters:Types, causes, factors, consequences: Geological (earthquakes, landslides, tsunami, mining), Hydro-meteorological (floods, cyclones, lightning, thunder-storms, hail storms, avalanches, droughts, cold and heat waves), Biological (epidemics, pest attacks, forest fire), Technological (chemical, industrial, radiological, nuclear) and Man-made (bomb blasts, building collapse, village and urban fire) hazards/disasters.

Module II

Disaster risk management cycle: Pre-disaster phase – hazard, vulnerability and risk zonation; monitoring, warning and alert system; awareness, preparedness, planning and capacity development; During Disaster phase – incident command system (ICS) and emergency operations centre (EOC), emergency communication, transportation, rescue, relief, damage and needs assessment, rehabilitation, and restoration of basic facilities and infrastructure; Post-disaster phase – reconstruction, relocation, recovery and redevelopment.

Module III

Applications of science, technology and engineering in disaster management including geo-informatics (GIS, GPS and RS), standards and codes for disaster resilient development practices; disaster management act, policies, guidelines, plans; Role of government (local, state and national), non-government and multilateral agencies; Monitoring, development and up-gradation of disaster management practices.

Examination Scheme:

Components	**A**	**CT**	**HA**	**EE**
Weightage (%)	5	15	10	70

A: Attendance, CT: Class Test, HA: Home Assignment, EE: End Semester Examination;

Suggested Readings

- Bell, F.G., 1999. Geological Hazards, Routledge, London.
- Bryant, E., 1985. Natural Hazards, Cambridge University Press.
- Patwardhan, A.M., 1999. The Dynamic Earth System.Prentice Hall.
- Smith, K., 1992. Environmental Hazards.Routledge, London.
- Subramaniam, v., 2001. Textbook in Environmental Science, Narosa International.

WORKSHOP/ SEMINAR/ CONFERENCE/ SYMPOSIUM

Course Code: ESC2633 **Credit Units: 01**

Objectives

A workshop is primarily an activity based academic event that is organized to provide the students a one to one and hands on experience on any aspect of their learning. The communication in a workshop has to be necessarily two ways. The trainer has to make sure that the aspects covered are practically practiced by the participants. The student will choose the option of workshop from amongst their concentration electives. The evaluation will be done by Board of examiners comprising of the faculties.

Guidelines for Workshop

The procedure for earning credits from workshop consists of the following steps:

1. Relevant study material and references will be provided by the trainer in advance.
2. The participants are expected to explore the topic in advance and take active part in the discussions held
3. Attending and participating in all activities of the workshop
4. Group Activities have to be undertaken by students as guided by the trainer.
5. Evaluation of workshop activities would be done through test and quiz at the end of the workshop.
6. Submitting a write up of at least 500 words about the learning outcome from the workshop.

Evaluation Scheme:

Attendance	Active Participation	Multiple Choice Questions/ Quiz	Solving the case/ Assignment/ Write up	Total
10	**30**	**30**	**30**	**100**

DISSERTATION

Course Code: ESC2637 **Credit Units: 09**

GUIDELINES FOR PROJECT FILE AND PROJECT REPORT

Research experience is a professional problem-solving activity and is equally significant as any other aspect of the curriculum. It provides exposure to research methodology and an opportunity to work closely with a faculty guide. It usually requires the use of advanced concepts, a variety of experimental techniques, and state-of-the-art instrumentation.
Research is genuine exploration of the unknown that leads to new knowledge which often warrants publication. But whether or not the results of a research project are publishable, the project should be communicated in the form of a research report written by the student.
Sufficient time should be allowed for satisfactory completion of reports, taking into account that initial drafts should be critically analyzed by the faculty guide and corrected by the student at each stage.

PROJECT FILE
The Project File may be a very useful tool for undertaking an assignment along-with a normal semester, an exploratory study, sponsored projects, a project undertaken during summer period or any other period as per curricula where the researcher is working with a company/organization. The project/ assignment may also be a part of the bigger research agenda being pursued by a faculty/ institution/ department.
The Project File is the principal means by which the work carried out will be assessed and therefore great care should be taken in its preparation. This file may be considered in continuous assessment

The Layout Guidelines for the Project File & Project Report:

- A4 size Paper
- Font: Arial (10 points) or Times New Roman (12 points)
- Line spacing: 1.5
- Top and bottom margins: 1 inch/ 2.5 cm; left and right margins: 1.25 inches/ 3 cm

Assessment Scheme:

Continuous Evaluation:
40% (Based on punctuality, regularity of work, adherence to plan and methodology, refinements/mid-course corrections etc. as reflected in the Project File.)

Final Evaluation:
60% (Based on the Documentation in the file, Final report layout, analysis and results, achievement of objectives, presentation/ viva)

It is recommended that the Final evaluation should be carried out by a panel of evaluators.