Learning Outcomes-Based Curriculum Framework for postgraduate education in Geology

1. Introduction

Geology is a discipline in the special category of science with a multi disciplinary approach. It is a fast-moving, diversifying, multidisciplinary field that ranges from understanding the Earths origin in the solar system, the evolution of hydrosphere and atmosphere as well as the earth's materials at the atomic level, through the geological processes that drive volcanoes and earthquakes, surface processes that shape landscapes and create the geological record, biological processes that build diversity and bring extinction, up to planetary-scale systems, such as plate tectonics, climate and the origins of life and ecosystems. The Earth Science takes you very close to the nature as this is basically a filed Science. The geology program integrates field trips with class room learning to give the candidate hands-on experience. These opportunities develop technical skills of the students using measuring instruments and laboratory equipment.

2. Learning outcomes-based approach to curricular planning:

2.1 Nature and extent of PG program in Geology:

The PG program in Geology builds on the basic Geosciences taught at the UG level. The curricula and syllabi are framed and implemented in such a way that the basic connection between theory and experiment and its importance in understanding Geology should be apparent to the student. This is very critical in developing a scientific temperament and urge to innovate, create and discover in Geology.

2.2 Aims of PG program in Geology

The aims and objective of PG educational programs in Geology are structured to

- to motivate and inspire the students to create deep interest in Geology, to develop broad and balanced knowledge and understanding of geological concepts, principles and theories of stratigraphy, geological mapping, exploration of natural resources and understand Earth evolution.
- Learn, design and perform experiments in the labs to demonstrate the concepts, principles and theories learned in the class rooms.
- Develop the ability to apply the knowledge acquired in the class room and laboratories to specific problems in theoretical and applied Geology.
- Expose the student to the vast scope of Geosciences as a theoretical and experimental science with applications in solving most of the geogenic problems in nature spanning from disaster management, watershed management, water pollution, oil exploration and mining, etc.
- To emphasize the importance of Geology as one of the most important disciplines for sustaining the existing industries and establishing new ones to create job opportunities at all levels of employment.

3 Post Graduate Attributes in Geology

Some of the characteristic attributes of a Geology student are

3.1 Education and Training

a) Provide training of the highest academic quality in Geosciences in a challenging and supportive learning environment.
b) Develop a systematic understanding of both core areas and advanced topics in the study of the Earth, its materials and structure, its history over 4600 million years, and the processes that have control edits evolution as a planet by viewing Earth from new and challenging perspectives of time, space, process and pattern.
c) Develop the ability to evaluate primary evidence critically; and the conceptual understanding to present arguments and solutions based on primary data and theory.
d) Promote an appreciation of the limits to our present understanding of the Earth, its processes and the interactions between them.
e) Stimulate students to see Geology as a vital component of our culture, where science develops as in formed curiosity about the Earth and Society's environment, promoting human development and sustainability through the search for energy sources, raw materials, water supplies, sites for safe waste disposal, and the mitigation of natural hazards.
f) Provide for student interaction with high-level scientific expertise and advanced equipment in an environment committed to scientific advance.
g) Develop skills in gathering and interpreting the geological and geophysical data used to gain this understanding and thereby equip students with the foundations for their professional careers or additional study.
h) Provide an excellent preparation for a career in professional practice in industrial or environmental Earth Sciences, research in Geosciences, and specialist areas of other physical and natural sciences.

3.2 Communication Skills:

a) Skills to communicate in written, numerical, graphical and verbal forms, in ways that are appropriate to different audiences and indifferent situations, ranging from scientific and industry reports, to group and individual oral presentations, and from blogs and outreach articles, to news articles and essays.
b) Formulate a coherent written, electronic or oral presentation on the basis of material gathered dependently on a given topic.
c) Express clearly ideas and arguments, both orally and in writing and in electronic media.
d) Use group discussions and joint seminar presentations to research and present work collaboratively; and Develop oral presentation and participation skills during seminars and group-work, and in written form through online-learning tools, dissertations and essays.

3.3 Critical Thinking:

a) Acquire an understanding of the concept in geology and related disciplines and an ability to understand, integrate, and extend it so that all fundamental geological concepts are accessible.
b) Acquire, digest and critically evaluate scholarly arguments, the assumptions behind them, and their theoretical and empirical components.

3.4 Problem Solving:

a) Skills to recognize and articulate a problem and then apply appropriate conceptual frameworks and methods to solve it.
b) Emphasis is placed on larger, integrated problem-solving exercises, during which students are taught how to process complex data sets using a diverse range of skills and knowledge. This provides the foundation for student-led independent, but academically directed, project work.

3.5 Analytical Reasoning:

a) Competency in both field and laboratory skills, and in data analysis, interpretation and presentation that permit the successful pursuit of pure or applied problems in geology.

3.6 Research-Related Skills:

a) Develop a research design which has an appropriate problem related to earth sciences incorporating some scientific methods, ability to plan and write a research paper.
b) Ability to process and interpret large, complex, datasets, to hypothesis set and test, and to function as a numerate, literate scientist able to prove insight and guidance related to real-world problems and issues.
c) Ability to collect, analyze, synthesize and summarize to formulate and test hypotheses and to reach conclusions.

3.7 Self and Time Management:

a) Time management skills are developed through interaction with the assessment process in all years: students must learn how to meet deadlines for submission of continuous assessment material and how to set aside appropriate time to prepare for end of year examinations.
b) Time management is integral to the student's independent mapping project.

3.8 Team Work:

a) Ability to contribute effectively to team objectives and interact productively with others both in project-related settings and in meetings.
b) This is addressed through group exercises in Geology programme, including in-class presentations, group lab-sessions where students use research equipment, mock-industry presentations to panels of outside industry experts, and group fieldwork mini-projects.

3.9 Scientific Reasoning:

a) View the Earth from new and challenging perspectives of time, space, process & pattern.
b) Develop a systematic understanding of both core areas and advanced topics in the study of the Earth, its materials and structure, its history over 4600 million years, and the processes that have controlled its evolution as a planet.
c) Provide for student interaction with high-level scientific expertise and advanced equipment in an environment committed to scientific advance.
d) Develop the ability to evaluate primary evidence critically; and the conceptual understanding to present arguments and solutions based on primary data and theory.
e) Promote an appreciation of the limits to our present understanding of the Earth, its processes and the interactions between them.

3.10 Digital Literacy:

a) Ability of advanced Word skills and advanced GIS, statistics, databases spreadsheets, digital drawing through online workbooks and workshops
b) ability to use digital resources for presentations

3.11 Moral and Ethical Values:

a) The degree to which every student engages with these themes will vary but it is important that all think especially about ethical issues
b) Avoid unethical behaviour such as fabrication, falsification or misrepresentation of data or committing plagiarism, not adhering to intellectual property rights, and adopting objectives, unbiased and truthful actions in all aspects of work.

3.12 Leadership Readiness:

a) Provide training of the highest academic quality in Earth Sciences in a challenging and supportive learning environment
b) Be accessible to those qualified at intake in a broad and diverse range of sciences.
c) Provide an excellent preparation for a career in professional practice in industrial or environmental Earth Sciences, research in Earth Sciences

3.13 Life-long Learning:

a) ability to blend academic and practical skills
b) ability to transfer such skills to other domains of one's life and work

3.14 Global Competency:

a) After completing course in Geology, the student is expected to be fully knowledgeable about the subject and not only from the point of view of examination.
b) The candidate will be ready to accept challenges and stand in competition at a national and global level.

4. Qualification descriptors for a PG programs in Geology

4.1 Qualification descriptors for a M. Sc Geology

The qualification descriptors for the M.Sc. programme in Geology should have five learning attributes such as understanding, use, communication, expansion, and application of subject knowledge. The key qualification descriptor for M.Sc. Geology should have clarity of communication as well as critical thinking and ethical awareness. Each candidate in Geology should be able to:

- Demonstrate a coherent and systematic knowledge and understanding of the field of

Geology making intelligible Geoscientific research frontiers and theoretical developments in this field in the global context. This would also include the student's ability to collect, analyze, synthesize, summarize and inter-relate diverse processes and facts, to formulate and test hypotheses and reach conclusions.

- Demonstrate the ability to identify and differentiate rocks, minerals, fossils, other Earth materials and Earth structures in the field, as hand specimens and using laboratory techniques including microscopy and spectroscopic analysis. Skill to observe and record original field and laboratory data and then apply these to evaluate and resolve geological and geotechnical problems.

- Demonstrate the ability to assemble and analyze in complete and varied observational data and develop test able hypotheses, predictions or explanations from them. Skills to recognize associations between geological observations and then integrate them into their 3D and 4D (space-time) frame works.

- Demonstrate the ability to share the results of academic and disciplinary learning through different forms of communication such as essays, dissertations, reports, findings, notes, etc. on different platforms of communication such as the classroom, conferences, seminars, workshops, the media and the internet

- Ability to devise and carry out an independent field-based project, including the formulation and testing of hypotheses whilst in the process of carrying out the project. The integration of field-based, experimental and theoretical principles needed for the Earth Sciences.

- Demonstrate a systematic, extensive and coherent knowledge and understanding of the academic field of Geology as a whole and its applications, and links to related disciplinary areas/subjects of study; including a critical understanding of the established theories, principles and concepts, and of a number of advanced and emerging issues;

- Demonstrate procedural knowledge that creates different types of professionals related to Geology, including research and development, teaching and government and public service;

- Demonstrate comprehensive knowledge about materials, including current research, scholarly, and/or professional literature, relating to essential and advanced learning areas pertaining to various sub fields in Geology, and techniques and skills required for identifying problems and issues in their area of specialization.

- Demonstrate skills in identifying information needs, collection of relevant quantitative and/or qualitative geostatistical data drawing on a wide range of sources from the field and labs around the world, analyses and interpretation of data using methodologies as appropriate to the subject of Geology in the area of specialization of the candidate.

- Use knowledge, understanding and skills in Geology for critical assessment of a wide range of ideas and complex problems and issues relating to the various sub fields like mineralogy, petrology, hydrogeology, disasters, etc., etc.

- Communicate the results of studies undertaken in the academic field of Geology accurately in a range of different contexts using the established and emerging concepts, constructs and techniques;

- Address one's own learning needs relating to current and emerging areas of study in Geology, making use of research, development and professional materials as appropriate, including those related to new frontiers of knowledge in science.

The goal of the Geology postgraduate program is to equip students with the fundamental knowledge of the diverse fields of Geology (encompassing Geomorphology and Surface Processes, Hydrology & Low-Temperature Geochemistry, Sedimentology and Paleoecology, and Tectonics and Solid-Earth Processes). In addition, it is critical that students learn to think like a scientist and to apply the scientific method in their coursework and in their lives. The geology program integrates field trips with classroom learning to give the hands-on experience to succeed. These opportunities develop your technical skills using measuring instruments and laboratory equipment. The skills have been split into two groups:

skills needed by any science professional and skills specifically needed by geosciences professionals.

Critical Geosciences Skills

1. Make inferences about Earth systems from observations of the natural world
2. Readily solve problems, especially those requiring partial and temporal interpretation
3. Work with uncertainty, non-uniqueness, incompleteness, ambiguity, and indirect observations
4. Integrate information from different disciplines and apply systems thinking
5. Have strong field skills
6. Have strong computational skills for managing and analyzing multi-component datasets
7. Be able to collect, illustrate, and analyze spatial data

Critical Professional Scientist Skills

8. Think critically and problem-solve
9. Communicate effectively to scientists and non-scientists
10. Integrate information from different sources and continue to learn

The student with the Degree M.Sc. Geology should:

- Acquire a solid base of knowledge in the science of geology as a whole as well as earth materials, earth history, sedimentation and stratigraphy, deformational processes and structural features, and geomorphic processes and landforms.

- Know the geologic time scale and place important geologic events in a temporal framework
- Use compasses, survey instruments, and images in geological investigations
- Understand the pathways, fluxes, and influence of water and other fluids at Earth's surface and in the subsurface
- Interpret topographic maps and terrain models and create profiles
- Interpret geologic maps and construct cross sections from them
- Interpret geophysical measurements of subsurface properties
- Distinguish between various structural features and determine the types of stress responsible for their formation
- Describe and interpret types of surfacial deposits and landforms
- Apply principles of mathematics, chemistry, and physics to geologic problems
- Develop proficiency in conveying complex geologic concepts in clear, technically correct writing.
- Develop proficiency in oral communication of complex geologic concepts.
- Develop the aptitudes and dispositions necessary to help democratize society by obtaining and maintaining employment as a professional geologist.

5.2 Program Learning Outcomes in M. Sc. Geology

The student graduating with the Degree M. Sc. Geology should be able to

- Acquire

a) A fundamental understanding of Geology, its different learning areas and applications in basic Geology like Mineralogy, Petrology, Stratigraphy, Palaeontology, Economic geology, Hydrogeology, etc. and its linkages with related interdisciplinary areas/subjects

b) procedural knowledge that creates different types of professionals related to the disciplinary/subject area of Geology, including professional seng aged in research and development, teaching and government/public service;

c) skills in areas related to one's specialization area within the disciplinary/subject area of Geology and current and emerging developments in the field of Geosciences.

- Demonstrate the ability to use skills in Geology and its related areas of technology for formulating and tackling geosciences-related problems and identifying and applying appropriate geological principle sand methodologies to solve a wide range of problems associated with geosciences.

- Recognize the importance of RS & GIS, mathematical modeling simulation and computing, and the role of approximation and mathematical approaches to describing the physical world.

- Plan and execute Geology-related experiments or investigations, analyze and interpret data/information collect educing appropriate methods, including the use of appropriate software such as programming languages and purpose-written packages, and report accurately the findings of the experiment/investigations while relating the conclusions/findings to relevant theories in Geology.

- Demonstrate relevant generic skills and global competencies such as

a) problem-solving skills that are required to solve different types of geoscience-related problems with well-defined solutions, and tack leopen-ended problems that belong to the disciplinary area boundaries;
b) investigativeskills,includingskillsofindependentinvestigationofgeoscience-related issues and problems;
c) communication skills involving the ability to listen carefully, to read texts and research papers analytically and to present complex information in a concise manner to different groups/audiences of technical or popular nature;
d) analytical skills involving paying attention to detail and ability to construct logical arguments using correct technical language related to Geology and ability to translate them with popular language when needed;
e) Personal skills such as the ability to work both independently and in Teams

- Demonstrate professional behavior such as

a) being objective, unbiased and truthful in all aspects of work and avoiding unethical, irrational behavior such as fabricating, falsifying or misrepresenting data or committing plagiarism;
b) the ability to identify the potential ethical issues in work-related situations;
c) appreciate on of intellectual property, environmental and sustainability issues; and
d) promoting safe learning and working environment.

SEMESTER - I

COURSE: I - STRUCTURAL GEOLOGY

(i) Course learning outcome:

The course deals with geological structures resulting from the action of these forces on rocks. The student will gain knowledge of the geometry of the rock structures, understand the mechanism of the evolution of rock structures and its application in the field.

(ii) Broad contents of the course:

The course is designed for the students to understand the geometry and mechanics of the various geological structures that result through the deformative processes operative within the earth.

(iii) Skills to be learned:

The students learn the skills of identifying different structure and measurements using Bruntoncompass. This is fundamental to geological mapping. This course also helps to know how to use structures and help students appreciate the dynamic nature of the Earth lithosphere.

Learn how to read geologic maps and solve simple map problems using strike and preparations of cross sections.

(iv) The detail contents of this course and references and suggested books:

Rock deformation: Theory of stress & strain, their relationship; Factors controlling rock deformation Properties of elastic, plastic and brittle materials; Progressive deformation.

Strain analysis: types of strain; strain ellipse; strain ellipsoid; Geological application of strain theory. Rheology. Stress analysis: compressive and shear stress; biaxial and triaxial stress. Mohr's Circle and envelope.

Fold: Definition, Geometrical and Genetic Classification of Fold. Fleutys Classification, Ramsay Classification and Dip Isogon Classification. Mechanism of Fold formation and types of fold Superimposed fold; Outcrop pattern of superimposed structure comprising of two fold system. Joints, and its types; their analysis and relation with major structures, Types and mechanism of faulting. Principal stress orientation for the main fault types; Relationship between stress and strain ellipsoid. Analyses of brittle-ductile and ductile shear zones.

Petrofabric Analysis: Field and laboratory techniques. Preparation of petrofabric diagrams and their interpretation.Cleavage & Schistosity: definition and types. Mechanism of formation of Cleavage & Schistosity; its relationship with major deformation structures Lineation: definition and its types; their mode of development and relation to major structures. Plutons: Definition & description; its role in progressive deformation.

Tectonites: definition and its types Stereographic Projection: Principles and application Tectonics and structural characteristics of Plate Boundaries; associated structures in extensional, compressional and strike-slip terrains. Geodynamic evolution of the Himalayas

Books Recommended:

Ghosh, S.K. (1993): Structural Geology: Fundamental and Modern Development. 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.

SEMESTER - I

COURSE: II – MINERALOGY

(i) Course learning outcome:

Studying the mineralogy helps in understanding and building the overall knowledge in Geology.

(ii) Broad contents of the course:

The course deals with the study of minerals in detail – their chemistry, optical and physical properties, paragenesis etc.

(iii) Skills to be learned:

The students will be able to identify common rock-forming minerals in hand specimens as well as in thin sections.

(iv) The detail contents of this course and references and suggested books:

Composition of minerals and Mineraloids. Physical Properties of Minerals depending on Crystal Growth, Crystal Structure, Chemical Composition and Interaction with light.Electrical Magnetic, Luminescence, Thermal and Radioactive Properties of Mineral. Structure of Silicates. Ionic Radius, Coordination Principles, Close Packing, Pauling's Rules. Unit Cell, Bonding Forces in crystals Ionic Bond, Covalent Bond, Van Der Waal's Bond, Metallic Bond.olid solution - Substitution, Interstitial and Omission solid solution. Ex-solution. Polymorphism, polytypism, pseudomorphism. Classification of Minerals. Systematic Mineralogy of Olivine Group b) Garnet Group c) Al2SiO5 Group d) Zircon,a) Topaz, b) Staurolite, c) Sphene. Sorosilicates – Epidote Cordierite b) Tourmaline c) Beryl, Pyroxene Group, Amphibole Group, Serpentine Group b) Mica Group c) Chlorite Group d) Clay Mineral Group – Kaolin and Talc, SiO2 Group, Zeolite Group, Feldspar Group, Feldspathoid Group, Carbonates and Phosphates Gem and Semi precious minerals.

Books Recommended:

Berry, L.G., Mason, B. and Dietrich, R.V. (1982): Mineralogy, CBS Publ. Dana, E.S. and Ford, W.E.(2002): A textbook of Mineralogy (Reprint).

Kerr, P.F. (1977): Optical Mineralogy, McGraw Hill.

Moorhouse, W.W. (1951): Optical Mineralogy, Harper and row Publ. Nesse, D.W. (1986): Optical Mineralogy, McGraw Hill.

Perkins, D. (1998): Mineralogy, Prentice Hall.

Winchell, E.N. (1951): Elements of Optical Mineralogy, Wiley Eastern.

SEMESTER - I
COURSE: III - GEOCHEMISTRY

(i) Course learning outcome:

The course provides a forum to introduce the concept of geochemistry and isotopes to the students and the use of radiogenic and stable isotopes in geosciences.

(ii) Broad contents of the course:

Geochemistry, radiogenic and stable isotopic studies are tools for understanding planetary differentiation, and tracing provenance and process in all spheres of the earth. This course examines the theory and application of geochemistry and isotope geochemistry to a broad range of geologic topics.

(iii) Skills to be learned:

At the end of the course the students will be appraised about the world of isotopesa md their use in dating or geochemical tracing

(iv)The detail contents of this course and references and suggested books

Cosmic Abundance of the Elements and Nucleosynthesis. Geochemical classification of elements. Formation of Solar System and Planets. Composition and Classification of Meteorites, Chondrules, Chondrites and Achondrites. Geology and Chemistry of Moon. Trace, Volatile, Semi volatile, Alkali and Alkaline earth elements its behaviour in Fractional Crystallization and Partial melting. REE and Y, HFSE elements, Transition & Noble elements-its importance and concentrations in various igneous rocks and its behaviour in various magmatic processes. Partition coefficient, Factors governing partition co-efficient. Compatible and incompatible elements, behaviour of these elements in Fractional Crystallization and partial melting.

Fundamental Laws of Thermodynamics. Free energy. Phase equilibrium and Gibb's Phase Rule. Thermodynamics of magmatic Crystallization. Geochemistry of island arcs. Geochemistry of Crust. Composition of Mantle, mineralogy of lower mantle. Phase transition in the Mantle, mineral-phase transition in lower mantle. Stable isotope geochemistry. Oxygen isotope studies. Isotope fractionation, application Oxygen isotope in geothermometry, use of oxygen isotope together with radiogenic isotope in correlation diagrams ,study of crustal contamination, Carbon isotope. Carbon isotope studies in association with Oxygen isotope for Carbonate rocks, Carbon isotope thermometry. Radiogenic isotopes. Decay scheme, Laws of decay, half life period. Decay scheme of K-Ar, Sm-Nd, U-Pb and Rb-Sr. Radiogenic isotopes in petrogenesis Isotopic reservoirs, Depleted mantle (DM), HIMU Mantle, Enriched Mantle, PREMA, Bulk Silicate Earth (BSE), Continental crustal source. Isotopes in geochronology, Concept of geological ages and isochron calculations in Rb-Sr, Sm-Nd systems. Model ages. Concordia and Discordia. Aquatic Chemistry- Acid Base reactions, Dissolution and Precipitation of CaCO3. Solubility of Mg, SiO2 and Al(OH)3Geochemical properties of clays - Kaolinite, Pyrophyllite and Chlorite Groups. Ion exchange properties of clays Redox in Natural Waters. Eutrophication. Factors controlling Weathering. Soil profile. Chemical andbiogeochemical cycling in the soil. Composition of Rivers. Composition of Seawater- Temperature variation.Density structure and deep circulation, Distribution of CO2 in Ocean. Carbonate dissolution and precipitation. Sources and sinks of Dissolved matter in seawater.

Books Recommended:

Drever, J. I., 1988. *The Geochemistry of Natural Waters,* Prentice Hall, Englewood Cliffs, 437 p.
Garrels, R. M. and C. L. Christ. 1965. *Solutions, Minerals and Equilibria*. New York: Harper and Row.
Burns, R. G. 1970. *Mineralogical Applications of Crystal Field Theory*. Cambridge: Cambr Univ. Press.
Henderson, P. 1986. *Inorganic geochemistry*. Oxford: Pergamon Press. Brownlow, A. H. 1996. *Geochemistry*. New York: Prentice Hall.
Krauskopf, K. B. and D. K. Bird. 1995. *Introduction to Geochemistry*. New York: McGraw-Hill.
Bowen, R. 1988. *Isotopes in the Earth Sciences*, Barking (Essex): Elsevier Applied Science Publishers.
Condie, K. C. 1989. *Plate Tectonics and Crustal Evolution*. Oxford: Pergamon. Rollinson Hugh R. *Using Geochemical Data: Evaluation, Presentation, Interpretation* Faure, G., 1986. *Principles of Isotope Geology,* 2nd ed., Wiley & Sons, New York, 589p. Hoefs Jochen: *Stable Isotope Geochemistry*
Dickin Alan P*.: Radiogenic Isotope Geology*
White, W. M. *Geochemistry*

SEMESTER – I

COURSE: IV - CRYSTALLOGRAPHY & CRYSTAL OPTICS

Course learning outcome:

The course will enable the students not only to differentiate minerals based on their optical properties, but also to understand how they originate and associate with each other in a rock.

Broad contents of the course:

The course covers the basics of geoscientific studies in mineralogy. The knowledge of optics is applied in understanding the genesis and identification of minerals.

Skills to be learned

This course will help the students to identify minerals in thin sections- an art and science essential for fundamental research in Geology.

The detail contents of this course and references and suggested books

Crystal growth. Development of ideas of internal structure of crystals. Space lattices and point systems. X-ray analysis of crystal structure, SEM, TEM. Morphology of crystals. Fundamental Laws of Crystal Zones and Zonal Symbols. Symmetry elements, operations. Classification of Crystals in 32 Classes. Symmetry and forms of crystals of isometric, tetragonal and hexagonal systems. Symmetry and forms of crystals of orthorhombic, monoclinic and triclinic systems. Goniometry of Crystals. Crystal Projections – Spherical, Gnomonic and Stereographic. Crystal Aggregates, Twinning, Irregularities & Imperfections in Crystals. Principles of transmission and reflection of light from crystals. Classification of minerals according to interaction of light, Interference colour. Refraction and Refractometry. Methods of determination of R.I. Birefringence in Crystals. Significance and use of plates, wedge and Bereck Compensator. Pleochroism in Crystals. Classification of Crystals into isotropic, Uniaxial and Biaxial minerals. Isotropic, uniaxial and biaxial indicatrix. Optical characters of Isotropic and uniaxial minerals. Optical characters of biaxial minerals. Optical Orientation – Extinction angle, Universal stage. Construction & Use. Dispersion in mineral optic axial angle. Optical anomalies. Systematic determination of optical properties of minerals.

Books Recommended:

Phillips, F.C (1971): Introduction to Crystallography,Longman Group Publ. Dana, E.S. and Ford, W.E. (2002): A textbook of Mineralogy (Reprint).

SEMESTER – II

COURSE: I – IGNEOUS PETROLOGY

(i) Course learning outcome:

On completion of the course the students will have gained an understanding of the processes involved in the formation of igneous rocks, their textures, structures, classifications and their importance.

(ii) Broad contents of the course:

Petrology is the science of rocks. The course will help the students to exhibit an improved understanding of fundamental petrologic processes and common rock types.

(iii) Skills to be learned:

Students learn to identify, describe and classify rocks using and specimens. The students will also acquire skills to determine and interpret geochemistry of rocks

(iv) The detail contents of this course and references and suggested books:

Factors affecting magma and its evolution. Composition of primary magma; mantle mineralogy. Partial melting of mantle – different models. Trace element behavior during partial melting. Magmatic differentiation processes. Behavior of major and trace elements during fractional crystallization. Concurrent assimilation and fractional crystallization. Magma mixing. Various criterion for classification of Igneous rocks. Petrographic Province. Different variation diagrams and their applications. Crystallization of basaltic magmas. Generation of magma with reference to plate tectonics. Study the petrogenetic significance of following silicate systems: Albite-Anorthite, Forsterite – Silica, Diopside-Albite-Anorthite, Diopside-forsterite-silica, Nepheline-kalsilite-silica, Dioside-Forsterite-Nepheline-Silica. Petrogenetic study of Basalt, Ophiolite, Peridotite, Ultramafite, Granite, Anorthosite, Komatite, Kimberlite and Lamproite, Carbonatite, Lamprophyre. Mid-ocean ridge volcanism and oceanic intra-plate volcanism. Magmatism associated with subduction related igneous activity- continental and island arcs. Magmatism in Large Igneous Plutons and continental alkaline magmatism.

Books recommended:

Bose, M.K. (1997): Igneous Petrology, World Press, Kolkata.

Best, Myron G. (2002): Igneous and Metamorphic Petrology, Blackwell Science. Cox, K.G., Bell, J.D.and Pankhurst, R.J. (1993):The Interpretation of Igneous Rocks, Champman and Hall, London.

Faure, G. (2001): Origin of Igneous Rocks, Springer. Hall, A. (1997): Igneous Petrology, Longman.

LeMaitre R.W. (2002): Igneous Rocks: A Classification and Glossary of Terms, Cambr University Press.

McBirney (1994): Igneous Petrology, CBS Publ., Delhi.

Phillpotts, A.R. (1994): Principles of Igneous and Metamorphic Petrology, Prentice Hall of India.

Sood, M.K. (1982): Modern Igneous Petrology, Wiley-Interscience Publ., New York. Srivastava, Rajesh K. and Chandra, R., (1995): Magmatism in Relation to Diverse Tectonic Settings, A.A. Balkema, Rotterdam.

Wilson, M. (1993): Igneous Petrogenesis, Chapman and Hall, London.

Winter, J.D. (2001): An Introduction to Igneous and Metamorphic Petrology, Prentice Hall, New Jersey.

SEMESTER – II
COURSE: II - METAMORPHIC PETROLOGY

Course learning outcome:

On completion of the course the students will have gained an understanding of the processes involved in the formation of metamorphic rocks, their textures, structures, classifications and their importance.

Broad contents of the course:

Petrology is the science of rocks. The course will help the students to exhibit an improved understanding of fundamental petrologic processes and common rock types.

Skills to be learned:

Students learn to identify, describe and classify rocks using and specimens. The students will also acquire skills to determine and interpret geochemistry of rocks

The detail contents of this course and references and suggested books:

Definition of metamorphism, significance of metamorphic rocks. Agents and kinds of metamorphism. Phase rule and its application in metamorphism. Structure and texture of metamorphic rocks and their significance. Classification of metamorphic rocks.Fabric of metamorphic rocks. Evolution of the concept of depth zones. Systematic study of Barrovian and Abukuma zones of metamorphism. Grade of metamorphism, Isograde & Isoreactiongrade and construction of petrogenetic grids. Concept of facies and facies series.Study of ACF, AKF and AFM diagrams. Polymetamorphism and paired metamorphic belts. Metamorphic differentiation. Retrograde Metamorphism and crystalloblastic series. General Characters of thermal and regional metamorphism of limestone, shale and basic igneous rocks.

Metamorphism in relation to magma and orogeny. Metasomatism-Principles and types of metasomatism. Granitization. Anataxis, Palingenesis. Origin of Migmatites in the light of experimental studies. Kinetics of metamorphic mineral reaction. Pressure – temperature – time paths. Ultra-high temperature and ultra-high pressure and ocean floor metamorphism.

Layering in metamorphic rocks. Petrogenetic significance of following rocks with special reference to Indian occurrences: charnockite, amphibolite, Khondalite, Gondite, Eclogite, and Blue schist.

Books Recommended:

Blatt, H. and Tracy, R.J. (1996): Petrology (Igneous, Sedimentary, Metamorphic), W.H. Freeman and Co., NewYork.

Bucher, K. and Martin, F. (2002): Petrogenesis of Metamorphic Rocks (7th Rev. Ed.), Springer–Verlag,.

Kerr, P.F. (1959): Optical Mineralogy, McGraw Hill Book Company Inc., New York. Philpotts, A.R. (1994): Principles of Igneous and Metamorphic Petrology, Prentice Hall. Powell, R. (1978): Equilibrium thermodynamics in Petrology: An Introduction, Harper and Row Publ., London.

Rastogy, R.P. and Mishra, R.R. (1993): An Introduction to Chemical Thermodynamics, Vikash

Publishing House.
Spear, F. S. (1993): Mineralogical Phase Equilibria and pressure – temperature – time Paths, Mineralogical Society of America.
Spry, A. (1976): Metamorphic Textures, Pergamon Press.
Winter, J.D. (2001): An introduction to Igneous and Metamorphic Petrology, Prentice Hall.
Wood, B.J. and Fraser, D.G. (1976): Elementary Thermodynamics for Geologists, Oxford University Press, London.
Yardley, B.W.D., Mackenzie, W.S. and Guilford, C. (1995): Atlas of Metamorphic Rocks and their textures, Longman Scientific and Technical, England.
Yardlley, B.W.D. (1989): An introduction to Metamorphic Petrology, Longman Scientific and Technical, New York.

SEMESTER- II
COURSE: III - SEDIMENTOLOGY AND CRUSTAL EVOLUTION

Course learning outcome:

On completion of the course the students will get a detailed picture of the sedimentation process and processes related to crustal evolution.

Broad contents of the course:

Various sedimentological processes as well as crustal evolution processes are dealt in detail

Skills to be learned:

Students will learn various sedimentological processes as well as crustal evolution processes

The detail contents of this course and references and suggested books

Earth surface system – liberation and flux of sediments. Processes of transport and generation of sedimentary structures. Flow regimes and related bed forms Stromatolites and their significance. Textural analysis of sediments, Graphical representation, statistical treatment and geological significance. Classification of sandstone and carbonate rocks. Dolomite and dolomitization. Volcaniclastics. Sedimentary environments and facies.

Continental: alluvial-fluvial facies, Lacustrine, Desert – Aeolian and glacial sedimentary environments. Shallow coastal clastics and shallow water carbonates. Evaporites. Deep-sea basins. Paleocurrents and basin analysis.
Clastic Petrofacies. Plaeoclimates and paleoenvironment analysis. Diagenesis of sandstone and carbonate rocks – changes in mineralogy, fabric, and chemistry.
Petrogenesis of arkoses, greywacke and quartz arenites. Evolution of lithosphere, hydrosphere, atmosphere and biosphere. Application of Trace, REE and stable isotopes geochemistry to sedimentalogical problems. Surface features of earth – island arcs, mid-oceanic ridges, Young mountain belts and their distribution. Evolution of continental and oceanic crust. Lithological, geochemical, stratigraphic characteristics of granite-greenstone belts Evolution of Proterozoic sedimentary basins of India. Anatomy of Orogenic belts and formation of mountain roots Life in Pre Cambrians, Pre Cambrian, Cambrian boundary with special reference to India

Books Recommended:

Blatt, H., Middleton, G.V. and Murray, R.C. (1980): Origin of Sedimentary Rocks, Prentice-Hall Inc.
Collins, J.D., and Thompson, D.B. (1982): Sedimentary Structures, George Allen and Unwin, London.
Lindholm, R.C. (1987) A Practical Approach to Sedimentology, Allen and Unwin, London.
Miall, A.D. (2000): Principles of Basin Analysis, Springer-Verlag.
Pettijohn;, F.J. (1975): Sedimentary Rocks (3rd Ed.), Harper and Row Publ., New Delhi. Reading, H.G. (1997): Sedimentary Environments and facies, Blackwell Scientific Publication.
Reineck, H.E. and Singh, I.B. (1973): Depositional Sedimentary Environments, Springer-Verlag.
Selley, R. C. (2000) Applied Sedimentology, Academic Press.
Tucker, M.E. (1981): Sedimentary Petrology: An Introduction, Wiley and Sons, New York.
Tucker, M.E. (1990): Carbonate Sedimentolgy, Blackwell Scientific Publication.
Allen P. A. and J.R.L. Allen (2005): Basin Analysis: Principles and Application, Blackwell Publ.
Perry, C.T. and Taylor, K.G. (2006): Envoronmental Sedimentology, Blackwell Publ., U.K.
Bird, J.M. (1980): Plate Tectonics, American Geophysical Union, Washington D.C. Briggs, J.C. (1987): Biogeography and Plate Tectonics, Elsevier.
Lieberman, B. L.(2000): Paleobiogeography: using fossils to study Global Change, Plate Tectonics and Evolution, Plenum Publ., New York.
Jacquelyne Kious, J. and Tilling, R.I. (2007): This Dynamic Earth: The story of Plate Tectonics, USGS Information Services.
Gass I.G. (1982): Understanding the Earth. Artemis Press (Pvt) Ltd.U.K. Windley B. (1973): The Evolving continents, John Wiley and Sons, New York.

SEMESTER – II

COURSE: IV - STRATIGRAPHIC PRINCIPLES AND INDIAN GEOLOGY

Course learning outcome:

The study of stratigraphy encompasses the aspects of the age of the earth, chronological arrangement of rocks and appearance and evolution of life through the geologic time. The knowledge of the concepts in stratigraphy, correlation, and paleontology would enable the students to understand the changes that occurred in the history of the earth and relate them to their field observations and also, in understanding the framework of the stratigraphy of India. The student will gain knowledge about the stratigraphy and geology of India with emphasis on the Stratigraphy of India with respect to Paleozoic, Mesozoic and Cenozoic Era which will help in understanding the different episodes on the earth during the geologic past.

Broad contents of the course: Stratigraphy, the branch of Geology work to unearth the secrets of age from rocks of the earth's crust. Stratigraphers study the composition and arrangement of layered or stratified rocks.. With these objectives in mind it becomes pertinent to understand the basic concepts of Stratigraphy

Skills to be learned:

The students will be exposed to the principles of stratigraphy including order of superposition. They will also be able to identify primary sedimentary structure and their depositional environments.

The detail contents of this course and references and suggested books:

Principles of stratigraphic scales and its divisions, dual classification. Stratigraphic units – lihtostratigraphic, biostratigraphic and chronostratigraphic. Rules of stratigraphic nomenclature. Stratigraphic correlation.Concept of sequence stratigraphy. Chief divisions of Indian sub continent and their physiographic characters. Archaean Era. Distribution and classification in Peninsula (Mysore, Bihar, M. P. and Rajasthan) and extrapeninsular regions. Their correlation and economic importance. Dharwar Supergroup (Classification, Distribution, Economic importance) Cuddaph Supergroup, Vindhyan Supergroup ,Chhattisgarh Group, Indravati Group and Khairagarh Group, Palaeozic formations of extra peninsular regions, Gondwana Supergroup. Gondwana formations. Jurassic system of rocks, Deccan Traps, Problems of Permo-triaassic and Cretaceous – Palaeocene boundaries. Distribution, succession, correlation and life of Siwalik formations. Distribution, lithology, correlation & life of the Cenozoics of Assam & Western India and Pleistocence (Quaternary) deposits, Karewa Beds, Indogangetic Alluvium. Quaternary climate, glacial and interglacial cycle, Eustatic changes

Books Recommended:

Boggs, S. (2001): Principles of Sedimentology and Stratigraphy, Prentice Hall. Danbar, C.O. and Rodgers, J. (1957): Principles of Stratigraphy, John Viley and Sons.

Doyle, P. and Bennett. M.R. (1996): Unlocking the Stratigraphic Record, John Viley and Sons.

Krishnan,M.S. (1982): Geology of India and Burma, C.B.S. Publ. and Distributors, Delhi. Naqvi, S.M. and Rogers, J.J.W. (1987): Precambrian Geology of India, Oxford University Press.

Pascoe, E.H. (1968): A Manual of the Geology of India and Burma (Vols.I-IV), Govt. of India Press, Delhi.

Pomerol, C. (1982): The Cenozoic Era? Tertiary and Quaternary, Ellis Harwood Ltd., Halsted Press.

Schoch, Robert, M. (1989): Stratigraphy: Principles and Methods, Van Nostrand Reinhold, New York.

Krumbein and Sloss (1963): Stratigraphy and sedimentation II Ed.Freeman & Co.

SEMESTER- III

Course –I - PALAEONTOLOGY

Course learning outcome:

The study of Palaeontology encompasses the aspects of the age of the earth, chronological arrangement of rocks and appearance and evolution of life through the geologic time. The knowledge of palaeontology would enable the students to understand the changes that occurred in the history of the earth and relate them to their field observations.

Broad contents of the course:

Palaeontologists study the fossils which have been preserved in the earth's crust by natural processes and are used to fingerprint a large chunk of the age of the earth in terms of time. Palaeontology encompasses study of micro-fossils, plant fossils, vertebrate and invertebrate fossils and their evolution. These aspects are fundamental not only to geology and stratigraphy but to inter-disciplinary fields of paleobotany, paleozoology and evolutionary biology.

Skills to belearned:

The students will acquire skills of discovering and describing fossils and their taxonomic classification. They will also be introduced to interpreting pale climate and pale environment conditions.

The detail contents of this course and references and suggested books:

Definition of fossil and modes of fossilization their application in age, determination, paleoclimatology, palaeogeography and evolution. Modes and theories of organic evolution, concept of bathymetric distribution of animals, migration and extinction of species.Study of morphology, classification, evolutionary trends and geologic and geographic distribution of Brachiopod, Pelecypoda, Gastropoda, Cephalopoda, Trilobites, Echinoids. Graptolites and Rugose Corals.Study of evolutionary history of Horse, Elephant and Man.General study of Siwalik mammalian fauna.Plant life through geologic ages.Study of fossil flora of Gondwana Group and Tertiary Formations of India. Detailed study of micropaleontology. Application of microfossils in stratigraphic correlation, age determination and palaeoenvironmental interpretations. Study of morphology of foraminifers. Classification, evolution and geological distribution of foraminifers.

Books Recommended:

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.
Dobzhansky, Ayala, Stebbins and Valentine (1977): Evolution, Freeman.

Horowitz, A.S. and Potter, E.D. (1971): Introductory Petrography of Fossils, Springer Verlag.
Mayr, E. (1971): Population, Species and Evolution, Harvard.

Prothero, D.R. (2004): Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.), McGraw Hill.
Raup, D.M. and Stanley, S.M. (1985): Principles of Paleontology ,CBS Publ.. Smith, A.B.(1994): Systematics and Fossil Record – Documenting Evolutionary Patterns, Blackwell.

Strean, C.W. and Carroll, R.L. (1989): Paleontology – the record of life, John Wiley. Bignot, G., Grahm and Trottman (1985): Elements of Micropaleontoogy, London. Romer, A.S. (1966): Vertebrate Paleontology (3rd Edn.) Chicago University Press

SEMESTER - III

COURSE: II - ORE AND FUEL GEOLOGY.

Course learning outcome:

A student will understand and learn about the concepts of origin of ores as well as petrology resources

Broad contents of the course:

To provide the student detailed study of the various processes for ore genesis. Further, origin and migration of oil and gas are also dealt

Skills to be learned:

The students will be appraised about the various processes for ore genesis and also about the origin, migration and accumulation of oil and natural gas

The detail contents of this course and references and suggested books:

Modern concepts of ore genesis. Spatial and temporal distribution of ore deposits- Global perspective. Concept of ore bearing fluids, their origin and migration. Fluid inclusion in ores – limitations and applications. Texture, papargensis and zoning in ores. Wall rock alteration. Structural, physico-chemical and stratigraphic controls of ore localization. Orthomagmatic ores of mafic-ultramafic association _ Diamonds in Kimberlites, REE in Carbonatite, Ti -V Ores, Chromite and PGE, Ni Ores.Cyprus type Cu-Zn Ores. Ores of Silicic igneous rocks- Kiruna type Fe-P. Pegmatoids, Greisen and Skarn deposits. Porphyry associations – Kuroko type Zn-Pb-Cu, Malanjkhand Type Cu-Mo deposits. Ores of Sedimentary affiliations- Chemical and Clastic sediments. Stratiform and Stratabound ore deposits. (Fe, Mn, non ferrous). Placers and paleoplacers.Ores of Metamorphic affiliations. Metamorphism of ores and metamorphogenic ores.Ores related to weathered surfaces – Bauxite, Ni and Au laterite. Mineralogy, genesis, distribution in India and uses of Cu, Pb, Zn. Mineralogy, genesis, distribution in India and uses of iron, aluminium, manganese, gold, chromium and silver ore deposits. National Mineral Policy and mineral concession rules. Definition and origin of Kerogene and coal. Rank, Grade and type of coal. Microscopic constituents of coal. Chemical characterization of coal Proximate and Ultimate analysis. Coal bed methane. Distribution of Coal in India. Origin, nature and migration of oil and gas. Characteristics of reservoir rocks. Oil bearing basins of India. Geology of productive oil fields of India. Mode of Occurrence and association of atomic minerals in nature. Productive geological horizons.

Books Recommended:

Branes, H.L. (1979): Geochemistry of Hydrothermal Ore Deposits, John Willey. Cuilbert, J.M. and Park,Jr. C.F.(1986): The Geology of Ore Deposits, Freidman. Evans, A.M. (1993): Ore Geology and Industrial Minerals, Blackwell.

James R. Craig and David J.Vaughan (1994): Ore Microscopy and Petrography. Klemm, D.D. and Schnieder, H.J. (1977): Time and Strata Bound Ore Deposits, Springer-Verlag.

Mookherjee, A. (2000): Ore Genesis-A Holistic Approach, Allied Publisher. Ramdhor, P. (1969): The Ore Minerals and their Intergowths, Pergamon Press. Stanton, R.L. (1972): Ore Petrology, McGraw Hill.

Wolf, K.H. (1976-1981): Hand Book of Stratabound and Stratiform Ore Deposits, Elsevier Publ.

Chandra,D.Singh, R.M.Singh,M.P.(2000):Textbook of Coal (Indian context), Tara Book Agency, Varanasi.

Singh, M.P. (1998): Coal and organic Petrology, Hindustan Publishing Corporation, New Delhi.

Texbook of Coal petrology, Gebruder Borntraeger,Stuttgart.

Van Krevelen, D. W. (1993): Coal, Typology-Physics-Chemistry-Constitution), Elsevier Science, Netherlands.

North, F.K. (1985): Petroleum Geology, Allen Unwin.

Selley, R.C. (1998): Elements of Petroleum Geology, Academic Press. Mineral Concession Rules 1960 (2005), IBM, Nagpur.

Sinha, R.K. and Sharma, N.L. (1976): Mineral economics, Oxford and IBH Publ.

SEMESTER- III
COURSE: III - GEMORPHOLOGY AND REMOTE SENSING

Course learning outcome:

The course is meant to address the fundamental techniques used for geomorphology and remote sensing. At the end of this course, the student will be appraised with all the theoretical knowledge, information and skills to use Remotely Sensed data for geological applications.

Broad contents of the course:

This course intends to introduce students to the fundamental principles and techniques of remote sensing, basic properties of electromagnetic radiation and its inter action with matter, It will also include topics like instruments and platforms used for remote sensing, and the ways those systems can be used to determine geological structure and rock types.

Skills to be learned:

After completion of this course, the student will be well versed with the world of Remote Sensing and the applications and Interpretation of data related to geosciences.

The detail contents of this course and references and suggested books

Geomorphic concepts and geomorphic cycle. Geomorphic processes – Weathering, soil formation, Mass-Wasting. Valley development, cycle of erosion, rejuvenation. Drainage patterns and their significance. Fluvial landforms and Glacial landforms. Karst topography. Arid and Eolian landforms, Coastal and volcanic landforms. Terrain evaluation and concept of morphometric analysis. Geomorphological mapping based on genesis of landforms. Geomorphic regions of India. Principles of terrain analysis. Concept and physical basis of remote sensing. Platforms: Terrestrial, Aerial and Space platforms. Advantages and limitations. Electromagnetic spectrum and principles of remote sensing. Interaction of EMR with atmosphere and earth surface features. Remote sensing sensors, data acquisition, visual interpretation and digital processing techniques. Interpretation of topographic and tectonic features Aerial photography, photographs and their geometry. Photogrammetry. Satellite remote sensing. Global and Indian space missions. Satellite exploration Programs and their characteristics. Application of remote sensing in geology. Application in Geomorphology. Application in groundwater evaluation, terrain evaluation and strategic purposes.

Books recommended:

Drury, S.A. (2001): Image Interpretation in Geology, Allen and Unwin. Gupta, R.P. (1991): Remote Sensing Geology, Springer-Verlag.

Halis, J.R. (1983): Applied Geomorphology.

Holmes,A.(1992): Holmes Principles of Physical Geology, Edited by P. McL. D. Duff. Chapman and Hall.

Lillesand, T.M. and Kiefer, R.W. (1987): Remote Sensing and Image Interpretation, John Wiley.

Sharma, H.S. (1990): Indian Geomorphology, Concept Publishing Co., New Delhi. Siegal, B.S. and Gillespie, A.R. (1980): Remote Sensing in Geology, John Wiley. Thornbury, W.D. (1980): Principles of Geomorphology, Wiley Easton Ltd., New York.

SEMESTER - III

COURSE: IV - MINERAL EXPLORATION

By the end of this course the student will have learnt about techniques of mineral exploration and exploitation, estimation of ore reserves, environmental impact of mining, and the importance conservation of mineral resources.

Broad contents of the course:

Mining being a key source of revenue generation for the Central as well as State governments, and an important job provider for Geologists, this course is designed to equip the undergraduate student with basic knowledge of key concepts of mining processes right from exploration to exploitation, together with an acquaintance of government regulations that control the mining and mineral conservation processes.

Skills to be learned:

Upon completion of this course, the student will acquire all knowledge and skills required for himself/herself becoming a mining geologist.

The detail contents of this course and references and suggested books:

Prospecting & Exploration: Definition and characteristic features. Stages of prospecting, regional and detailed exploration; objectives and practices of these stages. Guides to ore search: global, regional and local guides. Detailed study of Regional, Physiographic, Stratigraphic, Lithological, Mineralogical and Structural guides.

Drilling: Type of drills, Diamond drilling, Drilling records and logs, Duty of geologists during drilling. Sampling: General principles, various methods and procedures. Salting. Precautions during Sampling. Calculating grade and tonnage of ore: Average grade, volume, specific gravity, tonnage factor, UNFC classification. Gravity Method of prospecting: Principle and Instrumentation. Gravity field surveys. Gravity corrections: Free-air correction, Bouguer correction, Latitude correction, Terrain correction. Magnetic method of prospecting: Magnetic properties. Magnetic anomaly. Magnetometer. Field survey. Preparation of magnetic anomaly maps. Aeromagnetic surveys. Seismic prospecting: Fundamentals of seismic wave propagation. Methods of seismic prospecting: Refraction and reflection seismic methods. Seismic Stratigraphy, Detection of hydrocarbons. Electrical methods of prospecting: Basic principles of resistivity method. Electrical properties of rocks, Flow of current through ground surface, Apparent resistivity, Electrode arrangements, Resistivity survey. Application and interpretation of resistivity data. Electromagnetic methods of prospecting: Electromagnetic spectrum and induction, EM frequency and depth of penetration, EM response of conductors, Classification of EM methods and their description: Telluric current method, Magnetotelluric method, CSMT/CSAMT, Tilt angle method, Turam method, VLF method, Transient EM methods, Ground Penetrating Radar. Radiometric prospecting and Borehole Logging. Radiometric survey, Application and interpretation of data. Borehole logging: Different geophysical logs, Equipment; measurements and interpretation. Geochemical mobility and association of elements. Forms of primary and surficial dispersion patterns. Secondary dispersion processes and anomalies. Factors affecting dispersion patterns. Geochemical surveys: Litho-geochemical and Pedo-geochemical surveys. Geochemical surveys: Hydro-geochemical, Atmo-geochemical and Bio- geochemical surveys. Case studies of regional exploration for deposits of plutonic associations; vein and replacement types; magmatic sulphides and chromite; pegmatitic depsoits of Sn and rare metals;Case studies of regional exploration for deposits of hydrothermal deposits of Au- Ag, base metals, W-Mo, U; skarn deposits; sedimentary and supergene deposits. Instrumental analytical techniques. Statistical analysis and interpretation of geochemical prospecting data.

Books Recommended:

Dobrin, M.B. and Savit, C.H. Introduction to Geophysical Prospecting, McGraw Hill, New York, 1988
Sheriff, R.E. and Geldart, L.P. Exploration Seismology, Cambridge University Press, Cambridge, 1995.
Telford, W.M., Geldart L.P., and Sheriff, R.E. Applied Geophysics, Cambridge University Press, Cambridge, 1990.
DS Parasanis. Principle of Applied Geophysics (Chapman and Hall, London)
PB Sharma. Environmental and Engineering Geophysics (Cambridge University Press) TS Ramakrishna. Geophysical Practice in mineral exploration and mapping (Geological Society of India, Memoir 62), 2006.
Peters, W.C. 1987. Exploration and mining geology. 2nd edition. John Wiley & Sons, New York.
Rose, A.W., Hawkes, H.E. & Webb, J.S. 1979. Geochemistry in mineral exploration. Academic Press, London.
Levinson, A.A. 1974. Introduction to exploration geochemistry. Applied Publication Co., Calgary
Marjoribanks, R.W. 1997. Geological Methods in Mineral Exploration and Mining, Chapman & Hall, London.
Kuzvart, M. and Bohmer, M. 1986. Prospecting and Exploration of Mineral Deposits, Elsevier, Amsterdam, 1986.
Edwards, R.P and Atkinson, K. 1986. Ore Deposit Geology and its Influence on Mineral Exploration, Chapman & Hall, New York.
Moon, C.J., Whateley, M.K.G. and Evans, A.M. 2006. Introduction to mineral exploration, 2nd edition. Blackwell Publishing Ltd. Oxford.
Arogyaswami, R.P.N. (1996): Courses in Mining Geology, Oxford and IBH Publ. Bagchi,T.C.,Sengupta, D.K.,Rao, S.V.L.N. (1979):Elements of Prospecting and Exploration, Kalyani Publ.
Banerjee , P.K. and Ghosh, S. (1997): Elements of Prospecting for Non-fuel Mineral deposits, Allied Publ.
Chaussier, Jean – Bernard and Morer, J. (1987): Mineral Prospecting Manual. North Oxford Academic. Dhanraju, R. (2005): Radioactive Minerals, Geol. Soc. India, Bangalore. Rajendran, S. (2007): Mineral Exploration: Recent Strategies.
Sinha, R.K. and Sharma, N.L. (1976): Mineral economics, Oxford and IBH Publ.

SEMESTER - IV

COURSE: I – MINING GEOLOGY, ENGINEERING GEOLOGY AND MINERAL DRESSING

Course learning outcome:

The student will gain detail knowledge about the concepts, methods and hands on determination of soil and rock properties which will strength their knowledge of mining geology, Engineering Geology and mineral dressing.

Broad contents of the course:

This course deals with the mining, Geotechnical lab measurements used in Engineering Geology and mineral dressing

Skills to be learned:

The course provides vital skills in geotechnical lab work

The detail contents of this course and references and suggested books:

Definition of mining terms: pitting, trenching, adits, tunnels, and shafts. Role of geologist in mining industry. Geological structures of ore deposits and choice of mining methods. Mine Subsidence and mine support. Rock bursts, Mine Ventilation. Mine Drainage. Geological and geomorphic control on mining methods. Alluvial mining. Open pit mining. Methods of opencast mining; its advantages and limitations. Underground mining methods – drifting; cross cutting; winzing; stoping; room and pillaring; top –slicing; sub- level caving and block caving. Coal mining methods: Long wall, Board and Pillar method. Engineering properties of rocks and soil. Physical characters of building stones. Aggregate. Geological considerations for evaluation of Dam and reservoir sites. Dam foundation problems. Dam failure. Geotechnical evaluation of tunnel alignment and transportation routes. Methods of tunneling. Role of geologist in engineering projects. General principles and scope of Mineral Dressing. Primary and secondary breaking, crushing and grinding, liberation by sizes, reduction. Principles and methods of screening. Principles and methods of classification, classification as a means of concentration. Concentration methods, hand sorting, washing, jigging, tabling heavy fluid. Magnetic and electrostatic methods of separation of minerals. Floatation methods- Principles and techniques with examples. Application of ore microscopy in mineral dressing.

Books Recommended:

Dobrin, M. B.; Savit, C. H. (1988): Introduction to Geophysical Prospecting, McGraw- Hill.
Keary, P., Brooks, M. and Hill, I. (2002): An introduction to geophysical exploration, (3rd Ed.), Blackwell.

Krynine, D.H. and Judd, W.R. (1998): Principles of Engineering Geology, CBS Publ.. Rider, M. H. (1986): Whittles Publishing, Caithness. The Geological Interpretation of Well Logs, (Rev. Ed).
Schultz, J.R. and Cleaves, A.B. (1951): Geology in Engineering, John Willey and Sons, New York.
Singh, P. (1994): Engineering and General Geology, S.K. Kataria and Sons, Delhi. Bell F G Engineering Geology, Second Edition by, 2007. Butterworth-Heinemann, Oxford 5. Sathya Narayanaswami. Engineering Geology. Dhanpat Rai and Co. 1710, Nai Sarak, Delhi- 110006.. 2000

SEMESTER - IV
COURSE: II – ENVRIONMENTAL GEOLOGY

Course learning outcome:

Know the basic fundamentals of earth science as applied to the interaction between human activity and the natural environment. Understand the occurrence and availability of both surface and subsurface water resources and the role of the hydrologic cycle and pollution.

Broad contents of the course:

This course deals with environmental problems related to geology

Skills to be learned:

Students will be able to test and evaluate water quality for drinking and agricultural use. They will also have knowledge about various natural disasters.

The detail contents of this course and references and suggested books:

Basic concepts of Environmental Geology, Environment, Ecology, Ecosystems and habitat. Renewable and non-renewable natural resources. Role of geology in natural resources management and environmental planning. Landforms as ecosystem units.

Characteristics of various environmental regimes – fluvial, coastal, marine, Aeolian, desert, and glacial. Understanding their causes, types, Mitigation and Management. Geomorphic controls on biodiversity and its conservation. Conservation of soil and water resources. Geological hazards: Lands slides, Volcanic activity, Earthquake and Tsunami. Understanding their causes, types, Mitigation and Management. Draught and desertification, Measures of mitigation. Sea level changes. Measures of mitigation. Geological hazards -River flooding, erosion and sedimentation, coastal erosion, cyclones and tsunamis. Human modifications of nature on surface and subsurface by engineering. Human modifications of nature on surface and subsurface by mining activities. Human settlement and contamination of atmosphere, soil, surface water and groundwater by waste disposal and agro-industries. National Environmental Policy for air and water pollution. National Environmental Laws. Climate Change and global warming: Causes and Impact (Ozone layer depletion and ozone hole). Environment impact assessment report and preparation of environment Management plans.

Books Recommended:

Bryant, E. (1985): Natural Hazards, Cambridge Univ. Press. Keller, E.A.(1978): Environmental Geology, Bell and Howell, USA.

Nagabhushaniah, H.S. (2001): Goundwater in Hydrosphere, CBS Publ.

Perry, C.T. and Taylor, K.G. (2006): Environmental Sedimentology, Blackwell Publ. Singh, S. (2001): Geomorphology, Pustakalaya Bhawan, Allahabad.

Todd, D.K. (1995): Groundwater Hydrology, John Wiley and Sons.

Valdiya, K.S.(1987): Environmental Geology – Indian Context, Tata McGraw Hill. Montgomery, C.W. Environmental Geology, Won. C. Brown, Publishers, Iowa, 1989. Dorothy Merritts, Andrew de Wet, Kirsten Menking, Environmental Geology W. H. Freeman & Co. and Sumanas, Inc. USA, 1997

SEMESTER - IV
COURSE: III – HYDROGEOLOGY

Course learning outcome:

On completion of the course, the student will have gained an understanding of hydrogeological concepts, exploration, exploitation and recharge of groundwater and methods of monitoring groundwater quality and sources of pollution

Broad contents of the course:

To impart knowledge about groundwater, its movement, methods of its exploration, the criteria of its quality, methods of its conservation, recharge of groundwater monitoring of groundwater quantity and quality.

Skills to be learned:

Students will be able to acquire skills of systematic hydrogeological survey sand water quality monitoring

The detail contents of this course and references and suggested books

Scope of hydrogeology and its relation with hydrology, meteorology and their uses in the Hydrogeological investigation. Hydrologic cycle. Role of groundwater in the hydrologic cycle. Hydrograph, data collection and analysis. Water table and piezometric surface. Water table fluctuation. Water table contour maps, interpretation and uses.Water bearing formation. Isotropic, anisotropic aquifers. Porosity, permeability. Ground water movement: Darcy's law and its applications. Specific yield and specific retention. Storativity and transmissivity Steady and unsteady flow, leaky aquifers. Groundwater flow near aquifer boundaries. Bounded aquifers. Image wells. Water wells and their types. Well Development and completion. Pumping test and Yield of wells. Geological and Hydrogeological methods of groundwater exploration. Geophysical methods – Electrical resistivity method for groundwater exploration. Application of remote sensing in groundwater exploration. Basin wise development of groundwater with special reference to Chhattisgarh region.Groundwater provinces of India. Sources of dissolved constituents in groundwater. Groundwater quality standards-drinking, domestic, agriculture and industry. Groundwater pollution. Groundwater management. Safe yield, overdraft and spacing of wells. Conservation of Groundwater; conjunctive use of water. Artificial recharge.

Books Recommended:

C.F. Tolman (1937): Groundwater, McGraw Hill , New York and London.

D.K. Todd (1995): Groundwater Hydrology, John Wiley and Sons.

F.G. Driscoll (1988): Groundwater and Wells, UOP, Johnson Div.St.Paul. Min. USA.

H.M. Raghunath (1990): Groundwater, Wiley Eastern Ltd.

H.S. Nagabhushaniah (2001): Groundwater in Hydrosphere (Groundwater hydrology), CBS Publ.

K. R. Karanth (1989): Hydrogeology, Tata McGraw Hill Publ.

S.N. Davies and R.J.N. De Wiest (1966): Hydrogeology, John Wiley and Sons, New York

CORE ELECTIVE COURSES

ME- I ADVANCED HYDROGEOLOGY

Course learning outcome:

On completion of the course, the student will have gained an understanding of hydrogeological concepts, exploration, exploitation and recharge of groundwater and methods of monitoring groundwater quality and sources of pollution

Broad contents of the course:

To impart knowledge about groundwater, its movement, methods of its exploration, the criteria of its quality, methods of its conservation, recharge of groundwater monitoring of groundwater quantity and quality.

Skills to be learned:

Students will be able to acquire skills of systematic hydrogeological survey sand water quality monitoring

The detail contents of this course and references and suggested books

Hydrologic cycle, ground water in hydrologic cycle Hydrograph and hydrographic analysis Water balance studies,Springs (including thermal): Origin and movement of water. Geologic structures favouring groundwater movement. Groundwater reservoir properties. Forces and laws of groundwater movement. Well hydraulics: confined, unconfined, unsteady and radial flow. Water level fluctuation and its causative factors. Water well technology: Well types, drilling methods, construction, designing, development and maintenance of wells. Groundwater in arid and semiarid regions. Groundwater in coastal and alluvial regions. Groundwater in hard rocks and limestone terrain. Environmental impact on groundwater extraction. Ground water recharge: artificial and natural. Factors controlling recharge. Conjunctive and consumptive use of groundwater. Chemical characterization of groundwater in relation to domestic and industrial uses. Chemical characterization of groundwater for irrigation purposes. Water pollution: remedial measures and treatment Problems of arsenic and fluoride in water. Geological and hydrogeological methods of groundwater exploration. Geophysical surface resistivity and seismic methods in groundwater exploration. Geophysical water well logging. Application of remote sensing and radiogenic isotopes in hydrogeological studies. Basin-wise groundwater management.

ME-II PROJECT ORIENTED DISSERTATION

Course learning outcome:

To inculcate a culture of research and innovation at the undergraduate level so that the students are exposed to the nitty-gritty of the Scientific Research in their fields

Broad contents of the course:

This course is designed with great flexibility and involves the topico finterests of the students as well as his Research Supervisoror Institute where he intends to undertake the Dissertation work.

Skills to be learned:

The basic aim is to expose the students at anearly stage to field and laboratory technique sand sophisticated instrumentation.

The detail contents of this course and references and suggested books:

An opportunity to work on a six month-long research project in geosciences under the direct supervision of a faculty member in University/Institute or Government Organisation. Students will develop a research proposal, carry out data collection using field and/or laboratory studies, and complete a final report/presentation. Field studies, Laboratory studies / data processing, reference work and presentation of the thesis are four major components of the course. Students opting for this course should adhere to the following procedure.

1. Precise title and outline of work is to be submitted to the Head of the Department/Exam Coordinator.
2. The student shall spend at least one week in the field. The field work shall be carried out only during vacation or holidays, and in no case student will be permitted to be absent from regular teaching on account of dissertation. The student shall maintain field diaries and other record relevant to dissertation.
3. If (s) he is working on a laboratory project, the fieldwork component may or may not be essential.
4. Every month the students hall submit the progress report and laboratory work done, through the supervisor to Head of the Department/Exam Coordinator.
5. The student shall do dissertation at his own cost. The department will not spare funds for this purpose.
6. The students hall give a seminar before the submission of the dissertation.
7. The supervisor shall submit the practical sets based on topic of dissertation developed for the students to Head of the Department/Exam Coordinator prior to the commencement of practical examination.
8. Non-compliance of any of the above rules will disqualify students for grant of terms.
9. Four copies neatly typed on A4 paper, well bound together with maps and illustrations should be submitted.

Dissertation, on the basis of the work carried out by the student, will be submitted, through the supervisor concerned, to the Head of the Department//Exam Coordinator before the commencement of the practical examination, for being forwarded to the Board of Examiners. In case of student receiving help (training and / or participation in ongoing research activities) from other Institution/Organization for their dissertation work, the associated scientist from that Institute/ Organization will function as co-supervisor.