Revised Course Structure and Syllabus of

Integrated M.Sc. (Applied Geology)
and
M.Sc. (Applied Geology)

Adapted from 2015-2016

DEPARTMENT OF EARTH SCIENCES
SCHOOL OF PHYSICAL, CHEMICAL & APPLIED SCIENCES
PONDICHERRY UNIVERSITY
PONDICHERRY – 605 014

OCTOBER 2016

Integrated M.Sc. (Applied Geology)

A minimum of 192 credits need to be earned for completion of the Integrated M.Sc. (Applied Geology) course of 5 years duration.

Semester 1: Minimum Required Credits - 20

S. No.	Course	Hard/Soft Core	Credits
1.	CHEM100 General Chemistry Laboratory I	Hard Core	2
2.	CHEM101 General Chemistry I	Hard Core	3
3.	PHYS 130 Physics Laboratory I	Hard Core	2
4.	PHYS 131 Mechanics	Hard Core	3
5.	ENGL 111 Functional English	Hard Core	3
6.	MATH A Mathematics course	Hard Core	3
7.	EASC 111 Earth and Environment	Hard Core	3
TOTAL			19

Suggested Soft Core Course:

Sl. No.	Course	Hard/Soft	Credits
1.	Any course from the other departments in consultation with the faculty advisor.	Soft Core	2/3

Semester 2: Required Credits - 20

S. No	Course	Hard/Soft Core	Credits
1.	CHEM 102 General Chemistry II	Hard Core	3
2.	CHEM 120 General Chemistry Laboratory II	Hard Core	2
3.	PHYS 140 Physics Laboratory II	Hard Core	2
4.	PHYS A Course from Physics	Hard Core	3
5.	MATH A Mathematics course	Hard Core	3
6.	ENGL 121 Functional English II	Hard Core	3
7.	EASC 121 Geomorphology	Hard Core	2
TOTAL			18

Suggested Soft Core Course:

Sl. No.	Course	Hard/Soft	Credits
1.	Any course from the other departments in consultation with the faculty advisor.	Soft Core	2/3

Semester 3: Required Credits - 20

S. No	Course	Hard/Soft	Credits
1.	EASC 211 Crystallography and Mineralogy	Hard Core	3
2.	EASC 212 Paleontology	Hard Core	2
3.	EASC 213 Geology Lab-I (Crystallography, Mineralogy, Paleontology)	Hard Core	2
4.	A course from Maths/Physics/Chemistry	Hard Core	3
5.	A course from Maths/Physics/Chemistry	Hard Core	3
TOTAL			13

Suggested Soft Core Courses:

Sl. No	Course	Hard/Soft	Credits
6.	A language course from School of Humanities	Soft Core	3
7.	A course from Social Sciences	Soft Core	3

Semester 4: Required Credits - 20

S. No	Course	Hard/Soft	Credits
1.	EASC 221 Igneous and Metamorphic Petrology	Hard Core	3
2.	EASC 222 Sedimentary Petrology	Hard Core	2
3.	EASC 223 Structural Geology	Hard Core	2
4.	EASC 224 Geology Lab-II (Igneous, Metamorphic, Sedimentary Petrology, Structural Geology)	Hard Core	4
5.	A course from Maths/Physics/Biology	Hard Core	3
6.	A course from Maths/Physics/Chemistry	Hard Core	3
TOTAL			17

Suggested Soft Core Courses:

Sl. No	Course	Hard/Soft	Credits
7.	A language course from School of Humanities	Soft Core	3
8.	A course from other Departments	Soft Core	3

Semester 5: Required Credits - 20

S. No	Course	Hard/Soft	Credits
1.	EASC 311 Economic Geology	Hard Core	3
2.	EASC 312 Stratigraphy and Indian Geology	Hard Core	3
3.	EASC 313 Climatology	Hard Core	2
4	EASC 314 Geology Lab-III (Economic Geology)	Hard Core	2
5.	A courses from Maths/Physics/Chemistry	Hard Core	3
TOTAL			13

Suggested Soft Core Courses:

Sl. No	**Course**	**Hard/Soft**	**Credits**
1.	EASC 315 Summer Internship-I	Soft Core	2
2.	A course from social sciences	Soft Core	3

Semester 6: Required Credits - 20

S. No	Course	Hard/Soft	Credits
1.	EASC 321 Geohydrology	Hard Core	2
2.	EASC 322 Introduction to Remote Sensing & GIS	Hard Core	2
3.	EASC 323 Field Training-I	Hard Core	3
4.	EASC 324 Geology Lab-IV (Remote Sensing, GIS and Geohydrology)	Hard Core	2
5.	A courses from Maths/Physics/Chemistry	Hard Core	3
Total			12

Suggested Soft Core Courses:

Sl. No	**Course**	**Hard/Soft**	**Credits**
1	EASC 325 Physical Oceanography	Soft Core	3
2	EASC 326 Engineering Geology	Soft Core	2
3.	EASC 327 Environmental Geoscience	Soft Core	3

Semester 7: Required Credits - 18

S. No.	Course	Hard/Soft Core	Credits
1.	EASC 411 Crystallography and Crystal Chemistry	Hard Core	2
2.	EASC 412 Rock Forming Minerals	Hard Core	2
3.	EASC 413 Deformation and Rock Structures	Hard Core	3
4.	EASC 414 Geochemistry	Hard Core	3
5.	EASC 415 Advanced Geomorphology	Hard Core	2
6.	EASC416 Advanced Geology Lab-I (Crystallography, Mineralogy, Structural geology, Geochemistry)	Hard Core	4
TOTAL			16

Suggested Soft Core Course:

Sl. No.	Course	Hard/Soft	Credits
1.	EASC 417 Summer Internship-II	Soft Core	3
2.	EASC 418 Stable Isotope Geochemistry	Soft Core	2
3.	EASC 419 Statistics in Geosciences	Soft Core	3
4.	EASC 420 Computer Applications in Earth Sciences	Soft Core	3

Semester 8: Required Credits – 18

S. No	Course	Hard/Soft Core	Credits
1 .	EASC 421 Igneous Petrology	Hard Core	2
2.	EASC 422 Stratigraphy	Hard Core	2
3.	EASC 423 Metamorphic Petrology	Hard Core	2
4.	EASC 424 Vertebrate and Invertebrate Paleontology	Hard Core	2
5.	EASC 425 Advanced Geology Lab-II (Igneous, Metamorphic Petrology, Paleontology)	Hard Core	3
6.	EASC 426 Advanced Field Training-I	Hard Core	3
TOTAL			14

Suggested Soft Core Course:

Sl. No.	Course	Hard/Soft	Credits
1.	EASC427 Isotope Geology	Soft Core	2
2.	EASC 428 Radiogenic Isotope Geology	Soft Core	2
3.	EASC 429 Marine Geology	Soft Core	2
4.	EASC 430 Quaternary Geology	Soft Core	2

Semester 9: Required Credits - 18

S. No	Course	Hard/Soft	Credits
1.	EASC 511 Geology of Mineral Deposits	Hard Core	4
2.	EASC 512 Sedimentology	Hard Core	2
3.	EASC 513 Solid Earth Geophysics	Hard Core	2
4.	EASC 514 Micropaleontology	Hard Core	2
5.	EASC 515 Advanced Remote Sensing & GIS	Hard Core	3
6.	EASC 516 Advanced Geology Lab-III	Hard Core	4
TOTAL			17

Suggested Soft Core Courses:

Sl. No	Course	Hard/Soft	Credits
1.	EASC 517 Term Paper	Soft Core	2
2.	EASC 518 Professional Training	Soft Core	3
3.	EASC 519 Coal and Petroleum Geology	Soft Core	2
4.	EASC 520 Mineral Economics	Soft Core	2

Semester 10: Required Credits - 18

S. No	Course	Hard/Soft	Credits
1.	EASC 521 Geoexploration	Hard Core	4
2.	EASC 522 Advanced Geohydrology	Hard Core	2
3.	EASC 523 Advanced Geology Lab IV	Hard Core	3
4.	EASC 524 Advanced Field Training II	Hard Core	3
TOTAL			12

Suggested Soft Core Courses:

Sl. No	Course	Hard/Soft	Credits
1	EASC 525 Project	Soft Core	4
2.	EASC 526 Global Tectonics	Soft Core	2
3.	EASC 527 Mining Geology	Soft Core	2
4.	EASC528 Paleoclimatology	Soft Core	3
5.	EASC 529 Planetary Geosciences	Soft Core	2
6.	EASC 530 Well Logging	Soft Core	2

M.Sc. (Applied Geology)

Minimum of 72 credits need to be earned for compilation of the M.Sc. (Applied Geology) course of 2 years duration.

Semester 1: Required Credits - 18

S. No.	Course	Hard/Soft Core	Credits
1.	EASC 411 Crystallography and Crystal Chemistry	Hard Core	2
2.	EASC 412 Rock Forming Minerals	Hard Core	2
3.	EASC 413 Deformation and Rock Structures	Hard Core	3
4.	EASC 414 Geochemistry	Hard Core	3
5.	EASC 415 Advanced Geomorphology	Hard Core	2
6.	EASC416 Advanced Geology Lab-I (Crystallography, Mineralogy, Structural geology, Geochemistry)	Hard Core	4
TOTAL			16

Suggested Soft Core Course:

Sl. No.	Course	Hard/Soft	Credits
1.	EASC 418 Stable Isotope Geochemistry	Soft Core	2
2.	EASC 419 Statistics in Geosciences	Soft Core	3
3.	EASC 420 Computer Applications in Earth Sciences	Soft Core	3

Semester 2: Required Credits – 18

S. No	Course	Hard/Soft Core	Credits
1 .	EASC 421 Igneous Petrology	Hard Core	2
2.	EASC 422 Stratigraphy	Hard Core	2
3.	EASC 423 Metamorphic Petrology	Hard Core	2
4.	EASC 424 Vertebrate and Invertebrate Paleontology	Hard Core	2
5.	EASC 425 Advanced Geology Lab-II (Igneous, Metamorphic Petrology, Paleontology)	Hard Core	3
6.	EASC 426 Advanced Field Training-I	Hard Core	3
TOTAL			14

Suggested Soft Core Course:

Sl. No.	Course	Hard/Soft	Credits
1.	EASC427 Isotope Geology	Soft Core	2
2.	EASC 428 Radiogenic Isotope Geology	Soft Core	2
3.	EASC 429 Marine Geology	Soft Core	2
4.	EASC 430 Quaternary Geology	Soft Core	2

Semester 3: Required Credits - 18

S. No	Course	Hard/Soft	Credits
1.	EASC 511 Geology of Mineral Deposits	Hard Core	4
2.	EASC 512 Sedimentology	Hard Core	2
3.	EASC 513 Solid Earth Geophysics	Hard Core	2
4.	EASC 514 Micropaleontology	Hard Core	2
5.	EASC 515 Advanced Remote Sensing & GIS	Hard Core	3
6.	EASC 516 Advanced Geology Lab-III	Hard Core	4
TOTAL			17

Suggested Soft Core Courses:

Sl. No	Course	Hard/Soft	Credits
1.	EASC 517 Term Paper	Soft Core	2
2.	EASC 518 Professional Training	Soft Core	3
3.	EASC 519 Coal and Petroleum Geology	Soft Core	2
4.	EASC 520 Mineral Economics	Soft Core	2

Semester 4: Required Credits - 18

S. No	Course	Hard/Soft	Credits
1.	EASC 521 Geoexploration	Hard Core	4
2.	EASC 522 Advanced Geohydrology	Hard Core	2
3.	EASC 523 Advanced Geology Lab-IV	Hard Core	3
4.	EASC 524 Advanced Field Training-II	Hard Core	3
TOTAL			12

Suggested Soft Core Courses:

Sl. No	Course	Hard/Soft	Credits
1	EASC 525 Project	Soft Core	4
2.	EASC 526 Global Tectonics	Soft Core	2
3.	EASC 527 Mining Geology	Soft Core	2
4.	EASC528 Paleoclimatology	Soft Core	3
5.	EASC 529 Planetary Geosciences	Soft Core	2
6.	EASC 530 Well Logging	Soft Core	2

EASC 111 - EARTH AND ENVIRONMENT (Hard Core Course)

Credits: 3

This course aims to help a student see the Earth as a dynamic system of continuously interacting and changing subsystems of lithosphere, hydrosphere, atmosphere and biosphere. This would prepare a student to better appreciate global phenomena such as a global climate change.

Unit I Introduction

Methods of studying Earth: Observations, terminology, making and testing hypotheses. Historical development of the subject.

Origin of the Solar system and the Earth: The Origin of Planets, Early Earth and Formation of a Layered Planet, Earth as a System of Interacting Components, Earth Through Geologic Time.

Plate Tectonics: The Discovery of Plate Tectonics, The Mosaic of Plates**,** Consequences and effects of plate movements. The Grand Reconstruction, The Engine of Plate Tectonics.

Unit II Earth Materials

Minerals: The Atomic Structure of Minerals. Rock-Forming Minerals, Properties of Minerals.

Rocks: Igneous Rocks, Sedimentary Rocks, Metamorphic Rocks. The Rock Cycle, Rock and Fossil Record and the Geological Time Scale**.**

Unit III Earth Processes

Dynamic Processes of Solid Earth: Folds, Faults, and other Records of Rock Deformation, Earthquakes, Volcanism, Evolution of the Continents, Tectonics of Indian Plate, Origin of Himalayas

Weathering and Erosion: Physical weathering, Chemical weathering.

Natural Hazards: Earthquakes, Tsunamis, Volcanoes, Mass Wasting, Issues relating to prediction, protection and mitigation. **Landscapes,** Tectonic and Climate Interaction

Unit IV Hydrosphere & Atmosphere

The Hydrologic Cycle and Groundwater, Streams, Stream Loads and Sediment Movement, Deltas**, The Oceans,** Physical and Chemical Sedimentation in the Ocean, Waves and Tides, Shorelines. **Winds and Deserts** Atmospheric circulation, wind erosion**.**

Unit V Earth resources, Environment, Landscape and Global Change

Energy Resources: Oil and Natural Gas, Coal, Alternatives to Fossil Fuels. **Environment, Global Change, and Human Impacts,** The Climate System**,** Natural Climate Variability**,** The Carbon Cycle, Human Activity and Global Change.

Text Books:

Frank Press Raymond Siever: Understanding Earth (3rd ed). W.H. Freeman and Company. New York . 2000

B. J. Skinner and S.C. Porter: The Dynamic Earth – An Introduction to Physical Geology 3rd edition. John Wiley & Sons, New York. 1995

P. McL. D. Duff : Holme's Principles of Physical Geology (4th ed). Chapman & Hall. London. 1996

Reference books:

A. Cox & R.B. Hart Plate Tectonics How it works. Blackwell Scientific Publ. Co. Boston. 1986.

Philip A. Allen Earth Surface Processes Blackwell Sciences Ltd, Oxford 1997

B.W. Murck, B.J. Skinner & S.C. Porter Dangerous Earth – An Introduction to Geologic Hazards John Wiley & Sons New York 1996

B.W. Murck, B.J. Skinner & S.C. Porter, Environmental Geology. John Wiley & Sons, New York, 1996.

EASC 121 GEOMORPHOLOGY (Hard Core Course)

Credits: 2

Fundamental concepts of geomorphology. Theory of uniformitarianism. Cycle of erosion, base level control. Role of structure, process, time, and climate in landform evolution.

Tectonic and volcanic landforms. Landforms made by folding and faulting (tectonic scarps, fault valley and block mountains). Volcanic activity – distribution and landforms.

Weathering and soil formation. Physical and chemical weathering. Soil types and soil formation. Mass wasting and hillslope stability. Classification of mass wasting processes.

Fluvial erosion, transportation, and deposition mechanisms. Landforms formed by fluvial erosion (valleys, canyons, gorges, watergaps) and deposition (floodplains, deltas, alluvial fans and river terraces). Structural control of fluvial erosion.

Karst topography. Rock dissolution and cavern formation. Karst landforms.

Aeolian processes and landforms. Deflation basins, sand dunes – types and origins. Loess deposits.

Glacial and periglacial processes and landforms. Continental and alpine glaciation. Moraines, eskers, kames, kettles, drumlins, cirques, hanging valleys, U shaped valleys.

Coastal and submarine processes and landforms. Wave action, wave base. Wave cut platform, beaches and barrier islands. Sea floor topography - continental shelf, slope, and rise, abyssal plains, submarine canyons. Coral reefs and islands.

Applied Geomorphology. Application of geomorphogical knowledge in groundwater investigations, mineral exploration and engineering.

Text Books:

R.J. Huggest (2007) Fundamentals of Geomorphology. Routledge Publishers
M.A. Summerfield (1991), Global Geomorphology, Pearson Education Ltd.
W.D. Thornbury (1969) Principles of Geomorphology. Willey Eastern Ltd. New Delhi.
H.S. Sharma (1990) Indian Geomorphology. Concept Pub. Co., New Delhi.

EASC 211: CRYSTALLOGRAPHY AND MINERALOGY (Hard Core Course)
Credits:3

Unit I
Basic ideas about crystal morphology in relation to internal structures. Crystal parameters and indices. Crystal symmetry and classification of crystals into six systems and 32 point groups. Miller-Bravais indices, Stereographic projections of symmetry elements and forms.

Unit II
Crystal lattice and internal symmetry, Bravais lattices, Screw axis, glide planes Points, directions and planes in crystal lattices and 230 Space Groups. Defects in Crystals
Introduction to analytical techniques like XRD (X-ray diffraction), SEM (secondary electron microscopy).

Unit III
Physical properties of crystals. Cohesive and elastic properties, Thermal properties, Electrical and magnetic properties, piezo- and pyro- electricity, Nature of light and basic principles of interaction of light with crystals.

Unit IV
Elements of crystal chemistry and aspects of crystal structures. Minerals: definition and classification, physical and chemical composition of common rock-forming minerals.

Unit V
Physical properties, crystal structure and identification of common rock forming minerals. Origin and association of rock forming minerals in various geological environments.

Text books:

1. W. D. Nesse, 2000. Introduction to Mineralogy, Oxford University Press, ISBN 0-19-510691-1
2. J.A.K. Tareen and T.R.N. Kutty. A basic course in crystallography. Universities Press, 2001.
3. Nesse W.D. , Introduction to Optical mineralogy, 2008

Reference books:

1. F.D. Bloss, 1971. Crystallography and Crystal Chemistry, Holt, Reinhart & Winston. New York, 545 pp.
2. Cornelis Klein and Barbara Dutrow, The manual of Mineral Science, Wiley Publication 2007.
3. P. K. Verma , Optical mineralogy, CRC press 2009
4. Deer, W. A. , Howie, R. A. and Zussman, J., An introduction to the rock forming minerals, ELBS publication, 2nd Ed. 2005, 696 pp.

EASC 212: PALEONTOLOGY (Hard Core Course)

Credits: 2

(Pre requisite: EASC 111 - Earth and Environment or Teacher's consent)

Unit –I : The organic world; fossils and processes of fossilization; Geological time scale; types of fossils and their uses.

Unit –II : A brief knowledge of morphology and distribution of the following group of invertebrates – Protozoa, Coelenterata Brachiopoda, Mollusca, Echinodermata, Graptoloidea and Trilobita.

Unit –III : Brief account of geological distribution of important Gondwana flora in India. Siwalik vertebrate fossils.

Unit –IV : An outline of life through ages, its evolution and distribution

Text books:

1. Shrock,R.R and Twenhofel,W.H. 1987. Principles of Invertebrate Paleontology. McGraw Hill, New York.
2. Jain, P.C and Anantharaman, M.S., 2005. Palaeontology : Evolution and Animal Distribution. (6th edition), Vishal Publishing Co, New Delhi.
3. Moore,R.C, Lalicker, C.G & Fisher, A.G (1997). Invertebrate fossils. (1st Indian edition), CBS Publishers & Distributors, New Delhi.

Reference books:

1. Clarkson , E.N. 1993.Invertebrate Paleontology and Evolution, Chapman Hall India, Chennai.
2. Raup, D.M. and Stanley,S.M. 1985. Principles of Paleontology, CBS Publishers, New Delhi.

EASC 213: GEOLOGY LAB-I (CRYSTALLOGRAPHY, MINERALOGY, PALEONTOLOGY) (Hard Core Course)

Credits:2

Crystallography and Mineralogy

Study of symmetry in models (quartz, tourmaline, barite, gypsum, augite, hornblende),

Study of symmetry and forms in the models (Fluorite, garnet, pyrite, tetrahedrite,galena, zircon, beryl, calcite, olivine, orthoclase, albite)

Study of color, streak, luster, cleavage, fracture, hardness (Moh's scale), magnetism and forms of the minerals. Determination of specific gravity of minerals.

Study of isotropic, uniaxial and biaxial common rock forming minerals under petrological polarizing microscope and determination of relative refractive indices (RI), pleochroism, extinction angle interference color and order.

Paleontology

Megascopic study of major invertebrate fossils. Study of some important microfossils under binocular microscope.

Reference books:

Ehlers E.G. (1987) **Optical Mineralogy: Theory and Techniques,** Blackwell Scientific Publications, 158 p. New York, John Wiley & Sons, Inc., 192p.

Klein, C, Hurlbut, C.S., and Dana, J.D. 1998, **Manual of Mineralogy (after James D. Dana), 21st Edition,** John Wiley & Sons Inc.

Mackenzie, W.S. & Adams, 1994, A.E. **Color Atlas of Rock and Minerals in Thin Section,** John Wiley & Sons

Woods, H. 1982. Invertebrate Paleontology, CBS Publ. New Delhi.

EASC 221: IGNEOUS AND METAMORPHIC PETROLOGY (Hard Core Course)
Credits: 3

(Pre requisite: EASC 111 & EASC 211 or Teacher's consent)

Unit 1: Introduction: Concept of heat and temperature inside the Earth. Melting and crystallization. Magma and magmatic processes. Concept of intrusion and extrusion.

Unit 2: Forms and types of igneous bodies:- extrusive bodies- Flood basalts, Volcanoes and types of volcanoes. Pyroclastic deposits. Intrusive bodies:- concept of concordant and discordant intrusion, Dikes and sills and types of dikes, breccia pipes, Laccoliths, Lopoliths, Stocks and Batholiths.

Unit 3: Structure and textures of igneous rocks. Classification of igneous rocks- concept of mode and norm. Phase rule and concept of phase diagrams. Mineralogical and chemical description and significance of important igneous rocks of continental and oceanic association.

Unit 4: Concept of metamorphism, Agents of metamorphism, Types of metamorphism, Texture, structure and classification of metamorphic rocks. Nature of protoliths, Types of metamorphic reactions and isograd.

Unit 5: Metamorphic grade; facies and facies series, Progressive metamorphism of mafic/pelite rock, P-T-t paths.

Text books:

1. Best, M.G., 2002, **Igneous and metamorphic petrology,** 2nd Edition, Blackwell Publishers
2. Winter, J.D. (2001/7): **An introduction to Igneous and Metamorphic Petrology**, Prentice Hall.

Reference Books:

1. Philpots A.R., 1990, **Principles of Igneous and metamorphic petrology,** Prentice Hall.
2. Yardley, B.W., 1989, **An introduction to metamorphic petrology,** Longman

EASC 222 – SEDIMENTARY PETROLOGY (Hard Core Course)

Credits: 2

(Pre requisite: EASC 111 and 122 or Teacher's consent)

Unit 1:

Introduction to the process of formation of sedimentary rocks (Weathering, soil formation, erosion, transportation and their deposition.

Unit 2:

Texture and fabric of Clastic rocks (Rudaceous, arenaceous and argillaceous rocks). Classification of sedimentary rocks (Siliciclastic, Carbonate and Chemical deposits) and brief introduction to their origin

Unit 3:

Petrography of important clastic and carbonate rocks.

Unit 4:

Introduction to flow mechanics and genesis of sedimentary structures. Basic ideas about depositional environment and facies concept

Unit 5:

Post depositional changes and introduction to provenance interpretation

Text books:

1. Sengupta, S.M. (1994) Introduction to Sedimentology, Oxford & IBH.
2. Tucker, M.E. (1981) Sedimentary Petrology: an introduction. John Willey & Sons, New York.

Reference books:

1. Blatt, Middleton & Murray (1980) Origin of sedimentary rocks. Printice Hall Inc.

2. Pettijohn, F.J. (1975) Sedimentary rocks. Harper and Row Publ., New Delhi.

3. Prothero, D.R., Schwab, F., (2003) Sedimentary Geology. W. H. Freeman; 2nd edition

4. Allen, J. R. L (2001) Principles of Physical Sedimentology by Blackburn Press; 1st, corrected reprint edition (February 1, 2001)

EASC 223: STRUCTURAL GEOLOGY (Hard Core Course)

Credits: 2

Unit-1: Concept of force and stress, Stress components, Stress ellipsoid and Mohr circle, Concept of strain, measurement of strain. Homogeneous deformation, Shape change and strain ellipsoid, Rheology and behaviour of materials under stress.

Unit -2: Morphology, geometrical characteristics and classification of structures, Concept of attitude, Measurement of attitude, Conventions for representing structures

Unit -3: Folds: Concept and structural elements of fold, Classification of folds. Nature and recognition criteria of buckle folds. Fold interference, Characteristic outcrop pattern of superposed fold.

Unit -4: Faults: Concept and structural elements of Fault. Classification of faults. Criteria for recognizing fault in field, Anderson's model of faulting, Features associated with different types of faults.

Unit -5: Joints: Concept and structural elements of joint, Joints associated with fold and fault, Surface features of joint, Age relation of joints, Joint in relation to tectonic cycle.

Unit -6: Foliation: Concept and classification of foliation, Usefulness of foliation in structural analysis. Lineation: Concept and classification of lineation, Usefulness of lineation in structural analysis

Unit -7: Unconformity: Concept of unconformity, types of unconformity, Recognition criteria of unconformity,

Unit – 8: Shear zone: Concept and classification of shear zone, Shear zone pattern, Shear zone rocks, Shear sense indicators.

Text Books:

1. Ghosh, S.K. 1993. Structural Geology: Fundamentals and modern developments.
2. Davis, G.H., Reynolds, S.J., 1996. Structural geology of rocks and regions, 2nd Edition, John Wiley & sons.
3. Park, R. G., 1983. Foundations of Structural Geology, Blackie Academic and Professional
4. Billings, M. P. Structural Geology, Prentice Hall

Reference Books:

1. Turcotte, D.L., & Schubert, G., 2001. Geodynamics 2nd Edition, Cambridge University Press
2. Pollard, D.D. & Fletcher, R.C. 2005. Fundamentals of Structural Geology, Cambridge University Press
3. Ramsay, J.G. & Huber, M.I. 1987. The Techniques of Modern Structural Geology, Vol 2: Folds and Fractures, Academic Press.
4. Moores, E.M., Twiss, R.J. 1995. Tectonics, W.H. Freeman
5. Hamblin, W.K., Christiansen, E.H. 2003. Earth's Dynamic Systems, 10th Edition, Prentice Hall

EASC 224: GEOLOGY LAB-II (SEDIMENTARY, IGNEOUS AND METAMORPHIC PETROLOGY, STRUCTURAL GEOLOGY (Hard Core Course)

Credits: 4

Igneous and Metamorphic petrology

Study of hand specimen of various igneous and metamorphic rocks.

Preparation of thins-section for microscopic study.

Microscopic study of mineralogical and textural characteristics of igneous and metamorphic rocks.

Sedimentary Petrology

Study of clastic and non-clastic rocks in hand specimen.

Petrographic study of sedimentary rocks in thin-sections using microscope.

Plotting of size distribution data.

Structural Geology

Drawing exercises for Attitude of planes and lines: True and Apparent dip, strike, pitch, plunge, trend. Concept of structure contours and determining outcrop pattern. Interpretation of geological maps- determining exact attitudes from outcrop. Determining stratigraphic thickness. Constructing stratigraphic columns. Construction of a geological cross-section.

Reference books:

Philpotts, A. R.: Atlas of Igneous and metamorphic rocks under the microscope

Rowland, S. Duebendorfer, E. & Schiefelbein, I. 2006, **Structural Analysis and Synthesis, A Laboratory Course in Structural Geology**, 3rd Edition Blackwell Publishers

EASC-311 ECONOMIC GEOLOGY (Hard Core Course)

Credits: 3

(Pre requisite: Teacher's consent)

Unit 1: Economic minerals: chemical and industrial classification. Concept of ore minerals and gangue minerals; tenor and cut-off grade. Physical properties, chemical composition and mode of occurrence of important ore minerals, industrial minerals, fossil fuels and building stones.

Unit 2: Mineral deposits – types, morphology and forms of ore bodies. Spatial distribution of mineral deposits and their distribution through geological time. Genetic classifications of mineral deposits. Ore forming processes and physical-chemical environment of ore deposition. Magmatic (early magmatic, late magmatic, volcanic), sedimentary (syn-sedimentary, diagenetic), metamorphic, hydrothermal, and weathering-surface processes of ore formation. .

Unit 3: Geological characteristics and Indian occurrences of important types of magmatic deposits (chromite, titaniferous magnetite, Cu-Ni sulphide), pegmatitic deposits (muscovite and rare metals), skarn deposits and hydrothermal deposits (base metals, gold, tin, tungsten, molybdenum), and metamorphic deposits (gondite-type manganese, graphite).

Unit 4: Geological characteristics and Indian occurrences of sedimentary deposits (Banded iron formation, manganese), lateritic deposits (aluminium). Various types of coal deposits, and oil and natural gas occurrences. Petroleum reservoirs and various types of oil and gas traps. On-shore and off-shore petroliferous basins of India. Other important hydrocarbon resources (coal bed methane, gas hydrate).

Unit 5: Basic concepts of prospecting and exploration of mineral and fossil fuel resources. Geological, geochemical and geophysical methods of exploration. Elementary ideas on methods of mining – open cast and underground methods. Principles of mineral economics – strategic, critical and essential minerals; conservation of minerals. National mineral policy of India.

Text books:

1. A.M.Evans. 1993. Ore geology and industrial minerals - an introduction. Blackwell Science, New Delhi.
2. R.K.Sinha and N.L.Sharma. 1988. Mineral Economics. Oxford-IBH, New Delhi.
3. D.Chandra, R.M.Singh and M.P.Singh. 2000. Text book of coal (Indian context). Tara Book Agency, Varanasi.
4. A.I.Levorsen. 1985. Geology of Petroleum. 2nd Edition. CBS Publishers, New Delhi.

Reference books:

1. Jensen, M.L. & Bateman, A.M. 1981. Economic mineral deposits. John Wiley & Sons, New York.
2. L.Robb. 2004. Introduction to Ore-forming Processes. Blackwell Science, UK,384 p.
3. P.K. Banerjee and S.Ghosh 1997. Fundamental principles of prospecting. Allied Publishers.
4. S. Krishnaswami. 1988. Mineral resources of India. Oxford-IBH, New Delhi.

EASC – 312 STRATIGRAPHY AND INDIAN GEOLOGY (Hard Core Course)

Credits: 3

Unit –I : Scope of the subject, its relationship with other disciplines. Principles of stratigraphy. Geological time scale.

Unit –II : An outline of Stratigraphic classification . Correlation , facies and unconformities.

Unit –III : Physiographic divisions of India. Major stratigraphical divisions and their equivalents in India. Brief account of classification, lithology, structures and fossil content of Archaean, Cuddapah and Vindhyan Super Groups.

Unit –IV : An outline of Paleozoic rocks and Gondwana Super group – their classification, lithology, fossils and distribution in India. Brief knowledge on distribution, lithology , fossil content and classification of Triassic, Jurassic and Cretaceous rocks of India.

Unit–V : Short account of Deccan Traps – Intra and Inter trapeans – Origin, composition, distribution. Tertiary and Quaternary rocks of India.

Text books:

1. Lemon,R.R .1990. Principles of stratigraphy.. Merrill Publ. New York
2. Boggs,S.1987. Principles of Sedimentology and Stratigraphy, Merrill, NewYork.

Reference book:

1. Krishnan, M.S. 1982. Geology of India and Burma. CBS publishers, New Delhi

EASC-313 CLIMATOLOGY (Hard Core Course)

2 Credits

i. Atmosphere- Composition, Vertical structure, Air pressure, air density, Temperature and Heat transfer, Atmospheric green house effect. Greenhouse gases and global warming. Atmospheric pollution, ozone depletion.

ii. Earth's radiation balance; latitudinal and seasonal variation of insolation, temperature, pressure, wind belts, humidity, cloud formation, Cloud Classification

iii. Atmospheric stability, Cloud development, condensation nuclei, growth of cloud drops and ice-crystals, precipitation mechanisms: Bergeron, collision-coalescence process – Type of Precipitation, artificial precipitation, hail suppression, fog and cloud-dissipation, radar observation of clouds and precipitation.

iv. Atmospheric circulation- Single cell and three cell model, El Nino Southern Oscillation (ENSO). Air masses- Classification; Fronts- Stationary, cold, Warm and occluded fronts. Koppen's classification of climate.

v. General weather systems of India, - Monsoon system, cyclone and jet stream, Western disturbances and severe local convective systems, distribution of precipitation over India.

Reference books:

1. Edward Agnado, James E. Burt ; Understanding Weather and Climate; Pearson Prentice Hall, 2007.
2. D.S.Lal; Climatology, Sharda Pustak Bhavan, 2003.
3. John E. Oliver, John H.Hidore; Climatology: An Atmospheric Science; Prentice Hall, 2002.
4. C. Donald Ahrens; Essentials of Meteorology: An Introduction to Atmosphere; Cengage Learning, 2008.

EASC-314 GEOLOGY LAB-III (ECONOMIC GEOLOGY) (Hard Core Course)

2 Credits

Study of physical properties of ore minerals, industrial minerals and fossil fuels in hand specimen, and their identification. Study of textures and structures of economic minores in hand specimen.

Preparation of maps of major mining districts of India. Preparation of maps showing occurrence of various mineral deposits in India.

EASC-315 SUMMER INTERNSHIP-I (Soft Core Course)

2 Credits

Intensive training in any laboratory technique relevant to geological studies under the supervision of a faculty member of the Department or Scientist in a reputed national laboratory / academic institution, for 4 to 8 weeks. A report on summer internship must be submitted for evaluation.

EASC-321 GEOHYDROLOGY (Hard Core Course)

2 Credits

(Prerequisite: EASC 111 & EASC 212 or Teachers Consent)

Hydrological cycle, origin of groundwater, subsurface distribution of water, springs, hydrological properties water bearing materials

Mode of occurrence of groundwater, types of aquifers, groundwater provinces of India.

Movement of groundwater and aquifer performance tests, Darcy's law and its range of validity, theories of groundwater flow.

Introduction to surface and subsurface methods of groundwater exploration, physical and chemical characteristics of groundwater, classification of groundwater with respect to domestic, industrial and agricultural use, pollution of groundwater, salt water intrusion in coastal aquifers, the ghyben-herzberg equation.

Groundwater exploration and management, natural and artificial recharge of groundwater, water balance, hydrograph analysis, conjunctive and consumptive use of groundwater.

Text books:

Fetter, C.W. 2001. Applied Hydrogeolgy. Prentice Hall
Todd, D.K. 1980. Groundwater Hydrology. John Willey & Sons
Raghunath, H.M. 1987. Groundwater. Wiley Eastern, Calcutta.
Karanth. Development, Assessment & Management of Water Resources.

EASC-322 INTRODUCTION TO REMOTE SENSING AND GIS (Hard Core Course)
Credits: 2

Unit-1: Basic concepts of remote sensing. - Introduction to Electromagnetic Radiation (EMR) and its relationship to remote sensing in the ultraviolet, visible, infrared, and microwave region; Interaction of EMR with objects and Atmosphere; Spectral signature of common earth objects – water, vegetation, soil etc; Platforms and sensors - Ballons, Aircraft, Satellites- sun synchrounous/ geosynchrounous; Sensors – Active/passive; Imaging/Non imaging; push broom/ wishk broom.

Unit-2: Developments in aerial photography; Geometry and types of aerial photographs – vertical/oblique; Scale of photographs; Types of aerial cameras, films, and filters - Panchromatic, colour and infra-red films; Multiband photography; Tilt and height displacement; Vertical exaggeration; parallax; stereoscopy; Photo Mosaic; Flight planning.

Unit 3: Acquisition and processing of multispectral remote sensing data from satellites; Panchromatic, Multispectral and Hyperspectral remote sensing; Digital representation of satellite Image; concept of grey colour, RGB, natural color and FCC.

Unit 4: Interpretation of aerial photo/satellite images using photo interpretation elements - tone, texture, pattern, size, shadow, and association. Geological applications of remote sensed data.

Unit 5: Fundamentals of Geographical Information System (GIS). Data models – spatial and non spatial data; vector and raster formats; spatial data input and editing, visualization and query of spatial data, overlay analysis; geological application of GIS.

Text books

1. Lillesand, T.M. and Kiefer, R.W. (1987) Remote sensing and Image Interpretation, John Wiley.
2. Avery, T.E. and Berlin, G.L. 1992 Fundamentals of remote sensing and Airphoto intepretation. McMillion Publishing Co., New York.
3. Miller, V.C. & Miller, C.F. (1961). Photogeology. McGraw Hill, New York.
4. Ray, R.G. (1969) Aerial photographs in geologic interpretation. USGS Professional Paper 373.
5. Pandey, S.N. (1987). Principles and applications of photogeology. Wiley Eastern, New Delhi.

Reference books

1. Gupta, R.P. (1991) Remote Sensing Geology. Springer-Verlag.
2. Drury, S.A. 1987. Image interpretation in Geology. Chapman and Hall.

EASC-323 – FIELD TRAINING- I (Hard Core Course)

Credits:3

Introduction to Topographic maps, identifying various topographic features like peaks, hills, valleys etc., and relating them to topographic maps / aerial photographs /satellite imageries. Basics of Global Positioning System (GPS).

Identification of various igneous, metamorphic and sedimentary rocks in the field and Identification of minerals and characterizing the rocks on the basis of mineralogy and texture

Location of contacts between different rock units, lithological mapping on topographic maps / aerial photographs /satellite imageries.

Identifying planar and linear structures in field: - folds, faults, joints, unconformity, lineations and foliations. Use of clinometer compass to measure various structural elements: Measurement of attitude of planar and linear structure: dip, strike, pitch, plunge and trend.

Collection and plotting of structural elements. Field training on reconstruction of surface and subsurface geological units from available exposures. Total duration of the training will be about three weeks in the field.

EASC- 324 - GEOLOGY LAB-IV (REMOTE SENSING, GIS AND GEOHYDROLOGY)

(Hard Core Course)

Credits: 2

Remote Sensing and GIS

Reading peripheral informations on aerial photo. Determination of scale. Stereoscopic view; Height measurement using shadows; parallax measurements; Phtorecognition elements; Visual interpretation of Airphoto and satellite images for geological and geomorphological applications; Introduction to digital image processing and GIS application packages.

Geohydrology

Maps and numerical exercises. Problems on groundwater flow. Graphical representation of Ground water Quality.

Reference books:

1.Lillesand, T.M. and Kiefer, R.W. (1987) Remote sensing and Image Interpretation, John Wiley.
2. Miller, V.C. & Miller, C.F. (1961). Photogeology. McGraw Hill, New York.
3.Ray, R.G. (1969) Aerial photographs in geologic interpretation. USGS Professional Paper 373.
4. Pandey, S.N. (1987). Principles and applications of photogeology. Wiley Eastern, New Delhi.

EASC- 325 PHYSICAL OCEANOGRAPHY (Soft Core Course)

Credits:3

i. Ocean basins- Distribution of land and water, Hypsography of the continents and ocean floor –continental shelf, slope, rise and abyssal plains.

ii. Physical and chemical properties of sea water and their spatial variations. Residence times of elements in sea water. Distribution of temperature and salinity in the Ocean, surface circulation, thermohaline circulation.

iii. Ocean currents, causes of ocean currents and important current systems. Water masses- their formation and characteristics; convergence and upwelling of ocean waters

iv. Formation of subtropical gyres; western boundary currents; equatorial current systems; El Nino; monsoonal winds and currents over the North Indian Ocean; Somali current; Upwelling process in the Arabian Sea.

v. Waves and Tides, transformation of waves in shallow water; effects of stratification; effect of bottom friction, breakers and surf; littoral currents; seiches; tsunami, Sea level changes.

Reference books:

1. George L. Pickard, William J. Emery; Descriptive Physical Oceanography: An Introduction, Elsvier, 1990.
2. M. Grant Gross – Oceanography: A view of the earth, 1987.
3. M. Grant Gross-Prnciples of Oceanography,1995.
4. John A. Knauss, Introduction to Physical Oceanography, Waveland Press,2005.
5. Tom Garrison; Oceanography: An invitation to Marine Science, Cengage Learning,2008
6. M.P.M Reddy; Descriptive physical Oceanography, Taylor and Francis, 2001.
7. J.P.Kennet; Marine geology. Printice Hall Inc., New Jersy, 1982.

EASC-326 ENGINEERING GEOLOGY (Soft Core Course)
Credits: 2

1. Introduction to Role of Geology in civil construction.
2. Stages of Geological site Investigations for selection of site for engineering structures. Desk study. Analysis of Remote sensing data, Geological maps, cross sections and written reports. Subsurface site characterization. Coring, logging,
3. introduction to application of geophysical methods. Emphasis on pre-construction geological analysis to recognize potential hazards and problems.
4. Physical and Mechanical properties of rocks: Concepts of stress, strain, Mohr circle and failure theories. Strength, deformation, hydraulic aspects, geostresses, Weathering and Discontinuities in rock masses.
5. Engineering classification of Rocks. Construction materials

Text books:

1. K.R Karanth, 1989. Hydrogeology, Tata McGraw Hill
2. Bell, F.G. 1983. Fundamentals of engineering geology, Butterworths

Reference books:

1. D.K. Todd, 1980.Groundwater Hydrology, John Wiley and Sons.
2. C.F. Tolman, 1937.Groundwater, McGraw Hill, New York.
3. H.M. Raghunath, 1987Groundwater, Wiley Eastern. Calcutta.
4. Beavis, F.C. 1985. Engineering geology.
5. Krynine, D.P. Judd, W.P. 1957, Principles of Engineering Geology, McGraw Hill,
6. Davis, S.N. & De Wiest, R.J.N. 1966. Hydrogeology. John Wiley & Sons, New York.
7. Krynine, D.P. & Judd, W.R. 1957. Principles of engineering geology and geotechnique. McGraw Hill, New Yprk.
8. Goodman, R.E. 1980. Introduction to rock mechanics.
9. Schuster, R.L. & Krizek, R.J. 1978. Landslide analysis and control. National Academy of Science, Washington DC.

EASC-327 ENVIRONMENTAL GEOSCIENCE (Soft Core Course)

Credits: 3

(Pre requisite: EASC 111 or Teacher's consent.)

INTRODUCTION: Earth, man and environment: Environmental Geosciences-fundamental concepts. Basic environmental problems. Geoscience factors in environmental planning.

THE EARTH SYSTEMS AND BIOSPHERE: Conservation of matter in various geospheres - lithosphere, hydrosphere, atmosphere and biosphere. Concepts of ecology / Ecosystems. Biogeographical zonations of earth. The earth's major ecosystems-terrestrial and aquatic.

EARTH'S PROCESSES AND GEOLOGICAL HAZARDS: Earth's processes; Concept of residence time and rates of natural cycles. Catastophic geological hazards. Study of floods, landslides, earthquakes, volcanism and avalanche, with a view to assess the magnitude of the problem, prediction and perception of the hazards.

MINERAL AND ENERGY RESOURCES AND ENVIRONMENT: Resource and Reserves. Environmental impact of exploitation, processing and smelting of minerals. Environmental effects associated with each types of energy resource, viz. petroleum, natural gas, hydropower, nuclear, coal, solar and wind energy.

WATER RESOURCE AND ENVIRONMENT: Global Water Balance. Ice Sheets and fluctuations of sea levels. Origin and composition of sea water. Resources of oceans. Ocean pollution by toxic wastes. Human Use of Surface and Ground Waters. Ground Water Pollution.

WASTE DISPOSAL: Solid waste disposal – application of geology in planning and location of land fills. Radioactive waste management.

ENVIRONMENTAL HEALTH AND LAW: Biogeochemical factors in environmental health. Human use, trace elements and health. Possible effects of imbalance of some trace elements. Diseases induced by human use of land. Environmental legislations in India.

Text Books

Keller, E.A., 2010. Environmental Geology: CBS Publisher, New Delhi.
Valdiya, K.S., 2005 Geology Environment and Society. Universities Press, **ISBN-13:** 978-8173715051
Bryant, E, 2008. Natural Hazard. Camb. Univ. Press.

EASC-411- CRYSTALLOGRAPHY AND CRYSTAL CHEMISTRY
(Hard Core Course)

Credits: 2

UNIT 1

Geometric and algebric approaches to crystallography, Derivation and determination of point groups. Crystal forms. Space lattice and unit cell. Concept of space group. Stereographic projections.

UNIT 2

X-ray crystallography. Laue's and Braggs equations. X-ray diffractometer and powder method of mineral identification.

UNIT 3

Types of bonding in minerals. Chemical composition and unit cell content. Crystal structures and defects.

UNIT 4

Solid solution and polymorphism. Isomorphism. Crystallization process in different environments. Chemical classification of minerals.

UNIT 5

Crystal structures of silicates and other rock forming minerals. Chemical analyses of minerals.

Text books:

1. F. D. Bloss, (1971), Crystallogrphy and Crystal Chemistry, Holt, Rinehart, Winston, New York.
2. W. D. Nesse, (2000), Introduction to Mineralogy, Oxford University Press, ISBN 0-19-510691-1
3. Crystallography: An Introduction for Earth Science and other solid state students. Published by Pergamon Press, 1981.
4. Fundamentals of Crystallography (International Union of Crystallography Book Series, No. 2). Edited by C. Giacovazzo. Published by Oxford University Press.
5. The Basics of Crystallography and Diffraction (International Union of Crystallography Book Series). by Christopher Hammond Published by Oxford University Press. 3rd Edition 2009.

EASC-412 ROCK FORMING MINERALS (Hard Core Course)

Credits: 2

(Pre requisite: EASC 211 – Crystallography and Mineralogy or Teacher's consent.)

Unit I
Introduction. Structural and crystal chemical classification of minerals. Classification of silicate minerals.

Unit II
Ortho and Chain Silicates

Unit III
Sheet Silicates and Framework silicates

Unit IV
Oxides. Carbonates

Unit V
Phosphates, Sulphates, Sulfides and other mineral groups.

Text book:

1. Deer, W. A. , Howie, R. A. and Zussman, J., An introduction to the rock forming minerals, ELBS publication, 2nd Ed. 2005, 696 pp.

Reference books:

1. Deer, W. A., Howie, R. A. and Zussman, J., Rock forming minerals, volumes I to VII.
2. Mineralogical Society of America volumes on individual mineral groups

EASC-413 DEORMATION AND ROCK STRUCTURES (Hard Core Course)

Credits:3

Unit I: Structural elements in rocks, Concept of stress, State of stress, Mohr circle and failure criterion, Concept of Strain, Homogeneous deformation and concept of strain ellipsoid (ellipse), Types of strain ellipsoids, Stress-strain relation and rheological equations; Rheological equations and deformation behaviors, Factors controlling rock deformation, Flow laws and crystal defects, Deformation mechanism and Microstructures,

UNIT II: Fold: Concept and structural elements of fold, Classification of fold, Concept of fold interference, Types Superposed folds and characteristic outcrop patterns, Kinematics of superposed folding. **Foliation:** Concept and types of foliation, Mechanism, Cleavage in relation to fold. **Lineation:** Concept and types of lineation, usefulness of lineation, Lineation in relation to fold.

Unit III: Fault: Concept and structural element of Fault, Separation and net slip, Classification of fault, Recognition criteria, Anderson's model of faulting, Structures associated with normal fault, strike-slip fault and thrust fault. **Joint:** Concept and structural elements of Joint, Joint surface feature, Joint associated with fold and fault, Kinematics of jointing, Joints in relation to tectonic cycle. **Boudinage:** Concept and structural elements of boudinage,

UNIT IV: Heterogeneous deformation and concept of shear zone, Types of shear zone, Pattern and structure of ductile shear zone – R, P and D shears; C-S structure, Shear zone rocks, Shear sense indicators, Measurement of shear strain.

UNIT V: Concept of Unconformity, Types of unconformity, Recognition criteria of unconformity, Basement cover relationship. Deformation history and structural analysis in rock – Indian examples.

Text books:

1. Ghosh, S.K. 1993. Structural Geology: Fundamentals and modern developments.
2. Paschier C.W & Toruw, R.A.J . Micro-tectonics, Springer
3. Marshak, S and Mitra, G. Basic Methods of Structural Geology

Reference books:

1. Ramsay, J.G. & Huber, M.I. 1983. The Techniques of modern structural geology. V.1 & V2
2. Park, R.G. Foundations of structural geology.
3. Price, N.J. & Cosgrove, J.W. 1990. Analysis of Geological structures. Cambridge University Press.
4. Davis, G.H. 1984. Structural Geology of Rocks and Regions.
5. Suppe, J. 1985 Principles of structural geology. Printice-Hall.

EASC-414 GEOCHEMISTRY (Hard Core Course)

Credits: 3

Unit I Stellar evolution and origin of elements. Different processes of nucleosynthesis. Origin of the solar system and distribution of elements with respect to distance from the Sun. Abundances of elements, Oddo-Harkin Law. Meteorites. Geochemical and Cosmochemical classification of elements and their basis. Differentiation of the Earth and resultant elements distribution in core, mantle, crust.

Unit-II Laws of thermodynamics. Equations of State. Standard states. Enthalpy, entropy, heat capacity, changes in enthalpy and entropy with P and T, Gibbs free energy and equilibrium. Clapeyron equation. Simple thermodynamic calculations involving phase changes and equilibrium reactions.

Unit III Nuclides and atoms. Electronic configuration of atoms, arrangement of atoms in periodic table, electronegativity, ionization potential, chemical bonding. Properties of elements (volatiles, semi-volatiles, alkalis, alkaline earths, REE, HFS), Transition metals and noble metals.Silicate structures: Silicate polymers, cation sites in silicates, calculation of site occupancy, cation substitution, concept of distribution coefficients.

Unit IV Chemical weathering, soil formation, geochemistry of clays. Fundamentals of low-temperature aqueous geochemistry: ionic concentration, Molarity and molality, solubility and solubility product, acids and bases, dissociation constant. pH and oxidation and reduction processes: Eh-pH diagrams. Carbonate Equilibria**:** CO_2-H_2O interaction to form carbonic acid, dissolution of calcite. Introduction to chemical evolution of hydrosphere.

Unit-V **Isotopes:** Stability of nuclides. Radioactive decay schemes. Decay constant, half life, parent-daughter relations. Rb-Sr and Sm-Nd systematics and their use in geochemistry. Stable isotopes: processes of isotope fractionation, δ-notation for C and O isotopes. O isotopes: fractionation in the hydrologic cycle.

Text books:

1. H. Y. McSween, S. M. Richardson and M. E. Uhle : Geochemistry: Pathways and Processes. Second ed., 2004, Columbia University Press.
2. Robin Gill : 1988, Chemical Fundamentals of Geology. Chapman and Hall.
3. Brian Mason : 1982, Principles of Geochemistry. J. Wiley & Sons.
4. K. B. Krauskopf : 1979, Introduction to Geochemistry. McGraw Hill.

Reference books:

W. M. White : Geochemistry. Retrievable from http://www.geo.cornell.edu/geology/classes/geo455.

D. K. Nordstrom and J. L. Munoz : 2006, Geochemical Thermodynamics. Blackwell Scientific Publications. Gunter Faure: (1986, 2004)

EASC-415 – ADVANCED GEOMORPHOLOGY (Hard Core Course)

Credits:2

Geomorphic principles. Theory of Uniformaitarianism. Influence of structure, process, time, and climate on landforms. Energy flow in geomorphic systems.

Tectonic and Volcanic processes and landforms. Cenozoic diastrophism - orogeny and epierogeny. Landforms made by folding and faulting (tectonic scarps, fault valley and block mountains). Volcanic activity – distribution and landforms.

Fluvial Geomorphology. Rock weathering and soil formation. Soil types and soil profile. Karst processes and landforms. Mass wasting and hillslope evolution. Hydrological cycle. Drainage basins and networks. River and channel geometry. Sediment erosion and transportation mechanisms.
Concept of grade and base level of erosion. Fluvial deposition and landforms (alluvia fans, floodplains, and deltas). River terraces. Lakes – types and origins. Structural control on fluvial erosion. Landform evolution by fluvial processes.

Climatic Morphogenesis. Geomorphic processes in dry climates. Wind erosion and deposition. Landforms of arid, semi-arid, and savanna regions.
Perigacial and glacial morphogenesis. Mechanisms of erosion and transportation by moving ice. Continental and alpine glaciation. Glacial landforms. Permafrost and periglacial landforms.

Coastal and Marine Geomorphology. Shore zone processes and landforms. Classification of coasts. Sea level fluctuations. Submarine processes and landforms.

Applied Geomorphology. Application of geomorphogical knowledge in groundwater investigations, mineral exploration (placer deposits, residual deposits, oxidized zones), and engineering (construction materials, highway and railway routes)
Geomorphic provinces of India - Himalayas, Indo-Gangetic Plains, Peninsular region.

Text Books:

R.J. Huggest (2007) Fundamentals of Geomorphology. Routledge Publishers
A.S. Goudie (2004), Encyclopedia of Geomorphology (Vol. 1&2). Routledge Publishers.
D.W. Burbank & R.S. Anderson (2001), Tectonic Geomorphology, Blackwell Science Publishers.
A.L. Bloom (1992) Geomorphology – A systematic analysis of ate Cenozoic landforms. PHI, New Delhi.
M.A. Summerfield (1991), Global Geomorphology, Pearson Education Ltd.
W.D. Thornbury (1969) Principles of Geomorphology. Willey Eastern Ltd. New Delhi.
H.S. Sharma (1990) Indian Geomorphology. Concept Pub. Co., New Delhi.

EASC-416 ADVANCED GEOLOGY LAB – I (Hard Core course)

Credits: 4

Part 1: Crystallography (1 credit)

Crystallography and Mineralogy (1 credit)

Study of symmetry in models (quartz, tourmaline, barite, gypsum, augite, hornblende), Study of symmetry and forms in the models (Fluorite, garnet, pyrite, tetrahedrite, galena, zircon, beryl, calcite, olivine, orthoclase, albite)

Part 1: Mineralogy (1 credit)

Identification of minerals in hand specimen. Study of optical properties of minerals in transmitted light and their identification in thin section. Identification of minerals from X-ray diffractogram. Indexing and calculation of cell parameters of minerals in isometric, tetragonal and orthorhombic systems. Calculation of chemical formula of minerals from analytical data.

Part 2: Structural Geology (1 credit)

Interpretation of geological maps and drawing sections. Fold analysis by dip isogon method. Strain analysis from deformed objects. Structural problems concerning mineral deposits. Elementary structural analysis by stereographic methods.

Part 3: Geochemistry (1 credit)

Introduction to methods of sampling in field, and sample preparation. Lab protocols and safety. Understanding of basic principles of geochemical methods for the analysis of rocks, soils, and aqueous fluids. Hands on training of solution preparation for analysis. Introduction to key aspects of data presentation, analysis and interpretation. Principles and hands-on application of the major analytical tools necessary to characterize the geochemistry of natural systems including: Spectrophotometer, Flame photometer, AAS and ICP-AES.

Reference books:

Ehlers E.G. (1987) **Optical Mineralogy: Theory and Techniques,** Blackwell Scientific Publications, 158 p. New York, John Wiley & Sons, Inc., 192p.

Klein, C, Hurlbut, C.S., and Dana, J.D. 1998, **Manual of Mineralogy (after James D. Dana), 21st Edition,** John Wiley & Sons Inc.

Mackenzie, W.S. & Adams, 1994, A.E. **Color Atlas of Rock and Minerals in Thin Section,** John Wiley & Sons

EASC-417 SUMMER INTERNSHIP-II (Soft Core course)

Credits: 3

Intensive training in advanced field or laboratory technique relevant to geological studies under the supervision of a faculty member of the Department or Scientist in a reputed national laboratory / academic institution, for 4 to 8 weeks. A report on summer internship must be submitted for evaluation.

EASC-418 STABLE ISOTOPE GEOCHEMISTRY (Soft core Course)
Credits:2

Unit I: Introduction to stable isotope geochemistry, terminology used in stable isotope studies, principles of stable isotope mass spectrometry and various standards used in the mass spectrometric measurements.

Unit II: Isotopic fractionation: Equilibrium, kinetic and mass-independent.

Unit III: Chemical and biological separation of isotopes during various earth system processes.

Unit IV: Uses of isotopes of hydrogen, oxygen, carbon, sulfur and 'Non-traditional' isotopes in earth system processes. Applications of isotopes in climate, hydrologic/hydrogeologic and biogeochemical studies.

Unit V: Application of isotopes in hydrothermal, igneous and metamorphic systems. Stable isotopes in deciphering physico-chemical environment of ore and petroleum formation.

Text Books

Faure G., 1986. Principles of Isotope Geology, 2nd edition, J. Wiley & Sons, 608 p.
Clark, I., and Fritz, P., 1997. Environmental Isotopes in Hydrogeology, Lewis Publishers, Boca Raton, 328 p.
Hoefs, J., 1997. Stable Isotope Geochemistry, 4th edition, Springer-Verlag, Berlin, 285 p.
Faure, G., and Mensing, T., M., 2004. Isotopes: Principles and Applications, 3rd edition, J. Wiley & Sons, 928 p.
White, W., M.,. Geochemistry, an On-line Textbook, available at http://www.geo.cornell.edu/geology/classes/geo455/Chapters.HTML, 15 Chapters.

Reference Books

Valley, J., W., Taylor, Jr. H., P., and O'Neil, J., R., Ed., 1986. Stable Isotopes in High Temperature Geological Processes, Volume 16, Reviews in Mineralogy, Mineralogical Society of America and The Geochemical Society, 570 p.
Valley, J., W., and Cole, D., Ed., 2001. Stable Isotope Geochemistry, Volume 43, Reviews in Mineralogy and Geochemistry, Mineralogical Society of America and The Geochemical Society, 531 p.
Turekian, K., K., and Holland, H., D., Ed., 2003. Treatise of geochemistry: Chapters 4.06 to 4.09 (p.159-260) in Volume 4, The Atmosphere; Chapter 5.11 (p.320-364) in Volume 5, Surface and Ground water, Weathering and Soils; Chapter 6.11 (p.366-390) in Volume 6, The Oceans and Marine Geochemistry.
Johnson, C., M., Beard, B., L., and Albarede, F., Ed., 2004. Geochemistry of Non-Traditional Stable Isotopes, Volume 55, Reviews in Mineralogy and Geochemistry, Mineralogical Society of America and The Geochemical Society, 454 p.

EASC-419 STATISTICS IN GEOSCIENCES (Soft core Course)

Credits: 3

Introduction to organization and description of data: mean, median, mode, variance, standard deviation, quartile, percentile and covariance of data. Introduction to probability, discrete and continuous probability distributions. Introduction to statistical inference sampling distributions, point and interval estimation, hypothesis testing involving one and two univariate populations. Linear models for analysis of variance. Regression. Error propagation. Introduction to multivariate techniques.

Text Books

Harry Frank and Steven C. Althoen "Statistics concepts and applications" Cambridge University Press (1994)

Pitman, J. Probability, Springer-Verlag, (also Narosa Publ.), 1993. Creighton, J.H.C. First Course in Probability Models and Statistical Inference, Springer- Verlag, Berlin, 1994. Davis, J.C. Statistics and Data Analysis in Geology, John Wiley & Sons, New York, 1986.

Walpole, R.E. and Myers, R.H. Probability and Statistics for Engineers and Scientists, Macmillan, 1989.

Johnson, R.A. and Wichern, D.W. Applied Multivariate Statistical Analysis, Prentice Hall, New Jersey, 1982.

Cooley, W.W. and Lohnes, P.R. Multivariate Data Analysis, John Wiley & Sons, New York, 1971.

Morrison, D.F. Multivariate Statistical Methods, McGraw-Hill, New York,1967. Spiegel, M.R. Probability and Statistics, Schaums Outline Series, McGraw-Hill Intl., Singapore.

EASC-420 COMPUTER APPLICATIONS IN EARTH SCIENCES (Soft Core Course)
Credits: 3

Introduction to computers: PC configuration, CPU, I/O, memory, networking and peripheral devices. Operating system, BIOS, drivers and application software.

DOS platform: Boot sequence, system files, internal and external commands, file structure and commands. Brief exposure to DOS programs and utilities for geoscience applications.

Windows platform: Sharing of memory, time, program and data, features of graphical user interface, configuring desktop environment, installing and running applications. Working with spread sheet, presentation graphics, database and imaging software for geoscience applications. Image formats and compression techniques. Data compression and anti-virus programs. Network environment, LAN and internet protocols, internet resources in geosciences. Brief exposure to HTML and web publishing.

Linux platform: Common Linux features, file structure and commands, security features. Working with Red Hat Linux, text mode and desk top environments, installing and running geoscience applications.

Text books:

Crumlish (2000) The internet. 2nd Edition. BPB Publishers, New Delhi.
David Nash (2001) Linux in easy steps. IDG Books, New Delhi.
Nathan Wallace (2000) Windows 2000 in easy steps. IDG Books, New Delhi.
PC complete. 2nd Edition. BPB Publishers, New Delhi. (2000)
Peter Ingram (2000) Networking in easy steps. Dreamtech Press, New Delhi.
Stultz (1996) Illustrated MS-DOS 6.22. BPB Publishers, New Delhi.

EASC-421 IGNEOUS PETROLOGY (Hard Core Course)

Credits: 2

UNIT 1

Generation of magma, their nature, cooling behaviour and properties.

UNIT 2

Laws of thermodynamics. Gibbs free energy. Concept of activity, fugacity, ideal and non-ideal solutions. Phase rule.

UNIT 3

Classification of igneous rocks. Definition, geochemistry, phase equilibria studies and paragenesis of important magmatic systems.

UNIT 4

Tectonic settings and igneous rock associations. Geochemical and thermodynamical modeling of partial melting and magmatic processes. Role of Isotopes in studying the igneous rocks.

Text books:

1. Philpots A.R., Principles of Igneous and metamorphic petrology**,** Prentice Hall.

2. McBirney, A.R. Igneous Petrology, CBS Publishers and Distributors.

3. Cox, K.G. Bell, J.D. and Pankhurst, R.J. Interpretation of igneous rocks. George Allen Unwin.

4. Winter, J. D. An introduction to igneous and metamorphic petrology. Printice Hall.

5. Marjorie Wilson. Igneous petrogenesis: A global tectonic approach. Published by Chapman & Hall

6. Davis A. Young. Mind over Magma: The story of Igneous Petrology. Princeton University Press.

EASC-422 STRATIGRAPHY (Hard Core Course)

Credits: 2

Stratigraphic principles and practices. Classification and codeof stratigraphic nomenclatures. Sratification and sratigraphic column.

Lateral variation and facies. Graphic representation of sratigraphic data.

World stratigraphy: Brief description of the principal, stratigraphic units of the world in type areas. Paleogeographic reconstruction.

Indian stratigraphy: Physiographic subdivisions, structures and tectonic history of the Indian subcontinent. Study of the various geological formations of Precambrian, Paleozoic, Mesozoic, Tertiary and Quaternary Eras: distribution, geological succession, classification, correlation, paleogeography and life of each periods.

Gondwana Super Group - Distribution, succession, classification, flora and fauna, lower and upper age limit, structure of Gondwana basin, climate and paleogeography. Deccan Traps and associated sedimentary formations. Age of Deccan traps. Himalayan orogeny. Glacial and interglacial deposits.

Boundary problem of Precambrian - Cambrian; Permo-Triassic; Mesozoic - Tertiary.

Text books:

M.S.Krishnan 1982. Geology of India and Burma. CBS Publ. & Distributors, New Delhi.
C.O. Dunbar & J. Rodgers 1957 Principles of stratigraphy. John Wiley and Sons, New York.
Ramakrishnan, M. and Vaidyanathan, R. 2000. Geology of India. Geological Society of India, Bangalore.
Ravindra Kumar 1978. Historical Geology and Stratigraphy of India.

EASC-423 METAMORPHIC PETROLOGY (Hard Core Course)

Credits: 2

Unit 1: Agent of metamorphism, Types of metamorphism, Nature of protolith

Unit 2: Nature of metamorphic reactions, Mineral equilibria and Phase rule, Chemographic projections.

Unit 3: Concept of metamorphic facies and facies series, Progressive metamorphism of rock of varied compositions, Heat flow and geothermal gradient.

Unit 4: Geothermobarometry, P-T-t paths and pate tectonic overview.

Text books:

1. Winter, J.D. (2001/7): An introduction to Igneous and Metamorphic Petrology, Prentice Hall.
2. Bucher, K. and Martin, F. (2002): Petrogenesis of Metamorphic Rocks (7Rev. Ed.), Springer–Verlag
3. Yardley, B.W.D. 1989. An introduction of Metamorphic Petrology, Longman Scientific and Technical, NewYork.

Reference books:

1. Spear, F. S. (1993): Mineralogical Phase Equilibria and pressure – temperature – time Paths, MineralogicalSociety of America.
2. Philpotts, A.R. 1990. Principles of Igneous and Metamorphic Petrology. Prentice Hall.
3. Yardley, B.W.D., Mackenzie, W.S. and Guilford, C. (1995): Atlas of Metamorphic Rocks and their textures, Longman Scientific and Technical, England.

Journal Reference:

1. Journal of Metamorphic Geology, Elsevier.
2. Journal of Petrology, Springer-Verlag

EASC-424 VERTEBRATE AND INVERTEBRATE PALEONTOLOGY
(Hard Core Course)

Credits: 2

Invertebrate Paleontology:

An overview. Morphology, classification, evolutionary trend, composition and structure of shells of selected groups of organisms - A brief study of morphology, geological history and geographical distribution of Brachiopoda, Pelecypoda, Cephalopoda, Gastropoda, Echinoidea, Trilobita, Coelenterata and Graptoloidea.

Vertebrate Palaeontology:

Introduction, Brief study of vertebrate life through ages. General evolution of reptiles and mammals. Indian pre-Tertiary vertebrate - their distribution and paleogeographic implication; extinction of dinosaurs. Indian Tertiary vertebrate - Siwalik mammals; phylogeny - Equidae & Proboscidae. Indian fossil Hominoides and modern theories regarding human evolution.

References books:

Benton, M.J., "Vertebrate Paleontology", Chapman & Hall 1997

Moore, R.C., Lalicker, C.G. and Fisher, A.G.: Invertebrate Fossils. McGraw Hill

Shrock,R.R and Twenhofel,W.H. 1987. Principles of Invertebrate Paleontology. McGraw Hill, New York.

Walton, J., "An Introduction to the Study of Fossil Plants", Adam & Charles Black 1953

Clarkson,E.N.1993.Invertebrate Paleontology and Evolution, Chapman Hall India,Madras

Woods, H., "Paleontology Invertebrate", CBS Publications 1963

EASC-425 ADVANCED GEOLOGY LAB II (Hard Core course)

Credits: 3

Part 1: Igneous & Metamorphic Petrology (2 credits)

Study of igneous rocks and metamorphic rocks of different facies mineral assemblage, texture and structure) in hand specimen and in thin sections. Calculations of CIPW norms of igneous rocks. Plotting chemical data in various diagrams and trace element modeling to infer petrogenetic conditions. Graphic representation of metamorphic mineral assemblage in ACF and AFM diagrams.

Part 2: Paleontology (1 credit)

Megascopic study of major invertebrate fossils:Gastropoda, Pelecypoda, Cephalopoda, Brachipoda, Echinoids, Corals, Trilobita, Plant fossils etc.
Methods of Separation of fossils from sediments/sedimentary rocks.
Study of some important microfossils under binocular microscope.

EASC-426 ADVANCED FIELD TRAINING –I (Hard Core Course)

Credits: 3

Geological field training in lithological and structural mapping in sedimentary, igneous and metamorphic terrains. Study of igneous, metamorphic and sedimentary rocks and fossil occurrences in the field. Total duration of the training will be about three weeks in the field.

EASC-427 ISOTOPE GEOLOGY (Soft Core Course)

Credits: **2**

Discovery of radioactivity, stable and radiogenic isotopes. Literature on isotope geology.

Nuclear structure, atomic weights, nuclear stability and abundance.

Theory and mechanism of decay, particles emitted, positron, negatron and alpha decay, effect of mineral/crystal structures, growth and retaintion of daughter isotopes in earth systems.

Abundances of unstable nuclides in earth, core, mantle, crust, oceans and different rock types; their decay schemes, radioactive elements as major elements, minor elements and trace elements and their geochemical behaviour.

Mass spectrometer: Instrumentation, chemical separation, isotope dilution and ratio analysis.

Methods of dating: Isochron method, model/mineral ages, Fission track, 40Ar-39Ar, U and Th disequilibrium, choncordia method, 14C, Be and Al. Interpretation and geological significance of ages.

Isotope systematics of K-Ar, Rb-Sr, Sm-Nd, U-Th-Pb in igneous, metamorphic and sedimentary rocks and in evolution of ocean, crust and mantle.

Stable isotopes of oxygen and hydrogen, carbon, nitrogen and sulphur. Fractionation of stable isotopes in lithosphere, hydrosphere and atmosphere. Stable isotope geothrermometry and geobarometry.

Isotopes in mineral exploration, petroleum exploration, paleo-climate evaluation, health and environmental aspects.

Text books:

Faure, G. (1986). Principles of Isotope Geology. John Wiley, 589p.
Doe, B.R. (1970) Lead isotopes. Springer Verlag, 137p.
Faure, G. and Powell, J.L. (1972) Strontium Isotope Geology. Springer Verlag, 188p.

EASC-428 RADIOGENIC ISOTOPE GEOLOGY (Soft Core Course)
Credits: 2

UNIT 1

Scope of radiogenic isotope geology. Discovery of radioactivity and historical development of the subject. Nuclear structure, atomic weights, nuclear stability and abundance.

UNIT 2

Theory and mechanism of decay, particles emitted, growth and retention of daughter isotopes in earth systems. Mass spectrometery and laboratory methods.

UNIT 3

Geochronology. Methods of dating. Radio Isotope systematic- K-Ar, ^{40}Ar-^{39}Ar, Rb-Sr, Sm-Nd, Lu-Hf, Re-Os, U-Th-Pb and others.

UNIT 4

Cosmogenic radio-nuclides. Short-lived and extinct radio-nuclides.

UNIT 5

Radioactive and radiogenic elements as major , minor and trace elements and their geochemical behaviour. Applications of radio-isotope systematic in geochemistry and petrogenesis of Igneous, Metamorphic and Seimentary Rocks and applications in surface-processes.

Text books:

Dickins, Radiogenic Isotope Geology
Allegre (2008), Isotope Geology
Faure, G. (1986). Principles of Isotope Geology. John Wiley, 589p.
Doe, B.R. (1970) Lead isotopes. Springer Verlag, 137p.
Faure, G. and Powell, J.L. (1972) Strontium Isotope Geology.Springer Verlag, 188p.

EASC-429 MARINE GEOLOGY (Soft Core Course)

Credits: 2

Origin of seas and oceans. Ocean morphology, oceanic crust and ocean margin; sea bottom topography - continental margin, shelf, slope, submarine canyon; ocean basin floor; abyssal hills, plains and gaps; mid-oceanic rise; mid-oceanic ridges-origin, crust and flank province.

Ocean circulation: turbidity current, submarine and sedimentation processes. Oceanic sediments and microfossils. marine stratigraphy, correlation and chronology. Tectonic history of oceans. Mineral resources of the oceans.

Historical development of oceanography. Methods of measuring the properties of sea. Deep sea record. Sea level processes and sea level changes. Major oceanographic events in the Cenozic.

Text books:

J.P.Kennet (1982) Marine geology. Printice Hall Inc., New Jersy, 813p.
E. Seibold & W.H.Berger (1982) The sea floor. Springer-Verlag, Berlin.
J.Weisberg & H. Parish (1974). Introductory Oceanograpghy. McGraw Hill.
B.W.Pipkin, D.S.Gorslin, R.E.Casey & D.E. Hammord (1972). Laboratory exercises in oceanography. W.H.Freeman & Co., San Francisco, 255p.

EASC-430 QUATERNARY GEOLOGY (Soft core course)

Credits: 2

Quaternary Geology - an overview. Quaternary environments. Quaternary stratigraphy, lithology, genesis of quaternary deposits, fauna and flora, paleogeography and economic importance of Quaternary resources.

Major climatic changes during Quaternary period - Ice age, Pleis-tocene climate. Quaternary sea level changes and coastal geo-morphology. Atmospheric composition, ocean circulation and biological processes during Quaternary.

Quaternary fluvial, eolian and glacial systems. Paleoenvironments of Quaternary period in India. Evolution of Quaternary land forms in India. Study of lake deposits and laterites of India.

Text books:

Holmes, A. : Principles of Physical Geology, ELBS, U.K.
Bird, E.C.F: Coastline changes. John Wiley & Sons, New York.
Stowe, K. : Exploring Ocean Science: John Wiley, New York.
Bloom, A.L.: Geomorphology - A Systematic Analysis of Late Cenozoic Landforms. Prentice-Hall, New Delhi.
Wadia et al : Quaternary environments and geoarchaeology of India. Geol. Soc. India, Bangalore.
Thornbury, W.D. :Principles of Geomorphology, Wiley Eastern, New Delhi.
Vaidyanathan, R. (ed) : Quaternary Deltas of India: Geol. Soc. India, Bangalore.
Davis R.A. (ed) Coastal sedimentary environments. Springer Verlag, New York.
Ahmad, E. : Coastal Geomorphology of India. Orient Longman, New Delhi.
Leeder, M.R. : Sedimentary process and product: George Allen & Unwin, London.

EASC-511 GEOLOGY OF MINERAL DEPOSITS (Hard Core Course)

Credits: 4

Mineral deposits, morphology of ore bodies. Lithological and geochemical characteristics of mineral deposits. Spatial and temporal distribution of mineral deposits. Metallogenetic epochs and provinces. Role of plate tectonics in ore formation.

Ore forming processes. Source of ore constituents and ore fluids. Magmatic, metamorphic, hydrothermal, sedimentary and related processes. Deposits types and classification of mineral deposits.

Understanding ore genesis. Structure and texture of ores, ore mineral paragenesis. Fluid inclusion studies of ore mineral assemblages. Stable isotope geochemistry of ore mineral assemblages.

Geology of mineral deposits associated with (i) Ultramafic-mafic-intermediate-acidic igneous rocks, (ii) Low grade and high grade metamorphic rocks, (iii) Sedimentary and volcano-sedimentary sequences, (iv) Weathering surfaces, (v) Placers.

Geological characteristics and genesis of important metallic and non-metallic deposits in India, occurring in Aravalli, Dharwar, Singhbhum, Bastar cratons; southern granulite terrain, eastern ghats granulite terrain; Proterozoic and Phanerozoic sedimentary basins; and in Himalaya.

Text books:

Barnes, H.L. (Ed.). 1997. Geochemistry of hydrothermal ore deposits. John Wiley & Sons.
Craig, J.R. & Vaughan, 1994. Ore microscopy and ore petrography. John Wiley & Sons.
Evans, A.M. 1992. Ore geology and industrial minerals. 3rd edition. Blackwell Science.
Jensen, M.L. & Bateman, A.M. 1981. Economic mineral deposits. John Wiley & Sons.
Misra, K.C. 1999. Understanding mineral deposits. Kluwer Academic Publishers.
Mookherjee, A. 1998. Ore genesis – a holistic approach. Allied Publishers.
Sarkar, S.C. and Gupta, A. 2011. Crustal evolution and metallogeny in India. Cambrisdge University Press, Delhi.
Stanton, R.L. 1981. Ore Petrology. McGraw Hill.

EASC-512 SEDIMENTOLOGY (Hard Core Course)

Credits: 2

Sedimentary processes: weathering, sediment transport by fluids. Simple fluid flow concept.

Textures of clastic and non-clastic rocks. Sedimentary structures: classification, genesis and significance. Use of structures and textures in basin studies.

Sedimentary environment: physical and chemical properties of depositional environment and its classification. Lithologies, structures and vertical sequences formed in fluvial, deltaic, coastal, deep sea, glacial, aeolian and carbonate depositional environments.

Provinance: light minerals, heavy minerals and insoluble residue in provinance studies and correlation of sedimentary rocks.

Diagenesis: compaction, cementation, chemical alteration and recrystalisation.Sedimentation and Tectonics: tectonic control of sedimentation. Geosynclines and their lithological associations. Plate tectonics in relation to type and evolution of basins.

Clay Minerals: classification, techniques of identification, diagenesis and use in environmental inerpretation.

Text books:

F.J. Pettijohn (1975) Sedimentary rocks. Harper and Row Publ., New Delhi.
Blatt, Middleton & Murray (1980) Origin of sedimentary rocks. Printice Hall Inc.
J.D. Collins and D.B. Thompson (1982) Sedimentary Structures. George Allen & Unwin, London.
M.E. Tucker (1981) Sedimentary Petrology: an introduction. John Willey & Sons, New York.

EASC-513 SOLID EARTH GEOPHYSICS (Hard Core Course)

Credits: 2

Introduction

Introduction to Geophysics, Various Geophysical methods-dependant physical properties, applications, Planning of Geophysical Survey.

Seismology

Earthquakes. Observational seismology, Seismic waves. Seismological instruments and observatories. Travel time curves. Crust, mantle and Core. Phase transition inside the Earth. Internal distribution of density and other physical parameters. magnitude and intensity scales, Energy of earthquakes. World-wide distribution of earthquakes. Earthquake prediction.

Gravity Method

Gravitational field of the Earth; Spheroid and Geoid; Densities of rocks; Gravity units; Measurement of Gravity, Corrections to gravity Observations ; Anomalies of Gravity field- Free air , Bouguer and Isostatic anomaly; Models of Isostasy, Isostatic compensation and vertical crustal movements.

Magnetic Method

Principles of magnetic method, The Earth's magnetic Field; Geomagnetic elements; Magnetic properties of rocks- Induced and remnant, Magnetic surveying, Data reduction procedure- diurnal correction, IGRF; Paleomagnetism and Geomagnetic polarity transitions.

Geothermics

Thermal history of the earth. Temperature inside the earth. Heat transfer-conduction, convection, radiation; Thermal structures of the continental and oceanic lithosphere. Heat flow measurements. Regions of anomalous heat flow. Hot spots. Relationship of heat flow to radioactivity of the Earth.

Reference books:

1. Fowler, C.M.R. (1990) The solid earth: An introduction to Global Geophysics.
2. William Lowrie (1997). Fundamentals of Geophysics
3. John. M. Reynolds (1997). An Introduction to Applied and Environmental Geophysics
4. Alan E. Mussett and M. Aftab Khan (2000). Looking into the Earth
5. Robert J. Lillie (1999). Whole earth Geophysics
6. Philip Kearey, Michael Brooks, Ian Hill (2003). An introduction to Geophyical exploration
7. Bullen and Bolt. Introduction to the theory of Seismology.
8. Bath, M. Introduction to Seismology.
9. McElhiry. Paleomagnetism and Plate Tectonics.
10. Verma, R.K. Gravity field, Siesmicity and Tectonics of Indian Peninsula and the Himalayas.

EASC-514 MICROPALEONTOLOGY (Hard core course)

Credits: 2

Definition and Scope : Fossils and their preservation. Principles of taxonomic classification and nomenclature. Organic evolution and fossil record. Principles of paleoecology, biostratigraphy and paleogeography.

Micropaleontology : Sampling methods and sample processing techniques. Types of microfossils. Calcareous Microfossils - Foraminifera - major morphologic groups; Benthic Foraminifera; depth biotopes, value in paleobathymetric determination. Larger foraminifera - their utility in Indian stratigraphy. Planktonic foraminifera and calcareous nannofossils. Ostracoda - outline morphology, paleoecology & geological history. Brief knowledge about pteropods, calpionellids and calcareous algae.

Siliceous Microfossils : Radiolaria-outline morphology, classification. Brief knowledge of marine diatoms and silicoflagellates.

Phosphatic Microfossils : Conodont - outline morphology, paleoecology and geologic significance.

Organic Walled Microfossils : Brief account of dinoflagellates and acritarchs.

Palynology : General morphology of spores and pollen, their geological significance.

Applications : Micropaleontology in petroleum exploration. Environmental significance of microfossils - correlation of paleofacies, and paleobathymetry estimation of paleontemperature. The role of micropaleontology in marine geology and oceanography.

Text books:

1. B.U. Hag and A. Boersma (1978). Introduction to marine micropaleontology. Elsevier, Netherlands, 376p.
2. J.P. Kennet & M.S. Srinivasan (1983). Neogene-Planktonic Foraminifera. Hutchison Ross Publ. Co., U.S.A., 263p.
3. M.D. Brasier (1980). Microfossils. George Allen & Unwin, London, 193p.
4. G. Bignot (1985). Elements of Micropaleontology. Graham & Trotman, London, 212p.
5. E.N.K. Clarkson (1986). Invertebrate paleontology and evolution. George Allen & Unwin.
6. R.C. Moore, Lalicker & Fisher (1952). Invertebrate fossil. McGraw Hill Book Co., San Francisco.

EASC-515 ADVANCED REMOTE SENSING & GIS (Hard Core Course)
Credits: 3

Introduction to Remote sensing, basic concepts, electromagnetic radiation, interaction of atmosphere & earth surface objects with EMR, Spectral signatures; spectral signatures of common minerals, rocks, vegetation, water; sensors, platforms.

Brief Introduction to Digital Image Processing - digital data format; Image rectification and restoration techniques– radiometric and geometric corrections; noise suppression, Image Enhancement techniques – image histogram, contrast manipulation, spatial filtering and edge enhancement; Multi image analysis - Ratioing; vegetation indices; Principal Component Analysis; Image Classification techniques – supervised & unsupervised classification.

Fundamentals of GIS, data models, vector and raster data structure, spatial data input and editing; Georeferencing – projections and datums; digital elevation model; visualization and query of spatial data, spatial data transformations, spatial analysis; case studies & current trends in GIS.

Geological Application of Remote sensed data & GIS – lithological discrimination; drainage morphometry; identification of Land forms (geomorphology); interpretation of structural features; Application of mineral and groundwater exploration.

Text books:

Jensen, J.R. (1996) Introductory Digital Image Processing: a Remote Sensing Perspective, Prentice Hall, New Jersey.

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

Gupta, R.P. (1991) Remote Sensing Geology. Springer-Verlag.

Joseph,G., (2005) Fundamentals of Remote Sensing, University Press.

Benhardsen, T. (2002) Geographic Information Systems: an Introduction, John Wiley & Sons, New York

Campbell, J. B. (1996) Introduction to Remote Sensing.622pp.

EASC-516 ADVANCED GEOLOGY LAB-III (Hard Core course)

Credits: 4

Part 1: Ore Microscopy (1 Credit)

Identification of economic minerals in hand specimen. Study of optical properties of opaque minerals in reflected light and their identification in polished section. Study of ore textures and interpretation of paragenesis.

Part 2: Sedimentology (1 Credit)

Study of clastic and non-clastic rocks in hand specimen. Microscopic examination of important rock types. Separation of heavy minerals and study of their microscopic charcteristics. Grain size analysis by sieving, plotting of size distribution data. Determination of roundness and sphericity of grains.

Part 3: Micropaleontology (1 credit)

Techniques of separation of microfossils. Study of important benthic and planktonic foraminifera useful in bottom and surface water oceanography. Study of larger foraminifera important to the Indian stratigraphy.

Part 3: Remote Sensing & GIS (1 Credit)

Visual interpretation of satellite data on different scale for extraction of thematic information – lithology variation, geomorphology, land use/land cover, lineaments; structures; digital image processing system and enhancement of data classification; exposures of ARC GIS and ERDAS Imagine softwares

EASC-517 TERM PAPER (Soft core course)

Credits: 2

Individual literature survey and preparation of a term paper on a specialized topic in earth sciences, under the supervision of a faculty member of the Department, followed by a seminar presentation.

EASC-518 PROFESSIONAL TRAINING (Soft Core Course)

Credits:3

Intensive field and/or laboratory training on any applied aspect of geology including exploration and mining practices, petroleum well logging and related well site operations, geotechnical and geo-environmental investigations etc. Training will be conducted through professional organisations engaged in above activities. Total duration of the training will be about three weeks.

EASC-519 COAL AND PETROLEUM GEOLOGY (Soft Core Course)

Credits: 2

Unit-1

Nature of petroleum: chemical composition and physical properties of organic matters and hydrocarbon. Origin of petroleum: organic and inorganic theories. Transformation of organic matter into Kerogen, organic maturation, thermal cracking of kerogen. Diagenesis, ketagenesis and metagenesis. Formation of petroleum in relation to geological processes: temperature, time, and pressure. Timing of oil and gas generation.

Unit-2

Migration of oil and gas: evidence of migration, primary and secondary migration. reservoirs – porosity, permeability and capillary pressure, porosity types in clastic and carbonate reservoirs, reservoir heterogeneity, drive mechanisms. Trapping mechanism for oil and gas, characteristic of structural, stratigraphic and combination traps.

Unit-3

Petroleum exploration- surface indication of oil and gas, sequence of exploratory steps. Formation evaluation: well-logging, types of well logs, interpretation of lithology, quality and quantity of formation fluids from well logs. Geology of productive oil and gas fields of India.

Unit-4

Definition, origin, rank, and types of coal. Classification: Indian and International. Physical and petrographic characters: concept of Lithotypes, microlithotypes, and macerals. Chemical characterization: proximate and ultimate analyses.

Unit-5

Application of coal petrology in solving geological problems and in hydrocarbon exploration. Sedimentology of coal bearing strata, coal forming epochs in geological past, coal deposits of India and their distribution. Methods of Coal prospecting and estimation of its reserves. Coal bed Methane: generation and exploration of coal as reservoir of methane.

Text books:

1. Holson, G.D. and Tiratsoo, E.N., 1985: Introduction to Petroleum Geology-Gulf Publ. Houston, Texas
2. Tissot, B.P. and Welte, D.H., 1984: Petroleum Formation and Occurrence-Springer Verlag
3. Leverson, A.L. 1970. Geology of Petroleum. Freeman and co.,
4. Selley, R. C. 1998. Elements of Petroleum Geology, II Edition. Academic Press,
5. North, F.K. Petroleum Geology, Allen & Unwin, London, 1985.
6. Hunt, J.M. Petroleum Geochemistry and Geology, 2nd Edition, W.H. Freeman, San Fransisco, 1996.
7. Sahay, B., Rai, A. and Ghosh, M. Wellsite Geological Techniques for Petroleum Exploration, Oxford & IBH, New Delhi, 1984.
8. Stach, E., Mackowsky, M.T.H., Taylor, G.H., Chandra, D., Teichmuller, M. and Teichmuller, R., 1982: 7.Stach's Text Book of Coal Petrology- Gebruder Borntraeger, Stuttgart
9. Thomas, L ., 2002. Coal Geology. John Willey & Sons Ltd., England
10. Chandra, D., Singh, R.M. and Singh, M.P., 2000: Textbook of Coal (Indian Context)-Tara Book Agency, Varanasi.
11. Singh, M.P., (Ed.), 1998: Coal and Organic Petrology-Hindustan Publ. Corp., New Delhi

EASC-520 MINERAL ECONOMICS (Soft Core Course)

Credits: 2

Concept of mineral economics and its importance in national development. International mineral trade; peculiarities inherent in mineral industry. Mineral supply as a stock: assessment of world mineral supplies, reserves and resources, technology and price.

Mineral legislation; national mineral policy; mineral taxation, preservation of environment, mineral conservation. The mines and minerals (regulation and development) act. Structure and organization of mineral industry; valuation of mineral property.

Future mineral consumption and world economy; energy demand and supply in future; marine mineral resources; developments in mineral exploration and exploitation.

Text books:

Chatterjee, K.C. 2012. An introduction to mineral economics. New Age International Publishers, New Delhi.
Govett, G.J.S. & Govett, M.H. 1976. World mineral supplies. Elsevier, Amsterdam.
Sinha, R.K. & Sharma, N.L. Mineral economics. Oxford & IBH.

EASC-521 GEOEXPLORATION (Hard Core Course)

Credits: 4

Part 1: Geological and Geochemical Exploration

Unit -1
Introduction to past and present exploration practices. Prospecting criteria of various mineral deposits. Ore guides, regional and local parameters for exploration. Different stages and practices of geological prospecting, regional and detailed exploration.

Unit-2
Principles and methods of geochemical prospecting, pathfinders and indicator elements in rocks and soils. Mobility of elements. Primary and secondary dispersion patterns, geochemical anomalies and their interpretation.

Unit-3
Ore deposit evaluation techniques. Concept of cut-off grade and cu-off thickness. Objectives of drilling, types of drilling for exploration and their advantages. Selection of sites, angle and direction of bore holes, logging, borehole drift and deviation. Ore reserve estimation. Mineral resources and their classification.

Part 2: Geophysical Exploration

Unit-4
Introduction to geophysical methods of exploration and their applications. physical properties of rocks and minerals, types and scales of survey. Principles of gravity and magnetic methods, Working principle of gravimeters and magnetometers, gravity and magnetic surveys, data reduction, anomalies, geological interpretation and modeling for simple geometrical shapes.

Unit-5
Electrical properties of rocks. Fundamentals of resistivity and electromagnetic methods of prospecting, origin of self potential and induced polarization, surveys, instruments, application.

Unit-6
Theory and geometry of seismic wave propagation, Reflection and refraction methods, Data Acquisition, CMP gather, Data processing- velocity analysis, Moveout corrections, stacking and migration. Interpretation of Seismic reflection profiles. Introduction to well logging, formation evaluation, logging methods- Resistivity, induction, SP, radiometric, sonic, temperature.

Text/Reference books:

Peters, W.C. 1987. Exploration and mining geology. John Wiley & Sons, New York.
Annels, A.E. 1991 Mineral Deposit Evaluation. A practical approach. Chapman and Hall, London
Banerjee, P.K and Ghosh, S . 1997. Element of prospecting for non-fuel mineral deposits. Allied Publisher Ltd, New Delhi

Rose, A.W., Hawkes, H.E. & Webb, J.S. 1979. Geochemistry in mineral exploration. Academic
Press, London.
Moon, C.J., Whateley, M.K.G. and Evans, A.M. 2006. Introduction to mineral exploration, 2nd edition. Blackwell Publishing Ltd. Oxford.
Robert J. Lillie, Whole Earth Geophysics, 1999. An introductory textbook for geologists and Geophysicists, Prentice Hall,
Alan E. Mussett and M. Aftab Khan, 2000. Looking into the earth, An introduction to geological geophysics, Cambridge Univ. Press.
Telford, W.M. Geldart, L.P. and Sheriff, R.E.,1990. Applied Geophysics,Cambridge University Press.
Robinson, E.S. and Coruh, C. 1988. Basic Exploration Geophysics, John Wiley & Sons,
Reynolds, J M.1997 An introduction to applied and environmental Geophysics, John Wiley & Sons Ltd .

Text books:

Indian Bureau of Mines, 1979. Mineral exploration. IBM, Nagpur.
Peters, W.C. 1978. Exploration and mining geology. 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.
Dorbin, M.B. Introduction to geophysical prospecting.
Parasnis, D.S. Principles of applied geophysics.
Ramachandra Rao. Geophysical prospecting for geologists.

EASC-522 ADVANCED GEOHYDROLOGY (Hard Core Course)

Credits: 2

Hydrologic Cycle, Water Balance, Atmospheric Circulation, Hydrologic Elements, Peak Runoff Computation, Geological Influences on Groundwater Occurrence and Movement, Principles and Regional Equations of Groundwater Flow, Groundwater in regions of Climatic Extremes, Hydrological Divisions of India

Methods of Aquifer Delineation and Well Location, Pumping Test and Data Interpretation, Methods of Well Drilling, Development and Design, Sea Water Intrusion in Coastal Aquifers

Stable Isotopes, Radioactive Isotopes used in dating, contamination, and recharge studies

Water quality, standards, presentation of results of chemical analysis, carbonate equilibrium, thermodynamic relationship, groundwater contamination and restoration

Groundwater models, finite difference and element, steady and transient state, basics of VMODFLOW

Groundwater Development and management, water budget, water law, artificial recharge, Indian groundwater scenario, Remote Sensing and GIS applications for groundwater exploration

Text books:

Fetter, C.W. 2001. Applied Hydrogeology (4th edition). Prentice Hall
Todd, D.K. 1988. Groundwater Hydrology. John Willey & Sons
Davis, S.N. & De Wiest, R.J.N. 1966. Hydrogeology. John Wiley & Sons, New York
Raghunath, H.M. 1983. Groundwater. Wiley Eastern, Calcutta.
Clark, I. & Fritz. 1997. Environmental Isotopes in Hydrogeology. Lewis Publishers, Boca Raton.
Herman Bower, 1978. Groundwater Hydrology. Mc Graw Hill Book Co.
Pathak, B.D. 1988. Hydrogeology of India, Central Board for Irrigation and Power, Mecha Marg, Chanakyapuri, New Delhi.

EASC-523 ADVANCED GEOLOGY LAB IV (Hard Core Course)

Credits: 3

Part 1: Geological & Geochemical Exploration (1 credit)

Map exercises on use of geological and geochemical prospecting criteria. Selection of suitable sampling method. Recognition of anomalies. Preparation of level plans and sections. Various methods of ore reserve estimation.

Part 2: Geophysical Exploration (1 credit)

Geophysical Surveying, corrections to gravity and magnetic data, gravity and magnetic anomalies, qualitative and quantitative interpretation of geophysical anomalies, computations based on seismic reflection and refraction & interpretation.

Part 3: Geohydrology (1 credit)

Water balance calculation, groundwater budgeting, groundwater flow nets, Artificial recharge methods and analysis, Electrical resistivity for groundwater investigations – 1D, 2 D methods and interpretation, geo-logging - neutron, SP and resistivity log analysis and interpretation, Hydrochemical analysis of water samples, charge balance, ion exchange calculations, rock water interaction analysis, piper, Collins bar graph, USSL salinity plot and calculation of water suitability for agricultural, industrial and domestic utilities, thermodynamics and saturation index calculations, calculation of rainfall and runoff analysis.

EASC-524 ADVANCED FIELD TRAINING-II (Hard Core Course)

Credits: 3

Study of various geological features of mineral deposits in prospects and working mines. Methods of mining. Underground mine mapping, quality control operations. Geological operations at exploration sites. Field work related to petroleum exploration, engineering and environmental geological studies. Total duration of the training will be about three weeks in the field.

EASC–525 PROJECT (Soft Core Course)

Credits: 4

Individual project work on applied aspects of current interest in geosciences. One faculty member of the Department will be assigned as the Supervisor. In case of inter-disciplinary project, one more faculty member from related discipline can be co-opted as the second Supervisor.

EASC-526 GLOBAL TECTONICS (Soft Core Course)

Credits: 2

Introduction

Earth and its early history. Differentiation of earth into crust, mantle and core, Internal structure of the Earth.

Plate Tectonics

Development of theory of plate tectonics. Mechanism of plate-tectonics: Mantle convection, The forces acting on plates.

Plate boundary processes:

Accretionary Plate Boundary: Physiography, structure, magmatism and metamorphism along Mid-oceanic ridges. Sea-floor spreading. Continental rifting. Sedimentary basins.

Conservative Plate Boundaries: Physiography, structure and types of transform faults. Their relation to slipping rates.

Consuming Plate Boundaries: Geometry and structure of Benioff zones. Sedimentatiion, magmatism and metamorphism in subduction zones. developments of Island arcs.

Origin and evolution of land

Origin and evolution of continental-crust. Proterozoic orogenic belts. Pacific and Andean-type margins. Collision tectonics. Obduction and ophiolite emplacement. Supercontinent cycles.

Tectonic Activity within Indian plate

Configuration of Indian plate. Mobile belts in Peninsular India. Evolution of the Himalaya and Himalayan tectonics. Andaman subduction zone.

Text Books

Kearey, P. and Vine, F.J. (1996) Global Tectonics. Blackwell Science.
Windley, B.F. (1995) The evolving continents. John Wiley & Sons, 526 pp.
Rogers, J.J.W. A history of the Earth. Cambridge University Press.
Fowler, C.M.R. (1990) The solid Earth: an introduction to Global Geophysics. Cambridge University Press.
Brown, G.C. and Mussett, A.E. The Inaccessible Earth: an integrated view of its structure and composition. Chapman and Hall.
Brown, G., Hawkesworth, C. and Wilson, C. (1992) Understanding the earth. Cambridge Univesity Press.
Condie, K.C. (1976) Plate Tectonics and Continental Evolution. Pergamom Press Inc.
Le Pichon, and J.Francheteau. Plate tectonics.

EASC-527 MINING GEOLOGY (Soft Core course)

Credits: 2

Orebody reevaluation. Appraisal of exploration data for exploratory mining. Exploratory development works for mineral deposits by open-cast and underground mining methods. Mine design, metallurgical design and planning.

Environmental baseline data needed for mine planning, its acquisation and documentation during different stages of mineral exploration. Nature and extent of environmental problems due to surface and underground mining.

Mine waste management.

Role of the geologist at operative mines. Grade control in open-pit and underground operations. Blending and stock-piling of ores.

Economic appraisal of mines.

Text books:

H.E.McKinstry (1980) Mining Geology. Printice Hall, New York.
R.N.P.Arogyswamy (1994) Courses in mining geology. Oxford-IBH, New Delhi.
Indian Bureau of Mines (1979) Mineral exploration. IBM, Nagpur.
A.E. Annels (1992) Mineral deposit evaluation. Chapman and Hall, London.
R.T.Deshmukh (1993) Elements of mining technology. Dhanbad Publishers, Dhanbad.
W.C.Peters (1987) Exploration and mining geology. John Wiley & Sons, New York.

EASC –528 PALEOCLIMATOLOGY (Soft Core course)

Credits 3

Unit I: Factors affecting climate and climate variations: variations in solar insolation, changes in ocean circulation, plate tectonics and volcanic activity, the evolution of vascular plants, and fossil fuel burning. Ocean and atmospheric circulation.

Unit II: Interactions between the atmosphere, ocean, and land components of the earth's climate system.

Unit III: Introduction to climate proxies, timescales involved in climate reconstruction
and interpretations of climate proxies. Methods used for dating climate proxies: isotopic and non-isotopic; and methodology of paleoclimatic reconstructions.

Unit IV: Marine and terrestrial proxies.

Unit V: Salient features of Precambrian, Phanerozoic climate. Anthropocene.

Text books:

Bradley R.S. 1999. Paleoclimatology, reconstructing the climate of the quaternary. Academic Press, Amsterdam.
Ruddiman W.F. 2007. Earth's Climate: Past and Future (2nd edition). W.H Freeman and Co., New York.

Reference books:

Hartmann D. L. 1994. Global Physical Climatology, Volume 56 (International Geophysics), Academic Press, p. 411.
Crowley T. J. and North G. R. 1999. Paleoclimatology. Oxford University Press, p. 360.
Wallace J. M. and Hobbs P. V. 2006. Atmospheric Science: An Introductory Survey, Second Edition, Academic Press, p. 483.

EASC-529 PLANETARY GEOLOGY (Soft Core Course)

Credits: 2

UNIT 1

Scientific methods, units of measurements and mathematical fundamentals used in planetary science and astronomy. Historical development of planetary explorations and planetary geology

UNIT 2

Stellar evolution. Nucleosynthesis. Observations and facts of solar system. Solar nebula and origin of Solar Sytem. Planets and other objects of Solar system

UNIT 4

Physical and Chemical properties of Inner planets. Physical properties, atmosphere and celestial mechanics of Outer planets. Natural satellites of planets.

UNIT 5

Comets, Asteroids and Meteorites. Impact craters. Evolution of Earth as a planet. Earth-moon system. Lunar geology.

UNIT 6.

Extra solar systems. Exploration and evolution of life. Missions to other planets. Indian space missions.

Text books:

1. Introduction to Planetary Sciences, The geological perspective. Authors: Gunter Faure and Teresa, M. Mensing. Published by Springer, The Netherlands. 2007.

2. Planetary Geology: An Introduction. Author- Claudio Vita-Finzi. Publisher: Terra Publishing, 2005.

3. Introduction to Planetary Geology. Author- Billy P. Glass, Publisher Cambridge University Press.

4. The New Solar System Edited by J. Kelly Beatty and C. C. Petersen. Published by Cambridge University Press.

EASC-530 WELL LOGGING (Soft Core course)

Credits: 2

Basic Concepts: Fundamentals of drilling, drilling mud, flushed zone, invaded zone and uncontaminated zone. Physical properties of reservoir rocks, porosity, formation factor, water saturation and hydrocarbon saturation.

Electrical Logging: SP log, cause of SP in bore hole, principles of measurement, factors affecting SP log and interpretation of SP log. Resistivity log, principles and interpretation of various resistivity logs and their specific uses. Induction log, theory, procedure and interpretation of shallow, medium and deep induction tools.

Radiation Logging: Nature and properties of Gamma rays. Gamma log, detection system, principle of measurement and interpretation. Gamma-Gamma log, physical principle, photo electric effect, Compton scattering and pair production, estimation of density and porosity of formations. Neutron log, Gamma-Neutron log and Neutron activation log, basic principles, the instruments and interpretation.

Temperature, Magnetic, Gravity and Sonic Logging: basic principles, logging devices and interpretation.

Applications: Various approaches for porosity estimations. Correlation of sub-surface structures and comprehensive interpretation from available logging data. Application of well logging for mineral and groundwater exploration. A few case histories.

Text books:

S.J.Pirson: Hand book of well log analysis.
E.J.Lynch: Formation evaluation. Harper & Row.
M.R.J.Wyllie: The fundamentals of well log interpretation.
Y.I.Gorbachev: Well logging. John Wiley & Sons.