# Suggested framework of Syllabus of M.Sc. (Applied Geology)

**(Choice Based Credit System)**

Candidates who have passed the three year and/or six semester B.Sc. examination of the University of Allahabad or any other equivalent examination of other universities with at least two subjects out of Geology, Physics and Mathematics will be considered eligible for admission to the four Semester M.Sc. Applied Geology course. **The common semester rules and uniform grading system of the university will be followed.**

## M. Sc. PREVIOUS SYLLABUS

### SPRING SEMESTER

| Code | Core Papers | L | T | P | C | Marks |
|---|---|---|---|---|---|---|
| **EPS 501** | Crystallography & Mineralogy | 3 | 1 | 0 | 4 | 100 |
| **EPS 502** | Paleontology | 3 | 1 | 0 | 4 | 100 |
| **EPS 503** | Structural Geology | 3 | 1 | 0 | 4 | 100 |
| **EPS 504** | Remote sensing & GIS | 3 | 1 | 0 | 4 | 100 |
| | **Elective paper** | | | | | |
| **EPS 551/552/553** | **Elective I** | 3 | 0 | 0 | 3 | 100 |
| | **Practical papers** | | | | | |
| **EPS 531** | Practical I | 0 | 0 | 4 | 2 | 100 |
| **EPS 532** | Practical II | 0 | 0 | 4 | 2 | 100 |
| | **Total:** | **15** | **4** | **8** | **23** | |

**Total Credits in SPRING SEMESTER: 23**

| | **Elective I*** | | | | | |
|---|---|---|---|---|---|---|
| **EPS 551** | Introduction to Earth & Planetary Sciences | 3 | 0 | 0 | 3 | 100 |
| **EPS 552** | Geomorphology | 3 | 0 | 0 | 3 | 100 |
| **EPS 553** | Soil Geology | 3 | 0 | 0 | 3 | 100 |

*** Elective papers will be run depending on the availability of resource person and response of students.**

## AUTUMN SEMESTER

| | **Core Papers** | **L** | T | P | **C** | **Marks** |
|---|---|---|---|---|---|---|
| **EPS 505** | Igneous and Metamorphic Petrology | 3 | 1 | 0 | 4 | 100 |
| **EPS 506** | Sedimentology | 4 | 0 | 0 | 4 | 100 |
| **EPS 507** | Stratigraphy | 4 | 0 | 0 | 4 | 100 |
| **EPS 508** | Environmental & Engineering Geology | 4 | 0 | 0 | 4 | 100 |
| | **Elective paper** | | | | | |
| **EPS 554/555/556** | **Elective II** | 2 | 1 | 0 | 3 | 100 |
| | **Practical papers** | | | | | |
| **EPS 533** | Practical I | 0 | 0 | 4 | 2 | 100 |
| **EPS 534** | Practical II | 0 | 0 | 4 | 2 | 100 |
| | **Total:** | **17** | **2** | **8** | **23** | |

**Total Credits in AUTUMN SEMESTER: 23**

# Total Credits in M.Sc. Previous: 46

| | **Elective II*** | | | | | |
|---|---|---|---|---|---|---|
| **EPS 554** | Numerical Methods & Computer Programming in Geosciences | 2 | 1 | 0 | 3 | 100 |
| **EPS 555** | Field Geology & Instrumental Techniques in Geology | 2 | 1 | 0 | 3 | 100 |
| **EPS 556** | Environmental Hazards & Disaster Management | 2 | 1 | 0 | 3 | 100 |

*** Elective papers will be run depending on the availability of resource person and response of students.**

# M. Sc. FINAL SYLLABUS

## SPRING SEMESTER

| | **Core Papers** | L | T | P | **C** | **Marks** |
|---|---|---|---|---|---|---|
| **EPS 601** | Ore Geology | 4 | 0 | 0 | 4 | 100 |
| **EPS 602** | Geophysical Exploration | 3 | 1 | 0 | 4 | 100 |
| **EPS 603** | Geohydrology | 3 | 1 | 0 | 4 | 100 |
| **EPS 604** | Geochemistry | 3 | 0 | 0 | 3 | 100 |
| | **Elective paper** | | | | | |
| **EPS 651/652/653** | **Elective I** | 3 | 0 | 0 | 3 | 100 |
| | **Practical Papers** | | | | | |
| **EPS 631** | Practical I | 0 | 0 | 4 | 2 | 100 |
| **EPS 632** | Practical II | 0 | 0 | 2 | 1 | 100 |
| | **Total:** | **16** | **2** | **6** | **21** | **700** |

**Total Credits in SPRING SEMESTER: 21**

| | **Elective I** | | | | | |
|---|---|---|---|---|---|---|
| **EPS 651** | Coal & Petroleum Geology | 3 | 0 | 0 | 3 | 100 |
| **EPS 652** | Introduction to mining and Ore dressing | 3 | 0 | 0 | 3 | 100 |
| **EPS 653** | Gemology | 3 | 0 | 0 | 3 | 100 |

*** Elective papers will be run depending on the availability of resource person and response of students.**

**AUTUMN SEMESTER**

| | Subjects | L | T | P | C | Marks |
|---|---|---|---|---|---|---|
| | **Core papers** | | | | | |
| **EPS 605** | Seminar | 0 | 0 | 4 | 2 | 100 |
| **EPS 606** | Comprehensive Viva-voce | | | | 2 | 100 |
| **EPS 607** | Dissertation (Sixteen hours/week) | | | | 12 | 100 (Thesis 75, Seminar 15 & Viva 10) |
| | **Elective paper** | | | | | |
| **EPS 654** | Term paper | 0 | 0 | 4 | 2 | 100 |
| | **Practical Paper** | | | | | |
| **EPS 633** | **Field Geology** | | | | 2 | 50 |
| | **Total** | **0** | **0** | **8** | **20** | |

**Total Credits in AUTUMN SEMESTER: 20**

# Total Credits in M.Sc. Final: 41

# TOTAL CREDITS FOR M.SC. APPLIED GEOLOGY COURSE: 87

**Marks for theory examinations shall be as per the following;**

| Exam. Components | Marks for End Semester Exam. | **Sessional** Best of two class Tests &/or Assignment / Quiz / Seminar/ GD + Mid-Semester Exam.) | Total Marks |
|---|---|---|---|
| Theory | 60 | 40 (20+20) | 100 |

**Test and Examination Dates will be decided and announced by the Department.**

*****

# Syllabus for M. Sc. Applied Geology Course

Entire course content (theory paper) is divided in to five units. In the End-Semester Examination there will be one question of **12 marks** from each unit with an internal choice with each question.

## M. Sc. Previous : Spring Semester

**Core Papers:**

**EPS 501: Crystallography and Mineralogy (3:1:0:4)**

**Unit I**

Structure and classification of silicates. A detailed study of the important silicates with reference to general and structural formulae, classification, atomic structure, polymorphs/structural states, chemistry including substitution of elements/solid solution and experimental work on pressure-temperature stability of the minerals, modes of occurrence and alterations.

U**nt II**

Study of Gem and Gemstones.

**Unit III**

Optical crystallography of uniaxial and biaxial crystals, Indicatrix, pleochroism, Interference figures, crystal orientation, 2V and 2E.

Derivation of 32 classes of Symmetry. International System of crystallographic notation and study of Stereograms. Different types of crystal projections – spherical and stereographic and their uses.

**Unit IV**

Twinning and Twin Laws: common types of twins and their examples in minerals.

Liquid Crystals. Space Lattice and Symmetry of internal structures – 14 Bravais Lattice. Introduction to Space Group.

**Unit V**

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

Books recommended:

Dana, E.S. and Ford, W.E.: A Textbook of Mineralogy. Wiley Eastern Limited, New Delhi, 351 pages,

Deer, W.A., Howie, R.A. and Zussman, J. (2013) An Introduction to the Rock-Forming Minerals (3rd Edition) The Mineralogical Society, London, 498 pages ISBN-978-0903056-33-5.

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

**EPS 502: Paleontology (3:1:0:4)**

**Unit I**

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

**Unit II**

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

**Unit III**

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

**Unit IV**

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

**Unit V**

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

.

Books recommended:

Clarkson, E.N.K. (1998) Invertebrate Palaeontology and Evolution,ELBS/Allen & Unwin, London,382, ISBN 0-04-560010-4.
Prothero, D.R. (1998) Bringing Fossil to Life – An Introduction to Palaeontology (McGraw Hill),457 pages, ISBN 0070521972, 9780070521971.

Raup, D.M. and Stanley, S.M. (1985) Principles of Palaeontology (CBS Publications), W.H.Freeman and Company, New York , 481 pages.
Colbert, E.H. (1984): Evolution of Vertebrates. Wiley Eeastern Ltd., ISBN 085556 125 X, New Delhi, 535 pages.
Benton, M.J. (1990): Vertebrate Paleontology. Unwin Hyman, Lindon, 452 pages, ISBN 0-632-05614-2.
Haq, B. U. and Boersma, A.,(1998) Introduction to Marine Micropaleontology, Elsevier, 376 pages, ISBN 0444826726.

**EPS 503: Structural Geology (3:1:0:4)**

**Unit I**

Definition, Primary and Secondary structures, Methods and application of structural geology. Fold elements and terminology, Classification: geometrical, morphological and genetic, Origin and development of folds, Superposed Folds. Determination of top and bottom of beds. (Recognition and representation of folds).

**Unit II**

Classification, and origin of joints, relation to other structures. Faults, terminology and classification, structures associated with faults. Gravity, thrust and strike-slip faults classification and description. Mechanics of fracturing.
Block, rifted and wrench-faulted regions, thrusts and nappe structures, tectonic mélanges, dome and basin structures, metamorphic terrains, mylonite zone and pseudotachylytes.

Unit **III**

Unconformities and gravity structure, Meteoritic Impact structures and Impactites, collapse compaction, diapers, salt domes. Salient structural features of the Himalayan Arc. Indo-Gangetic Plains, Peninsular India and Indian Ocean.

**Unit IV**

Fundamental concept of Geotectonics, its practical and theoretical importance. Organic and Epeirogenic Phases; Concept and theories of Isostasy; Origin and significance of Mid-Oceanic Ridges and Trenches; Island arcs and mountain chains, their global distribution and evolution. Concept of Sea floor spreading; Evidence of continental drift, Concept of Plate Tectonics, Nature and types of Plate Margins, Geometry and Mechanism of Plate Motion. Tectonic and Economic significance of Plate Tectonics.

**Unit V**

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

Books recommended:

George H. Davis and Stephen J. Reynolds, 1996, Structural Geology of Rocks and Regions, John Wiley & Sons, Inc., 492p. ISBN- 047152621-5
Robert D. Hatcher, 1995, Structural Geology, principles, Concepts, and Problems, Prentice Hall, 525p. ISBN-0023557133.

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

**EPS 504: Remote Sensing & GIS (3:1:0:4)**

**Unit I**

**Remote Sensing:** Electromagnetic Radiation – Characteristics and Remote Sensing Regions and bands; Aerial photos – types, scale, resolution; properties of aerial photos, stereoscopic parallax, Relief displacement; General Orbital characteristics of remote sensing satellites;

**Unit II**

General sensor characteristics of remote sensing satellites; Spectra of common natural objects – soil, rock, water and vegetation.

**Unit III**

**Data Processing and Interpretation (Digital Image Processing – DIP)**

Characteristics of remote sensing data; preprocessing; Enhancements, Classification, Elements of photo and imagery pattern and interpretation – drainage, erosion, details, gray tones.

**Unit IV**

**Application in Geology**

Remote sensing applications in structure and tectonics; Systematic mapping, Mineral resources, Groundwater potentials, Environmental monitoring and mapping.

**Unit V**

**GIS** -Principles and components of GIS, Remote sensing data integration with GIS; Applications of GIS in various geological aspects.

Books recommended:

Drury, S.A. (1987) Image Interpretation in Geology. Allen and Unwin ,290 pages, ISBN 0-632-054085.
Lillesand, T.M. and Kiefer, R.W. (1987) Remote Sensing and Image Interpretation. John Wiley, New York, 610 pages.
Siegal, B.S. and Gillespie, A.R. (1980) Remote Sensing in Geology. John Wiley
Gupta, R.P. (1991) Remote Sensing Geology, Springer, Berlin, ISBN 81-8128-283-3, 655 pages.
Sabins, F.F. 2007, Remote Sensing: Principles and Interpretation, Waveland Pr Inc., NewYork, 432 pages, ISBN 0716724421.

**Elective Papers:**

**EPS 551: Introduction to Earth & Planetary Sciences (3:0:0:3)**

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

**Unit II**
Basic concepts and significance of Geomorphology; Typical landforms and their evolution;

**Unit III**
An elementary idea about morphogenesis and morphography; Morphometric analysis; Morphochronology, Geomagnetism,

Geomorphology of India,
Introduction to Applied Geomorphology.

**Unit IV**
Composition of the atmosphere and its internal structure; Study of atmosphere on the basis of lapse rate: prevailing and adiabatic lapse rates, isothermal constant lapse rate, dry adiabatic lapse rate, homogeneous lapse rate; Humidity: definition derivation of relative and absolute humidity; Potential temperature dew point temperature, instability of dry and moist air; geopotential; condensation nuclei; precipitation.

**Unit V**
Fundamental forces in the atmosphere; Corriolis Force and the geostrophic wind, gradient wind pressure gradient wind basic structure and mechanism of atmospheric general circulation; cyclones, anticyclones. Climate change, green house warming.

Books recommended:

Gass I.G. et al 1982: Understanding the Earth. Artemis Press (Pvt.) Ltd. U.K.
Thornbury, W.D. 1980: Principles of Geomorphology. Wiley Eastern Ltd., New York, 594 pages, ISBN 0-85226-885-8.

Sharma, H.S. 1990: Indian Geomorphology. Concept Publishing Co. New Delhi.358p.
Holmes, A. 1992: Holmes Principles of Physical Geology Edited by P. McL. D. Duff. Chapman and Hall, London, 791p.
Byers, H.R. 1974: General Meteorology, McGraw Hill.
William Lowrie,1997: Fundamentals of Geophysics, Cambridge University Press

**EPS 552: Geomorphology (3:0:0:3)**

**Unit I**

Basic concepts and significance of Geomorphology, Rock weathering and soils, Mass wasting. Influence of climate on processes. Concept of erosion cycles.

**Unit II**

Geomorphology of fluvial tracts, arid zones, coastal regions, Karst landscapes and glaciated ranges.

**Unit III**

Morphogenesis and morphography; Morphometric analysis; Morphochronology, Brief study of Terrain Evaluation for strategic purposes.

**Unit IV**

Applications of geomorphology in mineral prospecting, civil engineering, hydrology and environmental studies.

**Unit V**

Topographical maps. Geomorphology of India: Peninsular, extra-peninsular and Indo-Gangetic Plains.

Books recommended:

Thornbury, W.D. 1980: Principles of Geomorphology. Wiley Eastern Ltd., New York.

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

Halis, J.R. 1983: Applied Geomorphology

Sharma, H.S. 1990: Indian Geomorphology. Concept Publishing Co. New Delhi.

**EPS 553: Soil Geology (3:0:0:3)**

**Unit I**

Process of Soil Formation
Concept of soil, components of soil, soil profile, pedogenic processes. Classification of soil.

**Unit II**

Mineral stability of weathering. Soil organic matter form and function.

**Unit III**

Fabric Analysis: Size and shape: Concepts of size and shape, grade scale, methods of analysis, presentation of data, analysis and field grading.

Concepts of structure and fabric: Soil fabric, soil structure, soil texture and field grading units. Peds and pedalilty: Size and shape of peds, pedality, primary, secondary and tertiary structures, interpretation.

**Unit IV**
Voids: Concepts, size, shape, arrangement and morphological classification.

**Unit V**
Paleosols**:** Field recognition, description, origin and causes. Paleosol in stratigraphic records, Significance of paleosol study, Paleosols and human evolution.
Calcrete: Definition, classification, calcrete formation, pedogenic calcrete soil profile, macro features in calcretes, micromorphology (petrography), calcretes from Quaternary and ancient sedimentary sequences, significance of calcretes.
Laterite:Field and microscopic characters, genesis, Indian occurrences.

Books recommended:
Govinda Rajan, S.V. & Gopala Rao, K.H.G.: Studies of Soils of India.

Terzaghi, K. & Pock, R.G.: Soil Mechanics in Engineering

Jeffe, J.S.: The A.B.C. of soils

Tayler, D.W.: Fundamentals of Soil Mechanics

Hunt,C.B.: Geology of Soils

Graddy, N.C.: Nature and properties of soils.

Gerrard, A.J.J. : Soil and Land forms

Wright;, V. Paul (Editor): Paleosols: their recognition and interpretation, Blackwell Scientific Publication.

Wright;, V. Paul and Tucker, M.E. (1991) Calcretes. Blackwell Scientific Publication.

**Practical papers**

**EPS 531: Practical-I (0:0:4:2)**
*a)* ***Crystallography & Mineralogy****:* Identification of rock-forming minerals in hand specimens. Atomic structure models. Determination of length fast and length-slow characters of minerals. Characterization and identification of gems and gem stones.
Determination of order of interference colours. Scheme of pleochroism and absorption of a given mineral in thin section. Determination of extinction angle and composition of plagioclase. Study of interference figures of uniaxial and biaxial crystals, determination of optic signs. Goniometer and its use in measuring interfacial angle of crystals and calculation of axial ratio. Representation of symmetry elements of crystals belonging to 32 classes of symmetry and study of their stereograms.

*b)* ***Paleontology:*** Study of specimens illustrating various nature and modes of occurrence of fossils. Study of morphological characters of some important Invertebrate fossils. Study of functional morphology of bivalvia shells. Study of morphological characters of some important

Gondwana plant fossils. Preparation, picking and mounting of microfossils. Microscopic study of various types of microfossils. Microscopic study and sketching of important planktic and benthic foraminiferal genera. Study of various water mass dependant planktic foraminiferal assemblages. Study of various benthic foraminiferal depth biotopes.

**EPS 532: Practical-II (0:0:4:2)**

*a)* ***Structural Geology***: Determination of true dip from apparent dip measured in different directions, determination of angle of pitch, plunge, etc. from the knowledge of attitude of folds, interpretation of geological structures from maps, solution of various structural geological problems by graphical and stereographic projection. Practical Strain Analysis.

*b)* ***Remote sensing & GIS***: Determination of scale in aerial photos. 2. Measurement of heights of objects from aerial photos, 3. Study and interpretation of single and stereopair aerial photos; Preparation of interpretation keys. 4. Thematic mapping from aerial photos – structure, lithology, minerals, soils, groundwater, landforms. 5. Thematic mapping from satellite imagery/data – structure, lithology, minerals soils, groundwater, landforms.

## M. Sc. Previous : Autumn Semester

**Core Papers:**

**EPS 505: Igneous and Metamorphic Petrology (3:1:0:4)**

**Unit I**

Igneous Petrology: Definition of important rock types, structural and tectonic control and mode of emplacement of igneous rocks, classification of igneous rocks,

Unit II

Phase equilibria studies on different rock types at variable temperature and pressure under different oxygen and sulphur fugacity.

**Unit III**

Detaile studies on rocks of basalt family, granites family, kimberlites, peridotites, komatites, ophiolites, feldspathoid-bearing volcanic rocks, lamprophyres and anorthosites.

**Unit IV**

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

**Unit V**

Schreinamaker principle in relation to invariant, invarient and singular point assemblages, contact, burial and regional metamorphism, (Green Schist facies and almandine amphibolite facies), Granulite facies migmatization and Shock Metamorphism.

Books recommended:

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

**EPS 506: Sedimentology (4:0:0:4)**

**Unit I**

Surface processes and weathering of rocks, soil and paleosol, Clastic, chemical, biogenic and volcanogenic sediments, Sedimentary textures,

**Unit II**

Classification of sedimentary rocks: conglomerates, sandstones, shales, and carbonate rocks, Provenance of clastic sediments, Diagenesis of silicalstic and carbonate rocks,

**Unit III**

Elements of hydraulics, Flow regimes and processes of sediment transport, Important bedforms and Sedimentary structures-their genesis and stratigraphic significance,

**Unit IV**

Sedimentary facies and environments, Facies modelling for marine, non-marine and mixed sediments, Reconstruction of paleoenvironments,

**Unit V**

Tectonics and sedimentation, Formation and evolution of sedimentary basins: Geosynclinal and plate tectonic models, Basin analysis.

Books recommended:

Sengupta, S.M. 2007, Introduction to sedimentology. CBS Publ, New Delhi , ISBN 81-239-1491-1, 339 pages.

Prothero D.R. and Schwab, F. 2004, Sedimentary Geology. Freeman, 600 pages, ISBN(10)-716739054.
Mc Lane, M. 1995, Sedimentology, Oxford University press ,USA (April 27, 1995) ,448 pages, **ISBN-10:** 0195078683.
Blatt, H., Middleton, G.V. and Murray, R.C. (1980): Origin of Sedimentary Rocks, Prentice-Hall Inc, New Jersey, 782pages, **ISBN** 0-13-642710.
Collinson, J.D., and Thompson, D.B., 1982: Sedimentary Structures, George Allen and Unwin, London.194p.
Lindholm, R.C. , 1987 A Practical Approach to Sedimentology, Allen and Unwin, London, 276p.

Miall, A.D. (2000): Principles of Sedimentary Basin Analysis, Sjpringer-Verlag, 628 pages, **ISBN-10:** 3540657908
Pettijohn;, F.J. (1975): Sedimentary Rocks (3rd Ed.), Harper and Row Publ., New Delhi, 628 pages
Reading, H.G. (1997): Sedimentary Environments and facies, Blackwell Scientific Publication, ISBN 0-632-03627-3.
Reineck, H.E. and Singh, I.B. (1973): Depositional Sedimentary Environments, Springer-Verlag, ISBN 3-540-07377-9.
Selley, R. C. (2000) Applied Sedimentology, Academic Press, 523 pages, ISBN 012 636375 7.
Tucker, M.E. (1981): Sedimentary Petrology: An Introduction, Wiley and Sons, New York , 272 pages ,ISBN 0-632-05735-1.
Tucker, M.E. (1990): Carbonate Sedimentolgy, Blackwell Scientific Publication , 482 p, ISBN 0-632-01472-5.

**EPS 507: Stratigraphy (4:0:0:4)**

**Unit I**

Basic principles and definitions; Stratigrphic classification and Nomenclature; Brief account on Mgnetostratigraphy, Stable Isotope Stratigraphy, Tephrochronology and Event Stratigraphy; Stratigraphic correlation, Paleontologic and non-paleontologic criteria of correlation; Graphic correlation; Facies concept in stratigraphy; Lateral migration of facies.

**Unit II**

Introduction to Sequence stratigraphy depositional sequence, sequence architecture, types and boundaries, condensation and starvation; Conformity and types of sequence unconformities; Flooding surface, maximum flooding surface, marine flooding surface; Bed, bedset, parasequence, parasequence boundary, parasequence set; System tracts - lowstand system tract, transgressive system tract, transgressive surface and highstand system tract, overlap, offlap, toplap and onlap, aggradation, progradation, retrogradation, transgression and regression; Eustatic sea level changes, sediment supply, basin subsidence rate, and accommodation.

**Unit III**

Introduction, physiographic divisions; Structure and tectonic history of Indian subcontinent.
Precambrian basement of Indian Peninsula; Archaean rocks- distribution, classification and economic importance; Precambrian basement of Extra-peninsula- Tethyan basement, Lesser Himalaya; Basement-cover transition; Proterozoic formations of Indian Peninsula- Cuddapah, Delhi, Bijawar and Gwaliar Group and their equivalents. Vindhyan Supergroup and its equivalents; Correlation of equivalent Proterozoic formations in Extrapeninsular India. Chronology of Orogenies.

**Unit IV**

Paleozoic Era- Paleogeographic, paleoclimatic and tectonic set up. A detailed study of succession, lithology, age, depositional environments, economic importance and fossil contents of various formations of Salt Range, Tethys Himalaya and Lesser Himalaya Ranges; Gondwana sequences.

Mesozoic Era- Paleogeographic, paleoclimatic and tectonic set up. A detailed study of succession, lithology, age, depositional environments, economic importance and fossil contents of various formations of Extra-peninsular and Peninsular India.

**Unit V**

Cenozoic Era- Paleogeographic, paleoclimatic and tectonic set up alongwith Himalayan Orogeny. A detailed study of succession, lithology, age, depositional environments, economic importance and fossil contents of various Paleogene and Neogene formations of Extra-peninsular and Peninsular India; Siwalik Supergroup. Deccan Traps: distribution, petrology and age. Lameta beds, Bagh beds, Intertrappeans and Infratrappeans.

Books recommended:

Krishnan, M.S. 1982 Geology of India and Burma, CBS Publ, Delhi, 536 pages, ISBN 81-239-0012-0, John Wiley and Sons, New York. 356 pages.

Nichols, G. 1999, Sedimentology and stratigraphy, Blackwell Science , Oxford, 355 pages, ISBN 0-632-03578-1.

Ramakrishnan, M and Vaidyanadhan, R. 2008, Geology of India(In 2 Volumes), Geological Soc. of India , Banglore , ISBN 9788185867779.

Kumar, R. 1996, Fundamentals of Historical geology and stratigraphy of India , publisher: New Delhi: New Age International Publishers , 254 pages ,ISBN 0852267452.

Schoch, R.M. 1989, Stratigraphy: principles and methods, Van Nostrand Reinhold, 375 pages , ISBN 0442280211.

Coe, Angela, Dan Bosence, Kevin Church, Steve Flint, John Howell and Chris Wilson (2002): The Sedimentary Record of Sea Level Change , Cambridge Univ. Press.

Emery, D, (1996): Sequence Stratigraphy, Blachwell Scientific Publ.

Miall, A.D. (1997): The Geology of Stratigraphic Sequence, Springer-Verlag.

Reineck, H.E., and Singh, I.B. (1980): Depositional Sedimentary Environments, Springer-Verlag.

**EPS 508: Environmental & Engineering Geology (4:0:0:4)**

**Unit I**

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

- **Earthquakes:** Applied seismology, seismic waves, Ray-path geometry in layered ground, loss of seismic energy, seismic energy sources, detection and recording of seismic waves, Influence of neo-tectonics in seismic hazard assessment. Preparation of seismic hazards maps. Distribution, magnitude and intensity of earthquakes

Precaution and prevention measures of following hazards:-

- **Floods:** their causes and control.

- **Landslides:** Landslide hazards: causes and investigations;
- **Coastal erosion:** causes and related engineering structures.,
- **Global warming**: caused by $CO_2$ increase in present atmosphere due to indiscrete exploitation of fossil fuels, deforestation.
- **Water**: Impact assessment of degradation and contamination of surface water and ground water quality due to industrialization and urbanization.
- **Soil:** Soil profiles and soil quality degradation due to irrigation, use of fertilizers and pesticides.
- **Population increase**: Urbanization and land use changes and related hazards.

**Unit II**

**Environmental Geophysics:** definition and scope, interrelationship between various sub-disciplines, planning of geophysical survey, planning strategy, survey constraints, target identification, selection intervals, noise, data analysis.

- **Seismic reflection surveying**: applications, High resolution seismic profiling over land and water.
- **Seismic refraction surveying**: applications, Rock head determination for a proposed waste disposal site.

**Ground penetrating radar:** propagation of radio-waves, dielectric properties of earth materials, mode of data acquisition, data processing, interpretation techniques.

- Applications: Hydrogeology and groundwater contamination, engineering application on man-made structures, Voids within man-made structures, Archaeological investigations.

**Unit III**

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

**Unit IV**

**Engineering geology**

Importance of earth sciences in engineering. Functions and responsibilities of geologists at the investigations, construction and maintenance stages of engineering project.

**Mechanical Properties of Rocks and Soils**: elastic, an-elastic and plastic behavior of material, stress and strain state in rocks, longitudinal strain, shear strain, young's modulus, rigidity modulus, bulk modulus, compressibility, Poisson's ratio.

**Geological and Geophysical Methods of Investigations**: Test pits and trenches, Geophysical methods used in engineering geological investigations: Seismic refraction surveying, seismic reflection surveying, gravity methods, geomagnetic methods, electrical resistivity method and applications to engineering site investigations and landfill surveys.

**Earth Movements Types Causes and Remedial Measures**: Landslides in clayay rocks. Sliding movement in hard rocks. Stabilization of slopes in slide areas and other preventive measures.

**Construction Materials**: Geological criteria for selection of construction material for various uses, viz. concrete aggregate rip-rap, rigid and flexible pavements, facing, roofing and paving. Environmental impact on materials.

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

**Unit V**
**Hydraulic Structures:** Types of Dams. Basic considerations of forces on dams, geological and geomorphological criteria for selection of dam sites. Dam sites on igneous, metamorphic and Siltation of reservoirs.
**Route Location:** Geological and photogeological investigations for route locations. Curing and half curing.
**Mining Geology:**
Classification of mining methods. Mining Methods: Placer mining methods, open pit methods, Underground mining methods, Coal Mining methods and Ocean bottom mining methods; their advantages and disadvantages. Mining hazards and safety measures,

**Books recommended:**
**Valdiya, K.S.** (1987) Environmental Geology – Indian Context. Tata McGraw Hill.
ISBN: 0074519719 9780074519714.
**Keller, E.A.** (1978) Environmental Geology, Bell and Howell, USA, 562 pages, ISBN: 0-13-022466-9.
**Bryant, E.** (1985) Natural Hazards, CambridgeUniversity Press.
**Patwardhan, A.M.** (1999) The Dynamic Earth System. Prentice Hall, ISBN: 8120314964 9788120314962.
**Subramaniam, V.** (2001) Textbook in Environmental Science, Narosa International, 238 pages, ISBN: 0849324084 9780849324086.
**Bell, F.G.** (1999) Geological Hazards, Routledge, London, ISBN : 0-419-16970-9, 324 pages, ISBN 0 415 01217 1
**Reynolds J. M.** (1998) An introduction to Applied and Environmental Geophysics, John Wiely& sons, England, ISBN: 0-471-96802, pp. 796.
**Lowrie W.** (1997) Fundamentals of Geophysics, Cambridge University Press, ISBN 0-521-461642, pp.354.
**Krynine, D.H. & Judd, W.R.** (1998) Principles of Engineering Geology, CBS Edition, 730 pages, ISBN 81-239-0603-X.
**Schultz, J.R. & Cleaves, A.B.** (1951) Geology in Engineering, John Willey & Sons, New York.
**McKinstry, H.E.**(1976) Mining Geology, Prentice Hall, Englewood Clifts, N.J. 680 pages.
**Clark, G.B**. (1967) Elements of Mining, III ed. John Wiley, 780 pages, **ISBN-10:** 0471533319.
**Arogyaswami, R.P.N.** (1996) Courses in Mining Geology, IV Ed. Oxford IBH.

**Elective Papers:**

**EPS 554: Numerical Methods & Computer Programming in Geosciences (2:1:0:3)**

**Unit I**

Numerical Methods: Solution of algebraic and transcendental equations, bisection and Newton-Raphson methods, solution of simultaneous linear equations, interpolation,

**Unit II**

Newton and Lagrange formula, numerical differentiation, numerical integration, Simpson, trapezoidal and Gaussian quadrature methods, least square curve fitting, straight line and polynomial fits.

**Unit III**

Computer Programming: Low level and high level languages, overview of compilers, interpreters and operating systems,

**Unit IV**

Problem solving on a computer, algorithms and flow charts integer and floating point arithmetic,

**Unit V**

`C' preliminaries, constants, variables, data types and expressions, built in functions, executable and non-executable statements assignment, control and input /output statements, subroutines and functions, operations with files.

Books recommended:

S.S. Sastry (2005); Introductory Methods of Numerical Analysis, PHI Learning Pvt. Ltd, 456 pages ISBN: 8120327616, 9788120327610

Jain, Iyengar & Jain (2007); Numerical Methods for Scienti_c and Engineering Computation, New Age International Publishers, 328 pages, ISBN : 8122426107.

V Rajaram, Computer Oriented Numerical Methods, Prentice-Hall of India Pvt.Ltd ISBN: 8120307860.

Robert Lafore, (1999); Object Oriented Programming C++, Galgotia Publication, ISBN: 8185623228.

Balaguruswamy, (1994) ; Programming in C, Tata McGra-Hill, 411 pages, ISBN 0074604015.

Raja Raman (1996); Fundamentals of Computers ,4ed, PHI Learning Pvt Ltd, ISBN 8120325818, 9788120325814.

Gottfried, (1996); Schaums outline of Theory and Problems of programming with C, 532 pages, **ISBN-10:** 0070240353.

Jean-Paul Trembly and Paul Sorenson, (2001); An introduction to data structures with applications, (2nd edition), 872 Pages, ISBN: 0074624717.

Kerninghan and Ritchie, (1988); The C programming language, Prentice Hall Series, 274 pages, ISBN-10: 0131103628

Tremblay and Manohar, (1975); Discrete Mathematical Structures, Tata McGraw Hill, 606 pages, **ISBN:** 9780074631133.

**EPS 555: Field Geology and Instrumental Techniques in Geology (2:1:0:3)**

**Unit I**

Introduction to Field Geology and Mapping Techniques, Essential Equipments and Supplies, Compass, Clinometer and GPS, Topographic Maps, Aerial Photographs and Satellite images,

Mapping Methodology and basic field procedures, Recording Observations, Geological Mapping.

**Unit II**

Procedures to collect samples and specimens, Identification and description of various minerals, rock types, primary and secondary structures and fossils and biogenic structures, Stratigraphy of the area based on field observations.

**Unit III**

Preparation of field report, A Short Field Visit and submission of a Field Report.

**Unit IV**

Various sample preparation techniques in mineralogy; Historical development of X-ray crystallography and Bragg's equation, powder method in X-Ray crystallography; Electron probe micro analysis and scanning electron microscopy – principle, application and their utility in mineral sciences.

**Unit V**

Introduction to ion microprobe analysis and infra red spectroscopy; Introduction to mineral formulae calculation of important rock forming minerals.

Suggested Readings:

1. Mathur, S.M., 2001, Guide to Field Geology, Prentice-Hall of India Pvt. Ltd., New Delhi, 2001, ISBN- 81-203-1915-X, 220p.
2. Bhattacharyya, A. and Chakraborty, C. (2005) Analysis of Sedimentary Successions: A Field Manual, Oxford & IBH Publishing Co. Pvt. Ltd., New Delhi-Kolkata, 445p.
3. McClay, K.R. (2005) The Mapping of Geological Structures, John Wiley & Sons, Chichester, 161p.
4. Compton, R.R. (1962) Manual of Field Geology, John Wiley & Sons Inc., 378 p.
5. Barnes, J.W. and Lisle, R.J. (2004) Basic Geological Mapping (Geological Field Guide), John Wiley & Sons Inc., ISBN- 978-0-470-84986-6, 378 p.

**EPS 556: Environmental Hazards and Disaster Management (2:1:0:3)**

**Unit I**

Introduction to environmental geology, Earth's place in space, Fundamental concept of environmental geology, human population growth, sustainability, Earth as a system, hazardous Earth process, scientific knowledge and value, culture and environmental awareness.

**Unit II**

Ecology for geologist, geology and biodiversity, factors that increase or decrease biodiversity, human domination of ecosystem, ecological restoration.

**Unit III**

Hazard, disaster and natural process, natural disaster: loss of life and property damage, magnitude and frequency of hazards, benefits of natural hazards.

**Unit IV**

Fundamental principles concerning natural hazards, role of history in understanding hazards, linkage between hazardous events. identifying the location where a hazardous event will occur. Determining the probability that an event of a given magnitude will occur, forecasting the event, warning the public.

**Unit V**

Risk determination, acceptable risk, and human response to hazards, anticipatory response: perceiving, avoiding and adjusting to hazards, Disaster preparedness: artificial control of natural process.

**Books recommended:**

**Valdiya, K.S.** (1987) Environmental Geology – Indian Context. Tata McGraw Hill. ISBN: 0074519719 9780074519714.

**Keller, E.A.** (1978) Environmental Geology, Bell and Howell, USA, 562 pages, ISBN: 0-13-022466-9.

**Bryant, E.** (1985) Natural Hazards, CambridgeUniversity Press.

**Patwardhan, A.M.** (1999) The Dynamic Earth System. Prentice Hall, ISBN: 8120314964 9788120314962.

**Subramaniam, V.** (2001) Textbook in Environmental Science, Narosa International, 238 pages, ISBN: 0849324084 9780849324086.

**Bell, F.G.** (1999) Geological Hazards, Routledge, London, ISBN : 0-419-16970-9, 324 pages, ISBN 0 415 01217 1

**Reynolds J. M.** (1998) An introduction to Applied and Environmental Geophysics, John Wiely& sons, England, ISBN: 0-471-96802, pp. 796.

**Lowrie W** (1997) Fundamentals of Geophysics, Cambridge University Press, ISBN 0-521-461642, pp.354.

**Practical Papers**

**EPS 533: Practical-I (0:0:4:2)**

*a) Igneous and Metamorphic Petrology:* Plotting of important igneous rock suits on the map of India. Preparation of tables and charts of textures and structures. Calculation of normative c-composition of igneous rock series. Modal analysis of igneous rocks. Use of universal stage to determine the 2V angle of igneous minerals. Study of igneous rocks in hand specimen. Systematic study of igneous rocks under microscope. Plotting of Important metamorphic rock suited on the map of India. Preparation of tables and charts of textures and structures. Study of metamorphic rocks in hand specimen. Systematic study of metamorphic rocks under microscope.

*b) Sedimentology:* Grain-size analysis, Identification of clay minerals, Roundness and shape analyses of clastic grains, Heavy mineral analysis, Study of sedimentary structures and Paleocurrent analysis, Megascopic and microscopic study of sedimentary rocks, Staining

techniques for identification of carbonate minerals, Study of profile sections of some selected sedimentary environment.

**EPS 534: Practical-II (0:0:4:2)**

a) *a) Computer Programming:* To write and execute simple computer programs in C/C++ language.

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

## M. Sc. Final : Spring Semester

**Core Papers:**

**EPS 601: Ore geology (4:0:0:4)**

**Unit I**

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

**Unit II**

Mineralisation associated with (i) ultramafic, mafic and acidic rocks, (ii) greenstone belts, (iii) komatiites, anorthosites and kimberlites and (iv) submarine volcanism, Stratiform and stratabound ores. Ores and metamorphism cause and effect relations, Forms of ore deposits,

**Unit III**

Methods of ore microscopy, Geothermometry, Metallogenic epochs and provinces of India, Strategic , essential and critical minerals with examples. Origin and distribution of important metallic (base metals, iron, manganese, aluminium, chromium, nickel, gold, silver, molybdenum) and non-metallic mineral deposits (asbestos, barytes, gypsum, graphite, apatite and beryl), Phosphorite deposits, Rare earth mineral deposits,

**Unit IV**

Raw material for ceramic, refractory, cement, paint, fertilizer, and glass industries and building stones, Gemstones, Buildingstones, Strategic, critical and essential minerals.

**Unit V**

Indias status in mineral production. Changing patterns of mineral consumption. National Mineral Policy. Mineral Concession Rules. Marine mineral resources and Law of Sea, Sulphide and oxide phase equilibria,

Books recommended:

Prasad, U. 2003, Economic geology, CBS Publ, Delhi, 319 pages, ISBN 81-239-0460-6.
Bateman, A.M. 1959, Economic mineral deposits. Asia Publ. House, 916p.

Evans, A.M. 1993, Ore geology and Industrial minerals, Blackwell, 389pages, ISBN 0-632-02953-6.
Mookherjee, A. 2000, Ore genesis-A holistic approach, allied Publ, New Delhi, 657 pages, ISBN 81-7032-576-6.
Stanton, R.L. (1972): Ore Petrology, McGraw Hill, New York,713 pages, *ISBN* 10: 0070608431.

**EPS 602: Geophysical Exploration (3:1:0:4)**

**Unit I**

Basic principles of geophysical exploration. Gravity Method: Gravity force and potential, Stable and unstable gravimeters, Worden, Lacoste and Romberg, Hartley, Askania and Gulf gravimeters, field procedure and reduction of gravity data. Various types of corrections applied to gravity data, preparation of gravity anomaly maps and their interpretation in terms of shape and size using simple models.

**Unit II**

Magnetic Method: Basic Theory, inverse square law, concept of potential, magnetism on atomic scale, Dia- para- ferro magnetic materials, susceptibilities and densities of various rocks and minerals, magnetic properties of rocks, working principle of the Fluxgate, Proton Precession and Rubidium vapour magnetometers. Magnetic anomalies over single pole, and dipole.

**Unit III**

Electrical methods: Electrical resistively, current distribution in homogeneous ground due to single electrode and dipoles. Resistively method: Basic principles, various types of electrode configurations, Wenner, and Schlumberger configurations. theory of images, Tagg's method of interpretation. Elements of SP and IP method. Basic Principle of EM method.

**Unit IV**

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

**Unit V**

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

Books recommended:

Telford, Geldart, Sheri and Keys, (2004); Applied Geophysics, Cambridge University Press, 792 pages, **ISBN-10:** 0521339383.
Milton B. Dobrin, (1988); Introduction to Geophysical Prospecting, 3rd Ed., McGraw Hill, 630 pages, **ISBN:** 0070171955.
William Lowrie, (1997); Fundamentals of Geophysics, Cambridge University Press, 354 pages, ISBN 0 521 63454 7.

Edwin S. Robinson, (1988); Basic Exploration Geophysics, John Wiley & Sons, 562 pages, ISBN : 0-471-87941-x.
Gadallah, M.R., Fisher, R., Fisher, R.L.,(2008); Exploration Geophysics, ISBN 978-3-540-85159-2,Springer.

**EPS 603: Geohydrology (3:1:0:4)**

**Unit I**

Hydrology cycle, precipitation, evaporation, evapotranspiration, seepage, infiltration and runoff. availability of water in the world, origin of groundwater, subsurface distribution of water, springs. Hydrology Properties of Water Bearing Materials: Porosity, types of porosity, permeability, transmissivity, storativity, specific yield, specific retention.

**Unit II**

Mode of occurrence of groundwater, classification of rock with respect to their water bearing characteristics, aquifers, aquicludes, aquifuge, aquitards, classification of aquifers and groundwater provinces.

**Unit III**

Movement of groundwater: Darcy's law, Reynolds number, and range of validity of Darcy's law, theory of groundwater flow under steady and unsteady conditions, Hydraulic conductivity and intrinsic permeability, determination of permeability, transmissivity and storativity by discharging pump tests. General flow equation.

**Unit IV**

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

**Unit V**

Ground Water Exploration and Management: Natural and artificial recharge of groundwater, water balance, analysis of hydrograph, conjunctive and consumptive use of groundwater.

Books recommended:

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

**EPS 604: Geochemistry (3:0:0:3)**

**Unit I**

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

**Unit II**
Stable isotope geochemistry of Carbon and Oxygen and its application in Geology. Radiogenic isotopes. Decay scheme of K-Ar, U-Pb and Rb-Sr. Geochemistry of Uranium and Lithium.

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

**Unit IV**
Structure and types of atoms. Types of chemical bonding. Ionic radii. Coordination number. Lattice energy. Ionization potential. Electronegativity. Pauling's rule. Isomorphism and polymorphism.

**Unit V**
Crystal structure of elements and simple compounds with reference to Non-silicate minerals – (i) Natural elements: closed packed structures, structures of AS, Sb, Bi, Diamond and graphite, (ii) Structure of some simple compounds – AX structure (NaCl, CaCl, ZnS, NiAs), AX2 structure (Fluorite, Rutile, etc.) A brief idea about some other compounds such as $A_2X_3$ (Corundum), $ABX_3$ (Calcite, Ilmenite), and $AB_2X_4$(Spinel). Principles of ionic substitution in minerals.

Books recommended:

Rankama, K. and Sahama, Th. G. (1950) Geochemistry. Univ. Chicago Press.
Mason, B. and Moore, C.B. (1991) Introduction to Geochemistry, Wiley Eastern.
Krauskopf, K.B. (1967): Introduction to Geochemistry. McGraw Hill, 616 pages, ISBN 0-07-035447-2.
Fyfe, W.S. (1964) : Geochemistry of Solids. McGraw Hill, New York, ISBN 10: 0070226458
Evans, R.C. (1964): Introduction to Crystal Chemistry. Cambridge Univ. Press , Cambridge, 410 pages.
Bloss, F.D. (1971): Crystallography and Crystal Chemistry. Holt, Rinehart, and Winston, New York, 545 pages, ISBN 1878907026.
Klein,C. and Hurlbut, C.S.(1993): Manual of Mineralogy, John Wiley & Sons, New York, 682 pages, ISBN 0-471-31266-5.

**Elective Papers:**

**EPS 651: Coal and Petroleum Geology (3:0:0:3)**
**Unit I**
Definition and origin of coal. Sedimentology of coal bearing strata, types of seam discontinuities and structures associated with coal seams. Chemical analysis of coal (proximate and ultimate analysis).
**Unit II**

Coal Petrology – concept of 'Lithotype', 'Maceral' and 'Microlithotype'. Classification and optical properties of macerals and microlithotypes. Techniques and methods of coal microscopy. Elementary knowledge of the application of reflectance and fluorescence microscopy. Application of coal petrology. Classification of coal in terms of Rank, Grade and Type. Elementary Idea about coal preparation, coal carbonization, coal gasification, coal hydrogenation, coal combustion and fertilizer form coal.

**Unit III**

Coalbed methane – a new energy resource. Elementary idea about generation of methane in coal beds, coal as a reservoir and coalbed methane exploration. Coal as a source rock in petroleum generation.

Geological and geographical distribution of coal and lignite deposits in India. Coal exploration and estimation of coal reserves. Indian coal reserves and production of coal in India.

Geological and geographical distribution of coal and lignite deposits in India. Coal exploration and estimation of coal reserves. Indian coal reserves and production of coal in India.

**Unit IV**

Petroleum – its composition. Origin (Formation of source rocks-kerogen, organic maturation and thermal cracking of kerogen) and migration of petroleum. Reservoir rocks-porosity and permeability. Reservoir traps – structural, stratigraphic and combination traps. Oilfield fluids – water, oil and gas. Oil shale.

**Unit V**

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

Books recommended:

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

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

Scott, A.C., 1987: Coal and Coal-bearing strata: Recent Advances. The geological Society of London, Publication no. 32, Blackwell scientific Publications.

R., 1982: Stach Textbook of Coal petrology. Gebruder Borntraeger, Stuttgart.

Stach, E., Mackowsky, M-Th., Taylor, G.H., Chandra, D., Teichumullelr, M. and Teichmuller.

Holson, G.D. and Tiratso, E.N., 1985: Introduction to Petroleum Geology. Gulf Publishing, Houston, Texas.

Tissot, B.P. and Welte, D.H., 1984: Petroleum Formation and Occurrence, Springer – Verlag. ISBN: 3540086986

North, F.K., 1985: Petroleum Geology. Allen Unwin, ISBN: 0045530033 9780045530038 0045530041 9780045530045

**EPS 652: Introduction to Mining and Ore Dressing (3:0:0:3)**

**Unit I**

Introduction:Classification of mining methods. Mining Methods: Placer mining methods, open pit methods, Underground mining methods, Coal Mining methods and Ocean bottom mining methods; their advantages and disadvantages.

**Unit II**

Ventilation in underground mining: Purpose, types and arrangements of ventilation in underground mining.

**Unit III**

Mining hazards and safety measures.

**Unit IV**

Ore dressing and its importance, low grade ores and their beneficiation; Ore-microscopy and its contribution to ore-dressing techniques. Aggregate properties of minerals and rocks and their consideration in ore dressing techniques. Basic ore dressing operations viz. crushing, grinding, sizing, screening and classification. Concentration process. Magnetic and electrostatic separation, gravity concentration, Froth Floatation, Amalgamation and Agglomeration.

**Unit V**

Dressing of Indian Metallic and non-metallic ores: Sulphide ores, non-sulphide ores, native metals, coal washing and Beneficiation of Beach Sand.

Books Recommended

McKinstry, H.E. Mining Geology, Prentice Hall, Englewood Clifts, N.J.

Clark, G.B. (1967) Elements of Mining, III ed. John Wiley.

Arogyaswami, R.P.N. (1996) Courses in Mining Geology, IV Ed. Oxford IBH.

Gaudin, A.M. Principles of Mineral Dressing. McGraw Hill Pub. Co. Ltd. Bombay.

**EPS 653: Gemology (3:0:0:3)**

**Unit I**

Gem and Gemstones. General characteristics and chemical composition of gemstones: Physical characteristics: Form, cleavage, fracture, hardness and specific gravity.

**Unit II**

Optical characteristics: colour, luster, play of colour, refractive index, reflectivity, pleochroism, dispersion.

**Unit III**

Application of ultraviolet rays, X-rays and Infra-red rays in gem identification.

Electrical thermal and magnetic characters of gem. Classification of gem stones.

**Unit IV**

Systematic description, genesis, mode of occurrence, distribution in India and also important world occurrences of important precious and semi-precious stones.

**Unit V**

Synthetic gem stones: methods of synthesis, and its characteristics and identification. Gem enhancement methods and their identification: colourless/coloured impregnation, heat treatment, coating, irradiation, diffusion, treatment, etc.

Application of gemstones: (1) Technical application and (2) Application as jewels

Books Recommended

Max Bauer (1968) Precious stones, Vol. I and II

Bruton Eric F.G.A. (1970) Diamonds

Orlov Yu L (1973) The Mineralogy of the Diamond

Wilson, M. (1967) Gems

Brocardo, G. (1981) Minerals and Gemstones – An identification Guide.

**Practical Papers:**

**EPS 631: Practical-I (0:0:4:2)**

*a) Ore geology*: Preparation of polished ore specimens, Study of ore minerals in hand specimen and under microscope, mineral paragenesis, preparation of mineral map of India.

*b) Geo-exploration:*

1. Determination of velocities and depth of the interface by refraction method.
2. To estimate the overburden and vertical depth of horizontal layer.
3. To estimate the velocity and dip of the bed of the dipping bed.
4. To apply the corrections to gravity data.
5. Delineate the ore body using gravity and magnetic data.
6. To prepare the self-potential anomaly of a sulphide ore body and to calculate the parameters of the ore body.
7. Preparation of a residual map using Graphical method.
8. Computation of gravity effect of a sphere, horizontal cylinder and fault.
9. Computation of effect of a magnetic dipole of finite length, sphere and horizontal cylinder.

**EPS 632: Practical –II (0:0:2:1)**

*Geohydrology*

Determination of average rainfall. Determination of maximum intensity of rainfall for different time durations. Determination of Hydraulic conductivity and Radius of influence of the Well for different types of aquifers. Determination of Hydraulic conductivity for isotropic and inhomogeneous aquifers. Determination of Storativity coefficient and Transmissivity using different methods. Determination of porosity and permeability. Determination of evaporation and evapotranspiration. Classification of irrigation water on the basis of SAR and conductivity.

## M. Sc. Final : Autumn Semester

**Core Papers:**

**EPS 605: Seminar (0:0:4:2)**

Student has to give seminar regularly on different topics during the semester.

**EPS 606: Viva-voce (Credit: 2)**

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

**EPS 607: Dissertation (16hrs/week, Credit: 12)**

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

**Subjects for dissertation** are: Impact Cratering Research, Structural Geology, Experimental and Field-based Mineralogy and Petrology, Sedimentolgy, Micropaleontology, Geophysics, Geohydrology and Remote Sensing.

**Elective Paper:**

**EPS 654: Term paper (0:0:4:2)**

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

**Practical Paper**

**EPS 633: Field Geology (2 Credits)**

*a) Field Geology:* 2 weeks of geological field work in some appropriate areas of economic mineral deposits and visit to various laboratories of repute. Submission of report thereon.

**********