# SCHOOL OF ENVIRONMENTAL AND EARTH SCIENCES

'A' Grade
NAAC Re-Accredited
(3rd Cycle)

## KAVAYITRI BAHINABAI CHAUDHARI NORTH MAHARASHTRA UNIVERSITY, JALGAON

**REVISED SYLLABUS**

**(With CGPA System)**

**For**

# M. Sc. (Applied Geology)

**w. e. f.**

**July 2018**

# SCHOOL OF ENVIRONMENTAL AND EARTH SCIENCES
# Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon

## SEMESTERWISE DISTRIBUTION OF COURSES

## M. Sc. (Applied Geology)

### Semester I

GS 101: Mineralogy and Crystallography.
GS 102: Principles of Stratigraphy and Palaeontology
GS 103: Sedimentology
GS 104: Practicals related to Mineralogy, Crystallography and Palaeontology.
GS 105: Practicals related to Sedimentology
GS 106: Tutorial 1

### Semester II

GS 201: Igneous and Metamorphic Petrology
GS 202: Physics and Chemistry of the Earth.
GS 203: Geomorphology, Structural Geology and Tectonics
GS 204: Practicals related to Igneous and Metamorphic Petrology
GS 205: Practicals related to Geomorphology, Structural Geology and Tectonics
GS 206: Tutorial 2

### Semester III

GS 301: Indian Stratigraphy.
GS 302: Indian mineral deposits, exploration and mining
***GS 303: Remote sensing and GIS**
GS 304: Practicals related to Indian mineral deposits, exploration and mining.
GS 305: Practicals related to Remote sensing and GIS.
GS 306: Seminar 1

### Semester IV

GS 401: Petroleum Geology.
***GS 402: Hydrogeology**
GS 403: Engineering and environmental Geology.
GS 404: Practicals related to Petroleum Geology, Hydrogeology, Engineering and environmental Geology
GS405: Dissertation
GS 406: Seminar 2

**Note:** Industrial training/Geological field mapping/allotted geological project work/ Dissertation is compulsory for M. Sc. (Applied Geology) students.

*Employability and Skill Development Courses

**SCHOOL OF ENVIRONMENTAL AND EARTH SCIENCES**

**Kavayitri Bahinabai Chaudhari North Maharashtra University, Jalgaon**

**COURSE STRUCTURE WITH CREDIT**

**M.Sc. (Applied Geology)**

| | Course | Marks | Hrs./ Week | Credit | Total |
|---|---|---|---|---|---|
| **Semester I** | GS-101 | 100 | 04 | 04 | **21** |
| | GS-102 | 100 | 04 | 04 | |
| | GS-103 | 100 | 04 | 04 | |
| | GS-104 | 100 | 08 | 04 | |
| | GS-105 | 100 | 08 | 04 | |
| | GS-106 | 25 | 01 | 01 | |
| **Semester II** | GS-201 | 100 | 04 | 04 | **21** |
| | GS-202 | 100 | 04 | 04 | |
| | GS-203 | 100 | 04 | 04 | |
| | GS-204 | 100 | 08 | 04 | |
| | GS-205 | 100 | 08 | 04 | |
| | GS-206 | 25 | 01 | 01 | |
| **Semester III** | GS-301 | 100 | 04 | 04 | **21** |
| | GS-302 | 100 | 04 | 04 | |
| | GS-303 | 100 | 04 | 04 | |
| | GS-304 | 100 | 08 | 04 | |
| | GS-305 | 100 | 08 | 04 | |
| | GS-306 | 25 | 01 | 01 | |
| **Semester IV** | GS-401 | 100 | 04 | 04 | **21** |
| | GS-402 | 100 | 04 | 04 | |
| | GS-403 | 100 | 04 | 04 | |
| | GS-404 | 100 | 08 | 04 | |
| | GS-405 | 100 | 08 | 04 | |
| | GS-406 | 25 | 01 | 01 | |

**Grand Total: 84**

## SEMESTER - I

## GS-101: MINERALOGY AND CRSTALLOGRAPHY

**Unit – I: Mineral Optics and Introduction to Instruments**

1. Isotropic and anisotropic substances; Reflection, refraction and refractive index; Relief, birefringence and Becke line effect; Optically uniaxial and biaxial minerals; Determination of optic sign of uniaxial and biaxial minerals; interference figures; Pleochroism and determination of pleochroic scheme in minerals
2. X-ray crystallography and Bragg's equation; Application of X-ray diffraction spectrometry in mineral characterization
3. Application of following techniques in mineralogy: Differential Thermal Analysis (DTA), Thermogravimetric Analysis (TGA), Scanning Electron Microscope (SEM), Transmission Electron Microscope (TEM) and Electron Probe Micro Analyser (EPMA)
4. Application of thermal, magnetic and radioactive properties of minerals.

**Unit – II: Introduction to Mineralogy and Study of Non-Silicates**

1. Principle of crystal structure; Bonding in minerals; Coordination and co-ordination numbers; Silicate structures and structural formula; Isomorphism and solid solution; Types of ionic substitution; Polymorphism and types of polymorphic transformations and Pseudomorphism Conversions of oxide and element weight percentages; Calculation of mineral formulae.
2. A detailed study of Non-silicates mineral groups with reference to their general formulae, classification, atomic structure, chemistry, experimental work and paragenesis of Non-silicates: Carbonates- Calcite Group, Aragonite Group, Dolomite Group; Phosphates- Apatite, Monazite; Sulphates- Gypsum, Anhydrite, Barite, Alunite Group; Halides- Halite, Sylvite, Fluorite; Nitrates- Trona, Soda niter; Oxides and Hydroxides- Spinel Group, Hematite Group, Rutile Group, Bauxite Group, Periclase.

**Unit – III: Mineralogy of Silicates**

1. A detailed study of Sillicate mineral groups with reference to their general formulae, classification, atomic structure, chemistry, experimental work and paragenesis of Silicates: Nesosilicates- Olivine Group, Garnet Group and Aluminosilicate Group; Sorosilicates- Epidote Group, Scapolite Group; Cyclosilicates- Beryl, Tourmaline; Inosilicates- Pyroxene Group,Amphibole Group; Phyllosilicate- Mica Group, Chlorite Group, Serpentine Group, Pyrophyllite, Talc; Tectosilicates- Quartz, Feldspars, Feldspathoides and zeolite Group.

**Unit – IV: Crystallography**

1. Crystals, crystalline solids and their formation; Ordered patterns, nets and lattices; Symmetry in crystals; Axial ratio, indices, lettering and order of the crystallographic axes; Crystallographic notation (Weiss and Miller indices and convention in notation).

2. Classification of crystals, introduction to 32 classes of symmetry; The crystal systems and symmetry types; Stereographic representation of crystal symmetry and their uses; Imperfection of crystals and crystal defects; Twinning- causes, effects and genetic types.

**Unit – V: Gemology**

1. Physical properties, Optical properties and Chemical properties of inorganic gems like Diamond, corundum, beryl, chrysoberyl, garnet, spinel, topaz, tourmaline, ziroon, peridot, jadeite, nephrite, opal, quartz, chalcedony, orthoclase, moonstone, labradorite, lapis lazuli, apatite, cordierite, zoisite, malachite, bowenite, denburite, diopside, enstatite, serpentine, steatite, natural glasses (obsidian and moldavite).
2. Study of Organic gems like Pearl, corals etc., their formation, structure and identification.
3. Introduction to instruments used in the study of gems.

**Books Recommended**


- Battey, M.H. (1981) Mineralogy for students 2nd Edn. Longmans.
- Berry, L.G. and Mason, B. and Dietrich, R.V. (1983) Mineralogy, 2nd Edn, Freeman.
- Bunn, C.W. (1961) Chemical Crystallography, Clarendon.
- Donald Bloss (1971) Crystallography and Crystal chemistry, Holt, Rinehart and Winston.
- Deer, W.A., Howie, R.A., and Zussman, J. (1992) An Introduction to the rock forming minerals, Longman.
- Hutchinson, C.S. (1974) Laboratory Handbook of Petrographic Techniques, John Wiley.
- Klein, C. and Hurlbut, Jr., C.S. (1993) Manual of Mineralogy, John Wiley.
- Kerr, P.F. (1977) Optical Mineralogy 4th Edn., McGraw-Hill.
- Phillips, Wm, R. and Griffen, D.T. (1986) Optical Mineralogy, CBS Edition.
- Putnis, Andrew (1992) Introduction to Mineral Sciences, Cambridge University Press.
- Santosh, M. (1988) Fluid Inclusions, Geological Society of India, Banglore.
- Spear, F.S. (1993) Mineralogical Phase Equilibria and Pressure -Temperature-Time Paths, Mineralogical Society of America Publication.
- Winchell, A.N. (1962) Elements of Optical Mineralogy, John Wiley.
- Slemmons, D.B. (1962).Determination of Volcanic and Plutonic Plagioclases using a three- or Four- Axis Universal Stage, Geological Society of America.
- Szymanski, A. (1988). Technical Mineralogy and Petrography, Elsevier.
- Hota, R.N. (2011) Practical Approach to Crystallography and Mineralogy, CBS Publisher and Distributors Pvt Ltd., New Delhi.

## GS-102: PRINCIPLES OF STRATIGRAPHY AND PALAEONTOLOGY

**Unit – I: History and development**

1. History and development of Stratigraphy
2. Stratigraphic procedures (Surface and Subsurface)
3. Concept of Litho-facies and Bio-facies

**Unit – II: Stratigraphic Correlation**

1. Stratigraphic Correlation (Litho-, Bio- and Chrono-stratigraphic Correlation
2. Study of standard stratigraphic code (Lithostratigraphic, Biostratigraphic and Chronostratigraphic)
3. Concepts of Magnetostratigraphy, Chemostratigraphy, Event stratigraphy, and Sequence stratigraphy
4. Techniques in Palaeontology - megafossils - microfossils - nannofossils - ichnofossils - collection, reformation and illustration - binomial nomenclature

**Unit – III: Invertebrate Paleontology**

1. Invertebrate Paleontology - A brief study of morphology, classification, evolutionary trends and distribution of Molluscs i.e. Bivalves, Gastropods and Cephalopods.
2. study of morphology, classification, evolutionary trends and distribution of Trilobites, Graptolites, Echinoids, Corals and Brachiopods.

**Unit – IV: Vertebrate Paleontology**

1. Vertebrate Paleontology - Study of vertebrate life through Geologic time scale.
2. Study of reptiles, birds, fishes and mammals.

**Unit – V: Paleontological perspective**

1. Introduction to Micropaleontology, Types of Microfossils, Paleo-palynology
2. Foraminifera and Ostracods
3. Plants of Gondwana Period.
4. Paleontological perspective : Use of paleontological data in
   a) Stratigraphy b) Paleo-ecology c) Paleogeography

### Books Recommended


- Boardman, R.S., Cheethan, A.M. and Rowell, A.J. (1988) Fossil Invertebrates, Blackwell.
- Clarksons, E.N.K. (1998) Invertebrate Paleontology and Evolution, Allen and Unwin, London.
- Dobzhansky, Ayala, Stebbins and Valentine (1977) Evolution, Freeman.
- Horowitz, A.S. and Potter, E.D. (1971) Introductory Petrography of Fossils, Springer Verlag.

- Mayr, E. (1971) Population, Species and Evolution, Harvard.
- Prothero, D.R. (2004) Bringing Fossil to Life – An Introduction to Paleontology (2nd Ed.), McGraw Hill.
- Raup, D.M. and Stanley, S.M. (1985) Principles of Paleontology , CBS Publishers, New Delhi.
- Smith, A.B. (1994) Systematics and Fossil Record – Documenting Evolutionary Patterns, Blackwell.
- Strean, C.W. and Carroll, R.L. (1989) Paleontology – the record of life, John Wiley.

# GS-103: SEDIMENTOLOGY

**Unit – I: Field procedures**

1 Field procedures in Sedimentary Petrology
2 Geologic cycle
3 Sedimentary textures (Granulometric analysis, shape and roundness studies, surface textures)
4 Heavy mineral and Insoluble residue analysis

**Unit – II: Petrography**

1 Petrography of rocks of clastic, chemical and biochemical origin (Conglomerates, Sandstone, Mudstone, Limestone and Dolomite)
2 Evaporite, Phosphorite, Chert, Iron and Manganese rich sediments
3 Volcanogenic sedimentary rocks

**Unit – III: Clastic transport and fluid flow**

1. Clastic transport and fluid flow (fluid flow in theory and in nature, Reynold's Numbers, Froude Number, Sediment lift, transport, deposition, sedimentary gravity flow)

**Unit – IV: Sedimentary structures**

1. Sedimentary structures (Physical structures, Biogenic sedimentary structures, Diagenetic structures).
2. Sedimentary Textures.

**Unit – V: Sedimentation and Tectonics**

1. Concept of Sedimentary facies association models (Marine, Nonmarine, and Mixed Depositional Environment)
2. Sedimentation and Tectonics
3. Paleocurrents and Basin Analysis.

## Books Recommended


- Blatt, H., Middleton, G.V. and Murray, R.C. (1980) Origin of Sedimentary Rocks, Prentice-Hall Inc.
- Collins, J.D. and Thompson, D.B. (1982) Sedimentary Structures, George Allen and Unwin, London.
- Lindholm, R.C. (1987) A Practical Approach to Sedimentology, Allen and Unwin, London.
- Miall, A.D. (2000) Principles of Basin Analysis, Springer-Verlag.
- Pettijohn, F.J. (1975) Sedimentary Rocks (3rd Ed.), Harper and Row Publ., New Delhi.

- Reading, H.G. (1997) Sedimentary Environments and facies, Blackwell Scientific Publication.
- Reineck, H.E. and Singh, I.B. (1973) Depositional Sedimentary Environments, Springer-Verlag.
- Selley, R.C. (2000) Applied Sedimentology, Academic Press.
- Tucker, M.E. (1981) Sedimentary Petrology: An Introduction, Wiley and Sons, New York.
- Tucker, M.E. (1990) Carbonate Sedimentolgy, Blackwell Scientific Publication.
- Hota, R.N. (2011) Practical Approach to Petrology, CBS Publisher and Distributors Pvt Ltd., New Delhi

## GS-104: PRACTICALS ON MINERALOGY, CRYSTALLOGRAPHY AND PALEONTOLOGY

1. Study of interference figures - determination of optical sign of minerals, determination of 2V and 2E, determination of composition of plagioclase feldspars - determination of birefriengence of minerals - Scheme of pleochroism
2. Construction of Stereograms and Gnomonograms - measurement of interfacial angle with contact goniometer - study of X-ray diffractograms
3. Study of rock forming minerals in thin sections
4. Study of rock forming minerals in hand specimens
5. Construction of rank charts for lithostratigraphy, biostratigraphy andchronostratigraphy
6. Construction of graphical logs from text descriptions
7. Exercises in correlation from given data or logs
8. Study of palaeontological technique related to megafossils.
9. Study of morphology of Bivalves, Gastropods Echinoids, Brachiopods
10. Separation, Processing, wet sieve analysis, preparation of slides of microfossils.
11. Morphology and morphological descriptions of planktonic and benthonic foraminifera, ostracodes.

## GS-105: PRACTICALS ON SEDIMENTOLOGY

1. Size Analysis (Procedures, Cumulative curve, Histogram, Visher's curve and Statistical calculation)
2. Shape analysis (Calculation and Classification)
3. Heavy mineral analysis (Procedure and identification)
4. Insoluble residue analysis (Procedure and identification)
5. Megascopic and studies of conglomerate and breccia
6. Megascopic and microscopic study of sandstone
7. Megascopic and microscopic study of limestone
8. Sedimentary structure (identification and classification)
9. Paleocurrent and basin analysis calculation

## SEMESTER – II

## GS-201: IGNEOUS PETROLOGY AND METAMORPHIC PETROLOGY

**Unit – I: Igneous Petrology**

1. Magma- its nature and composition. Factors controlling evolution of magma
2. Classification of Igneous rocks - historic perspective and the IUGS systematic
3. Introduction to mantle petrology mantle metasomatism and mantle heterogeneities;
4. Magmatism in relation to plate tectonics
5. Chemical characteristics of igneous rocks in the following tectonic setting: Mid Oceanic Ridge, Island Arcs, Oceanic plateaus, Continental Margins, Continental Rifts and Continental intraplates; Plume magmatism and hot spots; Large igneous provinces, mafic dyke swarms and layered complexes.
6. Equipments used in petrological study: Scanning electron microscope (SEM), electron Probe Microanalysis (EPMA), Atomic Absorption Spectrophotometry, Inductively Coupled Plasma Mass Spectrometry (ICPMS) and infrared spectrometers.

**Unit – II: Igneous Petrology**

1. Mantle melting: Partial melting (batch and fractional melting); Crystal fractionation (equilibrium and fractional (Rayleigh) crystallization); Contamination (AFC process) and dynamic melting.
2. Crystallisation of magma, fractional crystallization and differentiation, liquid immiscibility and assimilation. Influence of volatiles and role of oxygen fugacity in magmatic crystallizations.
3. Phase equilibrium studies - binary systems, ternary systems and their relations to magma genesis and crystallization in the light of modern experimental works.

**Unit – III: Igneous Petrology**

1. Textures and structures of igneous rocks; Petrography and Interpretation of igneous textures in terms of rate of nucleation and crystal growth.
2. Major, Trace and Rare Earth Element systematics in igneous rocks
3. Silica/alumina saturation, variation diagrams (Harker, AFM and TAS diagrams) their applications and limitations; Mg Number, Alteration Index, Saturation Index and other geochemical parameters.
4. Fractional crystallization, liquid lines of descent and lever rule.
5. Indian Igneous Rocks and their genesis

**Unit – IV: Metamorphic Petrology**

1. Types of metamorphism and their controlling factors
2. Grades of Metamorphism
3. Common minerals of metamorphic rocks
4. Metamorphic Texture and Structures
5. Prograde and retrograde metamorphism, Metasomatism
6. Metamorphic facies

**Unit – V: Metamorphic Petrology**

1. Phase diagrams and graphic representation of mineral assemblages
2. Metamorphic reactions, elemental exchange and P-T conditions of isograds.
3. Plate tectonics and metamorphic processes.
4. Paired metamorphic belts, Archaean and Proterozoic terrains.
5. Pressure-temperature time paths in regional metamorphic rocks, Polymetamorphism

**Books Recommended**


- Best, M. G. (2003) Igneous and Metamorphic Petrology, 2nd Edn., Blackwell.
- Bose, M.K. (1997) Igneous Petrology, World Press, Kolkata.
- Cox, K. G., Bell, J. D. and Pankhurst, R. J. (1979) The Interpretation of Igneous Rocks, Unwin Hyman.
- Faure, G. (2001) Origin of Igneous Rocks, Springer.
- Hall, A. (1996) Igneous Petrology, 2nd Edn., Longman.
- LeMaitre R.W. (2002) Igneous Rocks: A Classification and Glossary of Terms, Cambridge Uni. Press.
- McBirney, A.R. (2006) Igneous Petrology, 3rd Edn., Jones and Bartlett.
- Middlemost, E.A.K. (1985) Magmas and Magmatic Rocks, Longman.
- Parfitt, E. and Wilson, L. (2008) Fundamentals of Physical Volcanology, Wiley-Blackwell.
- Phillpotts, A.R. (1994) Principles of Igneous and Metamorphic Petrology, Prentice Hall of India.
- Sood, M.K. (1982) Modern Igneous Petrology, Wiley-Interscience Publ., New York.
- Srivastava, R.K. and Chandra, R. (1995) Magmatism in Relation to Diverse Tectonic Settings, A.A. Balkema, Rotterdam.
- Wilson, M. (1993) Igneous Petrogenesis, Chapman and Hall, London.
- Winter, J.D. (2001) Introduction to Igneous and Metamorphic Petrology, Prentice-Hall.
- Bell, Keith (Ed.) (1989) Carbonatites: Genesis and Evolution, Unwin Hyman, London.
- Bell, K., Kjarsgaard, B.A. and Simonetti, A. (1998) Carbonatites – Into the twenty-first Century, Journal of Petrology, Spl. Vol.39 (11 and 12).
- Carmichael, J., Turner and Verhoogen (1974) Igneous Petrology, McGraw Hill.
- Fitton, J.G. Upton, B.J.G. (Eds) (1987) Alkaline Igneous Rocks, Geological Society, London.

- LeBas, M.J. (1977) Carbonatite-nephelinite Volcanis, Wiley.
- Rock, N.M.S., (1991) Lamprophyres, Blackie, Glasgow.
- Perchuk, L.L. and Kushiro, I. (Eds.) (1991) Physical Chemistry of Magmas, Springer Verlag.
- Gupta, Alok (1998) Igneous Rocks, Allied Publishers Limited.
- Allegre, C.J. and Hart, S.R. (1979) Trace elements in Igneous Petrology, Elsevier.
- Hughes, C.J. (1982) Igneous Petrology, Elsevier.
- Hota, R.N. (2011) Practical Approach to Petrology, CBS Publisher and Distributors Pvt Ltd., New Delhi.
- Harker, Alfred (1964) Metamorphism, Methuen, London.
- Turner, F.J. (1980) Metamorphic Petrology, McGraw Hill, New York.
- Yardlley, B.W.D. (1989) An introduction to Metamorphic Petrology, Longman Scientific and Technical, New York.
- Philopotts, A.R. (1994) Principles of Igneous and Metamorphic Petrology, Prentice Hall.
- Bhaskar Rao, B. ( 1986) Metamorphic Petrology, IBH and Oxford.

# GS-202: PHYSICS AND CHEMISTRY OF THE EARTH

**Unit – I: Universe and Planetary System**

1. Origin and components of solar system
2. Meteorites and their classification
3. Earth in relation to the solar system and universe
4. Cosmic Abundances of elements
5. Composition of the planets and meteorites

**Unit – II: Physics of the Earth**

1. Seismic waves and their velocities
2. Internal structure of the earth,
3. Density distribution, shape and mass of the earth. density Vs depth profile.
4. Gravity and gravitational mechanics, gravity anomalies and their interpretation
5. The earth as Magnet, Earth's magnetic field, changes in magnetic field, origin of geomagnetic field, palaeomagnetism.

**Unit – III: Introduction to Geochemistry**

1. Introduction to Geochemistry – its scope, Geochemical Classification of the elements
2. Geochemical Cycle, path finder Elements, threshold values and Mode of Occurrence.
3. Geochemical classification and distribution of elements in the earth
4. Structure and atomic properties of elements
5. The Periodic table
6. Laws of Thermodynamics and phase diagrams
7. Geochemistry of hydrosphere, biosphere and atmosphere
8. Elementary crystal chemistry and thermodynamics
9. Structure Composition and evolution of the earth and distribution of elements.

**Unit – IV: Geochronology and age of the Earth**

1. Law of Radioactivity,
2. Principles of isotopic dating, Decay schemes and Derivation of equation of age.
3. Introduction to isotope geochemistry
4. Rb/Sr, U-Th-Pb methods of dating the rocks.
5. Age of the Earth.
6. Trace elements

**Unit – V: Geochemical Methods**

1. Geochemical methods – Geochemical Anomalies – Dispersion patterns – Geobotonical indicators of minerals – surface and subsurface methods of sampling.
2. Geological Principles of ore search – Introduction to Assaying and valuation of mineral deposits

## Books Recommended


- Telford, W.M., Geldart, L.P., Sherrif, R.E. and Keys, D.A. (1976) Applied Geophysics, Cambridge Univ. Press.
- Howel, B.F. (1959) Introduction to Geophysical Prospecting, McGraw Hill.
- Lowrie, W. (1997) Fundamentals of Geophysics, Cambridge University Press.
- Mussett, A.E. and Khan, M.A. (2000) Looking into the Earth: An Introduction to Geological Geophysics, Cambridge University Press.
- Sharma, P.V. (1986) Geophysical Methods in Geology, Elsevier.
- Allegre, C.J. and Michard, G. (1974) Introduction to Geochemistry, Reidel, Holland.
- Anderson, G.M. (2005) Thermodynamics of Natural Systems, Cambridge University Press.
- Winter, J.D. (2001) Introduction to Igneous and Metamorphic Petrology. Prentice-Hall.
- Bloss, F.D. (1971) Crystallography and Crystal Chemistry, Holt, Rinehart, and Winston, New York.
- Drever, J.I. (1997) The Geochemistry of Natural Waters, 3rd Edn., Prentice Hall.
- Evans, R.C. (1964) Introduction to Crystal Chemistry, Cambridge Univ. Press.
- Faure, G. (1998) Principles and applications of geochemistry, 2nd Edn., Prentice Hall, New Jersy, 593p.
- Faure, G. (1986) Principles of Isotope Geology, 2nd Edn., John Wiley.
- Hoefs, J. (1980) Stable Isotope Geochemistry, Springer-Verlag.
- Klein, C. and Hurlbut, C.S. (1993) Manual of Mineralogy, John Wiley and Sons, New York.
- Krauskopf, K.B. (1967) Introduction to Geochemistry, McGraw Hill.
- Mason, B. and Moore, C.B. (1991) Introduction to Geochemistry, Wiley Eastern.
- Rollinson, H.R. (1993) Using geochemical data: Evaluation, Presentation, Interpretation, Longman U.K.
- Wood, B.J. and Fraser, D.G. (1977) Elementary Thermodynamics for Geologists, Oxford University Press, London.
- Rastogy, R.P. and Mishra, R.R. (1993) An Introduction to Chemical Thermodynamics, Vikash Pub. House.
- Anderson, G.M. and Crerar, D.A. (1993) Thermodynamics in Geochemistry- the equilibrium model, Oxford University Press, New York.
- Fletcher, P. (1993) Chemical thermodynamics for earth sciences. Longman Scientific and Technical, London.
- Glasstone, S. (1947) Thermodynamics for Chemists, East and West Pub.

## GS-203: GEOMORPHOLOGY, STRUCTURAL GEOLOGY AND TECTONICS

**Unit – I: Introduction to Geomorphology**

1. Introduction to Geomorphology : History, basic concepts type and tools
2. Landforms : Role of lithology, climate and tectonics
3. Denudational processes - weathering, erosion, transportation, weathering products and soils - profiles, types, duricrusts
4. Hillslopes : Their characteristics and development, fluvial processes on hill slopes
5. River and Drainage basin : Drainage patterns, network characteristics, Valleys and their development. Process of river erosion, transportation and deposition

**Unit – II: Geomorphic Landforms and Applied Geomorphology**

1. Landforms produced by geomorphic agents
   a) Fluvial b) Coastal c) Aeolian, d) Glacial, e) Karst, and Desert landforms
2. Applied Geomorphology : Application of geomorphology in geohydrology, mineral prospecting, engineering geology, watershed management, urban planning and environmental studies
3. Geomorphology of India : Geomorphological features and zones
4. Geomorphic mapping
5. Slope analysis and drainage basin analysis
6. Physiographic zones of Maharashtra
7. Topographical maps

**Unit – III: Introduction to Structural Geology**

1. Principles of geological mapping and map reading
2. projection diagrams
3. Mechanical principles of rock deformation,
4. Behaviour of rock material under stress, strain analysis
5. Classification and genesis of folds, faults, lineations, foliations, joints and fractures

**Unit – IV: Structural Analysis**

1. Scope of structural analysis , concept of Tectonite fabric and Tectonite Symmetry
2. Structural analysis on microscopic, mesoscopic and macrosopic scales
3. Introduction to petrofabrics
4. Structural behavior of igneous rocks, diapers and salt domes diapers and salt domes

**Unit – V: Tectonics**

1. Structure and physical characters of continental and oceanic crust
2. seismic belts of the earth

3. Continental drift – geological and geophysical evidence, mechanics, objections, present status
4. Sea - floor spreading and Plate Tectonics, Structure and Tectonics of divergent margins, transform faults, convergent margins
5. Geodynamics of the Indian Plate and Tectonic framework of India
6. Heterogeneity of the earth's crust
7. seismicity and Plate movements
8. Neotectonics - Features and evidences-characterastic landforms, Methods of analysis
9. Orogeny and epeirogency
10. Isostasy
11. Gravity and magnetic anomalies at Mid-ocean ridges, deep sea trenches, continental shield areas and mountain chains, , Island arcs, Oceanic islands and volcanic arcs,

**Books Recommended**


- Ghosh, S.K. (1993) Structural Geology: Fundamental and Modern Developments, Pergamon Press.
- Hobbs, B.E., Means, W.D. and Williams, P.F. (1976) An outline of Structural Geology, John Wiley and Sons, New York.
- Ramsay, J.G. (1967) Folding and fracturing of rocks, McGraw Hill.
- Ramsay, J.G. and Huber, M.I. (1983) Techniques of Modern Structural Geology, Vol. I, Strain Analysis, Academic Press.
- Ramsay, J.G. and Huber, M.I. (1987) Techniques of Modern Structural Geology, Vol. II, Folds and Fractures, Academic Press.
- Ramsay, J.G. and Huber, M.I. (2000) Techniques of Modern Structural Geology, Vol. III (Application of continuum mechanics), Academic Press.
- Turner, F.J. and Weiss, L.E. (1963) Structural analysis of Metamorphic Tectonites, McGraw Hill.
- Marshak, S. and Mitra, G. (1988) Basic methods of Structural Geology, Prentice-Hall, New Jersey.
- Condie, K.C. (1989) Plate Tectonics and Crustal Evolution, 3rd Ed., Pergamon, Oxford Press.
- Kearey Phillips and Vine, F.J. (1996) Global Tectonics, Blackwell Science, Oxford.
- Windley, B.F. (1977) The Evolving Continents, John Wiley and Sons, New York.
- Moores, E and Twiss, R.J. (1995) Tectonics. Freeman.
- Keary, P., Klepeis, K.A. and Vine, F.J. (2012) Global Tectonics. Third Edition (Reprint), Wiley-Blackwell, Wiley India Pvt. Ltd.
- Storetvedt, K.N. (1997) Our Evolving Planet: Earths History in New Perspective. Bergen (Norway), Alma Mater Fortag.
- Patwardhan, A.M. (1999) The Dynamic Earth System, Prentice-Hall, New Delhi
- Gass, I.G. (1982) Understanding the Earth, Artemis Press (Pvt) Ltd. U.K.
- Moores, Eldridge M. and Twiss, Robert J. (1995) Tectonics, Freeman and Company.
- Valdiya, K.S. (1984) Aspects of Tectonics -Focus on south central Asia, Tata McGraw- Hill.
- Sharma, H.S. (1990) Indian Geomorphology, Concept Publishing Company, New Delhi

- Thornbury, W.D. (1980) Principles of Geomorphology, Wiley Easton Ltd., New York
- Kale and Gupta, Introduction to Geomorphology.
- Rice, Fundamentals of Geomorphology.


## GS-204: PRACTICALS RELATED TO IGNEOUS AND METAMORPHIC PETROLOGY

1. Characterisation of Igneous rocks, textures and structures.
2. Characterisation of differentg rock types under microscope.
3. Igneous rocks and Metamorphic rocks
4. CIPW normative calcaluation for igneous rocks.
5. Variation diagrams (Binary and Ternary)

## GS-205: PRACTICALS RELATED TO GEOMORPHOLOGY, STRUCTURAL AND TECTONICS

1. Structural problems by orthographic and stereographic methods.
2. Construction of structural sections and interpretation of geological maps.
3. Plotting and interpretation of mesoscopic structural data
4. Drainage basin and network morphometry
5. Relief and slope anlysis - Profiles and maps
6. Identification of landforms on toposheets, aerial photographs and satellite images
7. Study of representative soil profiles

## SEMESTER – III

## GS-301: INDIAN STRATIGRAPHY

**Unit - I: Archeans**

1. Tectonic framework of India – Cratons and Mobile Belts
2. Dharwar Craton EDC and WDC (Gold Bering Schist belts and Iron Ore Group)
3. Singbhum Craton (OMG, OMTG and Iron Ore Group)
4. Baster Craton (Sukma, Bengpal and Bailadila Series)
5. Arvalli Craton (BGC, Sandmata Complex, Bhiwara Super group)
6. Budelkhand (Supracrustal Gneisses and Budelkhand Granite)

**Unit - II: Mobile Belts**

1. Satpura Mobile Belts
2. Pandyan Mobile Belts
3. Easter Ghats Mobile Belts (Charnockite and Khondalite)

**Unit - III: Proterozoics of Peninsular India**

1. Delhi Super Group
2. Vidhayan Super Group
3. Cuddapah Super Group
4. Sausar- Sakoli Group
5. Kaladgi Group Bhima
6. Pranhita-Godavari Group

**Unit - IV: Phanerozoic Stratigraphy of India**

1. Ophiolite Belt (Indus, Shayok, Trans- Himalaya and Karakoram Batholiths)
2. Stratigraphic and Tectonics of Siwalik
3. Stratigraphic and Tectonics of Spiti Valley
4. Gondwana Super Group
5. Deccan Volcanic Province (DVP)
6. Marine transgression and regression

**Unit - V: Recent Geology**

1. Cenozoic Geology of India
2. Quaternary Sediments
3. World stratigraphy – Time Scale and geologic events

## Books Recommended


- Boggs, S. (2001) Principles of Sedimentology and Stratigraphy, Prentice Hall.
- Danbar, C.O. and Rodgers, J. (1957) Principles of Stratigraphy, John Wiley and Sons.
- Doyle, P. and Bennett. M.R. (1996) Unlocking the Stratigraphic Record, John Wiley and Sons.
- Krishnan,M.S. (1982) Geology of India and Burma, C.B.S. Publ. and Distributors, Delhi.
- Naqvi, S.M. and Rogers, J.J.W. (1987) Precambrian Geology of India, Oxford University Press.
- Pascoe, E.H. (1968) A Manual of the Geology of India and Burma (Vols.I-IV), Govt. of India Press, Delhi.
- Pomerol, C. (1982) The Cenozoic Era: Tertiary and Quaternary, Ellis Harwood Ltd., Halsted Press.
- Schoch, Robert, M. (1989) Stratigraphy: Principles and Methods, Van Nostrand Reinhold, New York.
- Ramakrishnan, M. and Vaidyanadhan, R. (2008) Geology of India, Vol.1, Geological Society of India, Bangalore.
- Vaidyanadhan, R. and Ramakrishnan, M. (2008) Geology of India, Vol.2, Geological Society of India, Bangalore.

## GS-302: INDIAN MINERAL DEPOSITS, EXPLORATION AND MINING

**Unit – I: Ore genesis:**

1. Ore bearing fluid, Fluid inclusion studies, Ore deposits and ore minerals
2. Metallogenetic Epochs and Proviences
3. Magmatic processes of mineralization, Porphyry, Skarn and hydrothermal mineralization, Ores and metamorphism- cause and effect relations, Stratiform and Stratabound ores.
4. Mineralization associated with – (i) Ultramafic, mafic and acidic rocks. (ii) Greenstone belts. (iii) Komatites, Anorthosites and Kimberlites and (iv) Submarine volcanism

**Unit – II: Indian Mineral Deposits:**

1. Occurrence and distribution in India of metalliferous deposits – base metals, iron, manganese, aluminum, chromium, nickel, gold, silver and molybdenum.
2. Indian deposits of non-metals – mica, asbestos, barites, gypsum, graphite, apatite and beryl, Gemstones, refractory minerals, abrasives and minerals used in glass, fertilizer, paint, ceramic and cement industries, Building stones, Phosphorite deposits, Placer deposits and rare earth minerals.

**Unit – III: Indian Coal deposits and Mineral Economics:**

1. Coal deposits: Classification, genesis and distribution of coal fields in India
2. Strategic, critical and essential minerals,
3. India's status in mineral production changing patterns of minerals consumption, National Mineral Policy,
4. Mineral Concession Rules, Marine mineral resources and Law of sea.

**Unit – IV: Mineral exploration:**

1. Surface and subsurface exploration techniques
2. Guides to ore: Regional and Topographical Guides, Mineralogical Guides Structural Guides and Stratigraphic Guides
1. Prospecting for economic minerals – drilling, sampling and assaying,
2. Geophysical techniques – gravity, electrical, magnetic, airborne and seismic geophysical techniques.
3. Geomorphological and remote sensing techniques
4. Geobotanical and geochemical methods
5. Geochemical prospecting

**Unit – V: Drilling, Logging and Mining:**

3. Drilling Methods: Percussion Drills – Jumper bar drills- Pneumatic drills - Churn drills- Reich drills, Rotary Drills -Auger drills -Colyx drills-Turbo drills- Diamond drills
4. Borehole logging and surveys for deviation.
5. Mining Methods - Alluvial Mining- Open Cast Mining - Under ground Mining

**Books Recommended**


- Geochemistry In Mineral Exploration Awakes, H & Wobb J.S. Harper & Row New York.
- Principles Of Geochemical Prospecting, Ginsburg. I.I. Pentagon Press, N.Y. london.
- Geochemistry Of Rare And Dispersed Chemical Elements In Society, Vinogradev.
- Biochemical Methods Of Prospecting, Malyuga, D.P.
- Geochemistry Of Epigenesis - Faibidge.
- Principles of Mining Geology, Arogyaswamy.
- Introduction To Geophysical Prospecting - Milton B, Dobrin Mc-Graw Hill Book Company, Inc
- Exploraion Geophysics - Jakaosku, J.J.
- Outlines Of Geophysical Prospecting - A manual for Geologists. M.B.R. Rao. Prasaranga, Mysore University
- Geophysical Methods in Geology - P.V. Sharma.
- Applied Geophysics In The Search For Minerals - Eve. A.S.Keys.
- Geophysical Exploration - Heilava. C.H.
- Exploration Geophysics for Geologists And Engineers - Edited by Bhimasanakaran, V.L.S. Gour. V.K. - The Association of Exploration Geophysists - Hyderabad
- Principles of Applied Geophysics - D.S. Parasnis
- Introduction to Geophysics - C. H. Howel.
- The Geology Of Ore Deposits - John M. Guilbert and charles. F.Park, Jr.W.H.Freeman and Co., New York. 1986.
- Economic Mineral Deposits, Bateman, A.M.
- Ore Deposits - Park, Jr. C.F.
- Geology Of Mineral Deposits - Smirnov, U.J.
- The Ore Minerals And Their Intergrowths - Ramhor, Dr. Paul.
- Ore Petrology - Stanton, R.L.
- India's Mineral Resources - Krishnaswamy, S.
- Metallic and Industrial minerals - Lamey Carl, A.
- Introduction To India's Economic Minerals - Sharma, N.L. & Ram. K. S.
- A Treatise On Industrial Minerals Of India-Sinha, R.L.
- Mineral Deposits Of India, Mukerjee 1999: Allied publications.
- Elements of Mining Geology, Young
- Elements of Mining - Lewis
- Mining Of Mineral Deposits – Shevyekov
- Introduction Of Mining - Stoces

## GS-303: REMOTE SENSING AND GIS

**Unit – I: Fundamentals of Remote Sensing**

1. Concepts and principles of Remote Sensing
2. The nature and generation of EMR
3. Interaction of EMR with the atmosphere and earth's surface features.
4. Introduction to Photogrammetry

**Unit – II: Satellite Remote Sensing:**

1. Satellite Remote Sensing – Data products and their specifications
2. Remote Sensing observations and platforms
3. Types of sensors, Data Resolution
4. Global and Indian Space missions

**Unit – III: Digital Image Processing and Image Interpretation**

1. Digital Image Structure and Data recording formats
2. Image rectification and restoration
3. Image enhancement and classification
4. Image transformation and data fusion
5. Ground truths and training sets in image processing and in automated processing
6. Visual photo interpretation techniques based on 'photo elements' and 'terrain elements'

**Unit – IV: Geographic Information Systems (GIS)**

1. Principles and applications of GIS
2. Map Projections Systems, Map Visualization
3. Traditional maps, map scales and their interpretation
4. Components of GIS, GIS data models and structures
5. GIS analysis and GIS modeling
6. Integration of Remote sensing and GIS techniques and it's applications in Geological Sciences

**Unit – V: Computer Applications and GPS**

1. Basic concepts of computer, hardware, operating systems
2. Application software in Geology
3. Principles and applications of GPS

**Books Recommended**


- Lattman, L.H. and Ray, R.G. (1965) Aerial photographs in field geology, McGraw Hill.
- Pande, S.N. (1987) Principles and Applications of Photogeology, Wiley Eastern Limited.
- Drury, S.A. (1997, 2001) Image Interpretation in Geology, Chapman and Hall, London.
- Gupta, R.P. (1991) Remote Sensing Geology, Springer-Verlag.
- Lillesand, T.M. and Kiefer, R.W. (2000) Remote Sensing and Image Interpretation, John Wiley and Sons Inc., New York.
- Siegal, B.S. and Gillespie, A.R. (1980) Remote Sensing in Geology, John Wiley.
- Miller, V.C. (1961) Phologeology, McGraw Hill
- Sabins, F.F. Jr. (2000) Remote Sensing Principles and Interpretations, W.H. Freeman & Company, USA.
- Berhardsen, T. (1999) Geographic Information System: an introduction, Wiley, New York
- Curran, P.J. (1985) Principles of Remote Sensing, Longman Scientific & Tech. Group, Essex, England
- Richards, J.A. (1986) Remote Sensing Digital Analysis: an introduction, Springer-Verlag, Berlin.
- Burrough, P.P. and MacDonnel, R.A. (1998) Principles of GIS, Oxford University Press.
- Ray, R.G. (1969) Aeriat Photographs in Geologic Interpretations, USGS Proc Paper 373
- Mikhail, E.M. (1980) Photogrammatry, Harper and Row
- Paine, D.P. (1981) Aerial photography and Image Interpretation for Resource Management, John Wiley.
- Jensen, J.R. (1986) Introductory Digital Image Processing: A Remote Perspective. Prentice Hall, New Jersy.
- Jain, A.K. (1989) Fundamentals of digital image processing, Prentice Hall India.
- Bonham-Carter, G.F. (1994) Geographic Information System for Geoscientists: Modelling with GIS, Pergamon.
- Maguire, D.J., Goodchild, M.F. and Rhind, D.W. (1991) GIS - Principles and Applications, Longman Scientific and Technical.
- Burrough, P.A. (1986) Principles of Geographical Information Systems for land resources assessment. Clarendon Press, Oxford.

## GS-304: PRACTICALS RELATED TO INDIAN MINERAL DEPOSITS, EXPLORATION AND MINING

1. Delineation of ore deposit based on exploration data.
2. Economic evaluation of ore deposit.
3. Preparation of technical report.
4. Geochemical map interpretation, Interpretation of anomalies groundwater and river water, Selection of geochemical methods in mineral exploration.
5. Interpretation of field geophysical data gravity, magnetic, electrical, seismic and radio active in deciphering groundwater, mineralized zones and construction site evaluation.
6. Study of metallic and non- metallic economic minerals.

## GS-305: PRACTICALS RELATED TO REMOTE SENSING AND GIS

1. Determination of photo scale,
2. Study of traditional maps
3. Visual interpretation of earth's features from aerial photographs and satellite images
4. Stereo-photo interpretation
5. Photogrametric computation
6. Preparation of different thematic maps in GIS
7. Operation of GPS
8. Drawing flow charts for the computer programs required in solving Geoscientific problems

## SEMESTER – IV

## GS-401: PETROLEUM GEOLOGY

**Unit – I: Composition of Reservoir and Source rocks**

1. Composition of hydrocarbons & non hydrocarbons component
2. Physico-chemical properties of hydrocarbons (oil, gas, oil field waters, Coal bed methane, hydrates)
3. Surface & subsurface occurrences of hydrocarbons
4. Theories of Organic and inorganic Origin of hydrocarbons: Merits & De-merits
5. Organic petroleum geochemistry and conversion of organic matter into hydrocarbons
6. Kerogen : Composition, classification and types
7. Source & reservoir rocks (porosity & permeability); petroliferous basins

**Unit – II: Total Petroleum Systems**

1. Limestone Classification
2. Migration-Primary & Secondary, characteristics & processes
3. Accumulation: Favorable & unfavorable conditions; nature of accumulation
4. Clastic and Non-clastic Reservoirs rocks
5. Traps: introduction, conditions of formation and Types
6. Introduction to Oil-Water, Gas-Oil Contacts
7. Fluid flow within Reservoirs

**Unit – III: Exploration & Logging**

1. Introduction to Geophysical
2. Logging: Introduction, Types & Interpretation.
3. Seismic methods: Principles, techniques, tools and interpretation
4. Electrical logs: Principles, techniques, tools and interpretation
5. Gamma ray & neutron logs: Principles, techniques, tools and interpretation

**Unit – IV: Drilling Techniques**

1. Introduction to Drilling methods,
2. Rigs and their types used in oil exploration
3. Component of Rigs & Drilling Mechanism.
4. Drilling and mud parameters
5. Enhance Oil Recovery (EOR): Primary, Secondary & Tertiary

**Unit – V: Petroliferous basins**

1. World scenario and at least one case study of economically important Hydrocarbon deposits;
2. Petroliferous basins of India
3. Stratigraphy, lithology, structure and reserve estimation of – Bombay high, Krishna Godavari, Assam, Cambay and Jaisalmer Basins

## Books Recommended


- Leverson, A.L. (1970) Geology of Petroleum, Freeman and Company.
- North, F.K. (1985) Petroleum Geology, Allen and Unwin.
- Holson, G.D. and Tiratsoo, E.N. (1985) Introduction to Petroleum Geology, Gulf Publ. Houston, Texas.
- Tissot, B.P. and Welte, D.H. (1984) Petroleum Formation and Occurrence, Springer- Verlag.
- Selley, R.G. (1998) Elements of Petroleum Geology, Academic Press.
- Russel : Petroleum Geology
- Primer of Oil well drilling : By IADC
- Bhagwan Sahay : Mud logging
- Person : Geological Well drilling technology
- Cray and Cole : Oil & well drilling technology
- Kennedy : Fundamentals of Drilling
- Hearst & Nelson : Well logging for physical properties
- Killops & Killops (200) Organic Geochemistry
- F. K North Petroleum Geology

# GS-402: HYDROGEOLOGY

**Unit – I: Introduction**

1. Hydrosphere – Hydrological Cycle, Evaporation, condensation, precipitation, interception, runoff cycle (surface, subsurface and groundwater), infiltration.
2. Factors that affect occurrence of groundwater – Climate, topography and geology
3. Hydrogeological classification of rocks
4. Constraints of water resources
5. Hydrologic properties of Rocks – Porosity, Hydraulic conductivity
6. Derivation and validation of Darcy's Law.
7. Aquifers – Characteristics of unconfined and confined aquifers
8. Behaviour of alluvium, sedimentary, crystalline and volcanic rocks as aquifers

**Unit – II: Wells and Pumping tests**

1. Types of well
2. Flow net analysis
3. Pumping tests – principles – types of pumping tests, procedures, determination of aquifer properties and well characteristics by simple graphical methods.
4. Significance of Transmissivity, Storativity and specific capacity of wells.
5. Water Audit and its significance.

**Unit – III: Groundwater quality and Aquifer Mapping**

1. Quality of groundwater – chemical standards for drinking and irrigational water- concept of hydro-geochemical facies
2. Seawater intrusion – Ghyben Herzberg relation – remedial measures
3. Environmental interpretation of quality data and its impact.
4. Concept Aquifer Mapping, Methodology, Techniqes and Model Study.

**Unit – IV: Exploration techniques**

1. Integrated approach to groundwater prospecting: Role of toposheets and remote sensing in groundwater exploration
2. Hydrogeomorphological mapping
3. Surface and subsurface Geophysical methods,
4. Tracer techniques Exploratory Borewell programme.
5. Type of Ground water Investigation Processes.

**Unit – V: Watershed Development and management**

1. Introduction to Watershed development : Artificial recharge techniques, surface water harvesting techniques.
2. Conjunctive use of groundwater.
3. Groundwater provinces of India.
4. Groundwater in Maharashtra state.
5. Groundwater legislation

## Books Recommended


- Davies, S.N. and De Wiest, R.J.N. (1966) Hydrogeology, John Wiley and Sons, New York.
- Driscoll, F.G. (1988) Groundwater and Wells, UOP, Johnson Div. St. Paul. Min. USA.
- Karanth, K. R. (1989) Hydrogeology, Tata McGraw Hill Publishers.
- Nagabhushaniah, H.S. (2001) Groundwater in Hydrosphere (Groundwater hydrology), CBS Publ.
- Raghunath, H.M. (1990) Groundwater, Wiley Eastern Ltd.,
- Todd, D.K. (1995) Groundwater Hydrology, John Wiley and Sons.
- Tolman, C.F. (1937) Groundwater, McGraw Hill, New York and London.

## GS-403: ENGINEERING AND ENVIRONMENTAL GEOSCIENCES

**Unit – I: Introduction to Engineering Geology**

1. Scope of Engineering Geology
2. Engineering properties of rocks and soils; and their determination.
3. Rock mechanics: Behavior of rocks under stress, Rock failure mechanisms

**Unit – II: Construction Sites**

1. Geological considerations for the selection of dam sites
2. Geological considerations for Spillways,
3. Geological considerations for tunnels and Bridges

**Unit – III: Geo-material**

1. Building stones and road metals; Aggregates and its classification
2. Rock testing: Mechanical test, Chemical test, Durability test
3. Aggregate resource development:
   a. Requirement of primary fragmentation
   b. Planning of quarry, hill slope side or open pit.
   c. Removal of overburden and its disposition at suitable site
   d. Selection of drilling, blasting method for main blasting and secondary breaking for given size of fragmentation
   e. Selection of equipment's for drilling, loading, hauling to crusher site
   f. Methods of extraction of aggregate resources
   g. Use of synthetic materials used as remedial measures
   h. Estimation of overburden thickness & rock strata classification

**Unit – IV: Introduction to Environmental Geology**

1. Introduction, Fundamental concepts, scope. Man and environment.
2. Natural and Man- made hazards and disasters
   a. Lithospheric hazards- volcanoes, earth quakes, landslides, land subsidence, tsunamis, meteorite strike, etc.
   b. Hydrospheric hazards- sea level changes, coastal hazards, water pollution (sea, river and ground water), floods
   c. Atmospheric hazards- air pollution, acid rain, etc
   d. Man-made hazards- industrial, nuclear, mining, etc
3. Remedial measures: Introduction, origin, characteristics and preventive measures- water pollution, soil pollution and air pollution.
4. EIA (Environmental Impact Assessment) and case studies.

**Unit – V: Marine Geology**

1. Introduction and significance of Physical, Chemical and Biological oceanography
2. Shallow and deep water Marine Resources and significance: E.g. Polymetalic nodules and oozes

3. Tidal Energy: Introduction and harnessing
4. Marine pollution: Oil spills and nuclear waste disposal

**Books Recommended**


- Bell, F.G. (1999) Geological Hazards, Routledge, London.
- Bryant, E. (1985) Natural Hazards, Cambridge Univ. Press.
- Keller, E.A. (1978) Environmental Geology, Bell and Howell, USA.
- Lal, D.S. (2007) Climatology, Sharda Pustak Bhawan, Allahabad.
- Perry, C.T. and Taylor, K.G. (2006) Environmental Sedimentology, Blackwell Publ.
- Patwardhan, A.M. (1999) The Dynamic Earth System, Prentice Hall.
- Smith, K. (1992) Environmental Hazards, Routledge, London.
- Subramaniam, V. (2001) Textbook in Environmental Science, Narosa International.
- Valdiya, K.S. (1987) Environmental Geology – Indian Context, Tata McGraw Hill.
- Bell, F.G. (1981) Engineering properties of Soils and Rocks, Butterworths Publication, London.
- Bell, F.G. (1993) Fundamentals of Engineering geology, Butterworths Publication, London.
- Garg, S.K. (2009) Physical and Engineering Geology, (6th Ed.), Khanna Publishers, New Delhi.
- GSI (1975) Engineering Geology Case Histories, Geological Survey of India, Misc. Publ., No. 29.
- Gupte, R.B. (2002) Text Book of Engineering Geology. Vidyarthi Griha Prakashan, Pune.
- Keary, P., Brooks, M. and Hill, I. (2002) An introduction to geophysical exploration, (3rd Ed.), Blackwell.
- Kesavulu, N.C. (2009) Textbook of engineering geology, (2nd Ed.), Macmillan Publishers India ltd.
- Krynine, D.P. and Judd, W.R. (1998) Principles of Engineering Geology and Geotechnics. CBS Publishers & Distributors, New Delhi.
- Reddy, D.V. (1998) Engineering Geology for Civil Engineering. Oxford & IBH Pub.Co. Pvt. Ltd., Delhi.
- Rider, M.H. (1986) The Geological Interpretation of Well Logs. (Rev. Ed.) Whittles Publishing, Caithness.
- Ries, H. and Watson, T.L. (1947) Elements of Engineering Geology (2nd Ed.). John Wiley & Sons, New York.
- Schultz, J.R. and Cleaves, A.B. (1951) Geology in Engineering. John Willey and Sons, New York.
- Singh, P. (1994) Engineering and General Geology. S.K. Kataria and Sons, Delhi.
- Telford, W.M., Geldart, L.P., Sherrif, R.E. and Keys, D.A. (1976) Applied Geophysics, Cambridge Univ. Press.
- Verma, B.P. (1997). Rock Mechanics for Engineers (3rd Ed.), Khanna Publishers, New Delhi.
- Wittke, Walter (1990). Rock Mechanics: Theory and Applications with case Histories, Springer – Verlag Publication.

- Kennet : Marine Geology
- Menard : Marine Geology

## GS-404: PRACTICALS RELATED TO PETROLEUM GEOLOGY, HYDROGEOLOGY, ENGINEERING AND ENVIRONMENTAL GEOLOGY

1. Lithofacies analysis
2. Preparation of structure contour maps and structural cross sections
3. Porosity and permeability measurements
4. Well correlations: geologic and bio-stratigraphic
5. Well log interpretations
6. Isopach and lithofacies maps, Fence diagram
7. Oil Reserve Estimation
8. Core analysis
9. Analysis of rainfall data
10. Preparation of water level contour maps and their interpretation
11. Analysis of pumping test data using different methods of aquifer and well characteristics determination.
12. Plotting and analysis of hydrogeochemical data
13. Morphometric analysis and site selection for water conservative measures.
14. Water audit.
15. Various methods of Surveying used in engineering geology, Chain Surveys, Plane table surveys, Use of Surveying equipments
16. Determination of Engineering properties of Geological materials
17. Interpretation of borehole data, Preparation of bore logs / Lithologs.
18. Preparation of Report and Presentation of Engineering data
19. Water and Soil analysis, Plotting and interpretation of geochemical data.
20. Preparation of hazard Zonation map.
21. Quantification of EIA.
22. Heavy Mineral: Separation, identification and interpretation
23. Sediment Size and shape Analysis and interpretation
24. Trace element Analysis
25. Organic Carbon and Total Phosphorus Analysis
26. Foraminiferal and nano-planktons studies

## GS-405: DISSERTATION

Topic of the Dissertation work will be allotted to students as per the specialization of the teacher and interest of the students.

**SCHOOL OF ENVIRONMENTAL AND EARTH SCIENCES**
**North Maharashtra University, Jalgaon**

## Model for implementation of the

## Credit-Grade based Performance and Assessment (CGPA) system

### M.Sc. course

In tune with the concept and suggestions of the UGC and NAAC, technological advancement and social needs and to make the teaching effective and meaningful, School of Environmental and Earth Sciences has been permitted to adopt Credit-Grade based Performance and Assessment (CGPA) system from the academic year 2009-2010 for the course M.Sc. (Applied Geology) being run in the school. The modalities and operational details of the credit system shall be as follows.

**A. Features of the CGPA System:**

1. Master's degree course, M.Sc. being run in School would be of 84 credits each.
2. One credit for the theory course shall be of the one clock hour per week running for 15 weeks. Thus, each theory course of 4 h per week teaching shall be of 4 credits.
3. Four credits for each practical course shall be awarded to the 8 h of laboratory exercise per week for a semester. As per the guidelines of the work load, each batch for practical course shall consist of 10-12 students and each batch shall perform the laboratory exercise twice in a week. Thus, each practical course shall be of 8 h laboratory exercise per week with 4 credits.
4. Four credits shall be awarded to the Project course, which will commence from III Semester and the final work and report will be completed during IV Semester. The marks and the credits will be allotted in IV Semester.
5. Two credits, one each in first two semesters (i.e. for Semester I and II) have been allocated for the Tutorials/Home assignments. Besides, for every theory course one Take Home Assignments of 25 marks each shall be conducted. Average marks of all the home assignment in the given semester will be considered. No grade will be given for the tutorial. However, the completion of the credit for the tutorial shall be compulsory.
6. Two credits, one each in the III and IV semesters have been allocated for the Seminar. There shall be one seminar per student. Marks out of 25 will be allocated per semester for this as per break up given below in (g). No grade will be given for the seminar. However, the completion of the credit for the seminar shall be compulsory.
7. Every student shall complete 84 credits in a minimum of four semesters. All Semesters will have 21 credits each.
8. Academic calendar showing dates of commencement and end of teaching, internal assessment tests and term end examination shall be duly notified before commencement of each semester every year by the School.

**B. Evaluation of the student:**

**(a)** The evaluation of the student shall be divided into two parts viz. **Internal Assessment** and **Term End Examination (semester end examination)** with a weightage in the ratio of 25:75, as approved by the committee.

**(b)** Standard of passing –

(i) There shall not be pass or fail for the internal assessment. However, the attendance for the internal assessment shall be compulsory.

(ii) Minimum marks for passing the Term End Examination in theory/practical/project course shall be 40%.

(iii) Minimum marks for passing the theory/practical/project course ( i.e. sum of the marks obtained in internal and term end examination) shall be 40%.

**(c)** The distribution of marks for each theory paper of 4 credits at term (Semester) end examination and for continuous internal assessment (Minor tests), as approved by the committee shall be as follows:

| **Theory Examination** | **Maximum marks** |
|---|---|
| Internal assessment | 25 |
| Term end examination | 75 |
| Total marks | 100 |

**(d)** The distribution of marks for each laboratory course of 4 credits at term (Semester) end examination and for continuous internal assessment (Minor tests), as approved by the committee shall be as follows:

| **Practical Examination** | **Maximum marks** |
|---|---|
| Internal assessment | 25 |
| Term end examination | 75 |
| Total marks | 100 |

**(e)** The Project course will commence from III Semester and the final work and report will be completed during IV Semester. The marks and the credits will be allotted in IV Semester. The distribution of marks for Project course of 4 credits at term (Semester) end examination and for continuous internal assessment (Minor tests), as approved by the committee shall be as follows:

| **Practical Examination** | **Maximum marks** |
|---|---|
| Internal assessment | 25 |
| Term end examination | 75 |
| Total marks | 100 |

**(f) Internal Assessment:**

(i) Internal assessment for each course would be continuous and dates for each internal test/practical test will be pre-notified in the time table for teaching or placed separately as a part of time table.

(ii) Each subject teacher shall coordinate this activity and maintain the record of the internal tests conducted.

(iii)

| Heads | Marks | Evaluating Authority |
|---|---|---|
| Marks for journal | 05 | Concerned practical incharge |
| Experimental work carried by student | 15 | |
| Viva-voce | 05 | |
| Total marks | 25 | |

Internal assessment for each course shall be of 25 marks.

(iv) There shall not be pass or fail for the internal assessment. However, the attendance for the internal assessment shall be compulsory.

**For Theory Courses:**

(i) Two internal tests for each theory course comprising of 4 credits shall be conducted by the subject teacher.

(ii) Each test shall be of 25 marks.

(iii) The marks for each test shall be displayed on notice board within seven days of conducting the test.

(iv) It is mandatory to show the answer sheets of all tests to the students.

**For Practical Courses:**

The internal assessment for the practical courses will be based on the following 03 heads:

**For Project course**

(i) The Project course will commence from III Semester and the final work and report will be completed during IV Semester.

(ii) Every student has to undertake a project of interest. The project may be related to a theoretical analysis, an experimental investigation, a proto-type design, a new correlation and analysis of data, fabrication and setup new equipment. Ordinarily, the Project Co-ordinator shall be chosen by the student depending on his/her subject interest. The project co-ordinator assigns the topic for the project and the work is done uniformly during both the semesters of the final year.

(iii) The marks and the credits will be allotted in IV Semester.

(iv) On the basis of marks obtained in Seminar, the marks out of 25 will be given for the Seminar.

| Heads | Marks | Evaluating Authority |
|---|---|---|
| Performance of the student in the collection of reference material for project work and punctuality | 05 | Concerned Project guide |
| Experimental work carried out by the student | 15 | |
| Viva-voce | 05 | |
| Total marks | 25 | |

**For Tutorial:**

(i) Two credits based on Tutorial component, one each in I and II semesters will constitute the compulsory part.
(ii) For every theory course one Take Home Assignments of 25 marks each shall be given.
(iii) The evaluation will be based on following two heads:

| **Head** | **Marks** | **Evaluating Authority** |
|---|---|---|
| Take Home Assignment | 25 | Concerned subject teacher |

(iv) On the basis of marks in Tutorials for theory courses, the average will be calculated and the marks out of 25 shall be awarded for the Tutorial.

**For Seminar:**

(i) Two credits based on Seminar component, one each in the III and IV semesters will constitute the compulsory part.
(ii) Each student shall deliver one seminar per semester and there will be a continuous evaluation of the seminar.
(iii) The evaluation will be based on following four heads:

| **Heads** | **Marks** | **Evaluating Authority** |
|---|---|---|
| collection of reference material for seminar | 05 | Concerned course teacher |
| Content of the seminar | 15 | |
| Performance in seminar/presentation | 05 | |
| Total marks | 25 | |

iv) On the basis of marks obtained in Seminar, the marks out of 25 will be given for the Seminar.

**g) Term end examination:**

(i) The term end examination for 75 marks per course would be held about a week after completion of teaching for the semester.
(ii) The term end examination of maximum marks 75 and its assessment work shall be conducted by the School from the academic year 2009-10 under the academic flexibility granted to the School by the University.

**For Theory Courses:**

(i) The pattern of the question paper for the academic year 2009-2010 remains same as at present.
(ii) Each theory paper of 75 marks shall be of the three hours duration.

**For Practical Courses:**

(i) The term end practical examination shall be of 75 marks and it is of duration 06 h.
(ii) There shall be two examiners for the practical examination out of which one examiner shall be from the other University/Institute.

**For Project course:**

(i) The project report should be submitted by the prescribed date. Submission of the project cannot be postponed beyond the date specified in the calendar.
(ii) Students should submit 2 bound typed copies of Project Report to the department. A student who is unable to complete his/her Project may be

awarded 'X' grade and he/she will be required to register for the next Semester and pay the fees under following circumstances:
Exceptional circumstances beyond students / supervisor control
Medical grounds

(iii) There shall be two examiners for the evaluation of Project, out of which one examiner shall be from the other University/Institute.

(iv) The examiners shall evaluate the report and an oral examination shall be conducted. The assessment of the project work is done on the following basis-

| **Heads** | **Marks** | **Evaluating Authority** |
|---|---|---|
| Performance of the student in the presentation of the project work and report | 10 | Panel of examiners |
| Experimental work carried out by the student | 50 | |
| Viva-voce | 15 | |
| Total marks | 75 | |

**C. Grades:**

(i) Marks for each course would be converted to grades as shown in Table 1.
Table 1: Conversion of marks to grades in credit system

| **Marks obtained** | **Grade** | **Grade Points** |
|---|---|---|
| 90-100 | A+ | 10 |
| 80-89 | A | 9 |
| 70-79 | B+ | 8 |
| 60-69 | B | 7 |
| 55-59 | C+ | 6 |
| 45-54 | C | 5 |
| 40-44 | D | 4 |
| 39 and less | F | 0 |

(ii) The grade point will be given on the total marks (sum of mark obtained in internal assessment and term end examination) obtained in the said subject.

(iii) A student who fails in a course (i.e. He scores less than 30 out of 75 marks in the Term End Examination or less than 40 out 100 marks) shall be given F grade. Student with F grade in course would be granted credit for that course but not the grade for that course and shall have to clear the concerned course within 1.5 year from appearing for first time in the concerned paper.

(v) The **total grade points earned in each course** shall be calculated as –

*Grade points obtained (vide Table-1) X Credits for the course*

Maximum grade points that can be earned in a semester are 200.

*(vi)* **Semester Grade Point Average (SGPA)** –

The performance of a student in a semester is indicated by a number called SGPA. SGPA is the weighted average of the grade points obtained in all courses registered by the student during the semester. It shall be calculated as follows-

$$SGPA = \frac{\sum_{i=1}^{n} C_i p_i}{\sum_{i=1}^{n} C_i}$$

whereCi = the number of credits earned in the i'th course of a semester for which SGPA is to be calculated **(Audit credits should not be included).**
pi = grade point earned in the i'th course
i = 1,2,3,……n represent the number of courses in which a student is registered in the concerned semester.
That is,

$$SGPA = \frac{Total\ earned\ grade\ points\ for\ the\ semester}{Total\ credits\ for\ the\ semester}$$

The SGPA is rounded upto one decimal places.

(vii) **Final result** – Up to date assessment of the overall performance of a student from the time of his/her first registration is obtained by calculating a number called Cumulative Grade Point Average (CGPA), which is weighted average of the grade points obtained in all courses registered by the student since he/she entered the School/Department.

$$CGPA = \frac{\sum_{j=1}^{m} C_j p_j}{\sum_{j=1}^{m} C_j}$$

whereCj = the number of credits earned in the jth course up to the semester for which CGPA is to be calculated
pj = grade point earned in the jth course. A letter grade lower than D (i.e. grade point < 4) in a course shall not be taken into consideration for the calculation of CGPA.
j = 1,2,3……m represent the number of courses in which a student is registered up to the semester for which the CGPA is to be calculated.

The CGPA is rounded upto one decimal places.

(viii) The final grade earned shall be as per Table 2 given below-

**Table-2**

| CGPA | Grade |
|---|---|
| 8.0-10 | A+ |
| **7.0-7.9** | A |
| **6.0-6.9** | B+ |
| **5.5-5.9** | B |
| **4.5-5.4** | C+ |
| **4.0-4.4** | C |
| **0 -3.9** | F |

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