# M.Sc., Applied Geology and Geomatics

**Centre for Applied Geology**
**GRI_DTBU**
**(From 2021 Onwards)**

**SCHEME OF EXAMINATIONS**
**FIRST SEMESTER**

| Course Code | Paper Title | C | Hours | | | CFA | ESE | Total |
|---|---|---|---|---|---|---|---|---|
| | | | L/T | P | E | | | |
| 21GEOP0101 | Physical Geology and Geomorphology | 3 | 3 | - | 3 | 40 | 60 | 100 |
| 21GEOP0102 | Structural Geology, Geotectonics and Palaeontology | 4 | 4 | - | 3 | 40 | 60 | 100 |
| 21GEOP0103 | Stratigraphy and Indian Geology | 4 | 4 | - | 3 | 40 | 60 | 100 |
| 21GEOP0104 | Crystallography, Mineralogy and Gemology | 4 | 4 | - | 3 | 40 | 60 | 100 |
| 21GEOP0105 | Remote Sensing and GPS | 3 | 3 | - | 3 | 40 | 60 | 100 |
| 21GEOP0106 | Crystallography and Mineralogy - Practical I | 2 | - | 4 | 3 | 60 | 40 | 100 |
| 21GEOP0107 | Structural Geology, Palaeontology and Remote sensing - Practical II | 2 | - | 4 | 3 | 60 | 40 | 100 |
| 21GTPP0001 | Gandhi in Everyday Life | 2 | 2 | - | - | 50 | - | 50 |
| | **Semester Total Credits** | **24** | | | | | | |

**SECOND SEMESTER**

| Course Code | Paper Title | C | Hours | | | CFA | ESE | Total |
|---|---|---|---|---|---|---|---|---|
| | | | L/T | P | E | | | |
| 21GEOP0208 | Igneous and Metamorphic Petrology | 4 | 3 | - | 3 | 40 | 60 | 100 |
| 21GEOP0209 | Economic Geology and Ore Dressing | 3 | 3 | - | 3 | 40 | 60 | 100 |
| 21GEOP0210 | Environmental Geology and Natural Disaster Management | 3 | 3 | - | 3 | 40 | 60 | 100 |
| 21GEOP0211 | Digital Image Processing | 4 | 4 | | 3 | 40 | 60 | 100 |
| | Elective_Generic | 4 | 4 | - | 3 | 40 | 60 | 100 |
| 21GEOP0212 | Igneous and Metamorphic Petrology and Economic Geology - Practical III | 2 | - | 4 | 4 | 60 | 40 | 100 |
| 21GEOP0213 | Digital Image Processing - Practical IV | 2 | - | 4 | 4 | 60 | 40 | 100 |
| 21ENGP00C1 | Communication and Soft Skills | 2 | 2 | - | - | 50 | - | 50 |
| | **Semester Total Credits** | **24** | | | | | | |

**THIRD SEMESTER**

| Course Code | Paper Title | C | Hours | | | CFA | ESE | Total |
|---|---|---|---|---|---|---|---|---|
| | | | L/T | P | E | | | |
| 21GEOP0314 | Sedimentary Petrology and Marine Geology | 3 | 3 | - | 3 | 40 | 60 | 100 |
| 21GEOP0315 | Geophysics and Geochemistry | 4 | 4 | - | 3 | 40 | 60 | 100 |
| 21GEOP0316 | Meteorology and Climatology | 3 | 3 | - | 3 | 40 | 60 | 100 |
| 21GEOP03EX | Elective_Discipline Centric | 4 | 4 | - | 3 | 40 | 60 | 100 |
| 21GEOP0317 | Geophysics, Geochemistry and Sedimentology - Practical - V | 2 | - | 4 | 4 | 60 | 40 | 100 |
| 21GEOP0318 | Geographic Information System, and GPS –Practical VI | 2 | - | 4 | 4 | 60 | 40 | 100 |
| 21GEOP03MX | Modular Course | 2 | 2 | - | - | 50 | - | 50 |
| 21EXNP03V1 | Village Placement Programme | 2 | - | - | - | 50 | - | 50 |
| 21GEOP03F1 | Geological Field Study | 2 | - | 4 | - | 50 | - | 50 |
| **Semester Total Credits** | | **24** | | | | | | |

**FOURTH SEMESTER**

| Course Code | Course Title | C | Hours | | | CFA | ESE | Total |
|---|---|---|---|---|---|---|---|---|
| | | | L /T | P | E | | | |
| 21GEOP0419 | Petroleum Geology, Coal Geology, and Geothermal Resources | 3 | 3 | - | 3 | 40 | 60 | 100 |
| 21GEOP0420 | Mining Geology and Engineering Geology | 3 | 3 | | 3 | 40 | 60 | 100 |
| 21GEOP0421 | Hydrogeology | 4 | 4 | - | 3 | 40 | 60 | 100 |
| 21GEOP0422 | Hydrogeology Practical - VII | 2 | - | 4 | 4 | 60 | 40 | 100 |
| 21GEOP04MX | Modular Course | 2 | 2 | - | - | 50 | - | 50 |
| | Human Value and Professional Ethics | 2 | 2 | - | - | 50 | - | 50 |
| 21GEOP0423 | Dissertation | 6 | | - | | 75 | 75*+50** | 200 |
| | **Total** | **22** | | | | | | |

*Evaluation by External Examiner
**Evaluation by External and Internal Examiner

| Electives_Discipline Centric |
|---|
| 21GEOP03D1 - Experimental Petrology |
| 21GEOP03D2 - Advanced Ore Geology |
| 21GEOP03E3- Geographic Information System |
| **Modular Courses** |
| 21GEOP03M1 – Medical Geology |
| 21GEOP03M2 – MicroPalaeontology |
| 21GEOP04M1 - Geostatistics |
| 21GEOP04M2 - Advanced Hydrogeology |

| Electives_Generic | | | | | | | |
|---|---|---|---|---|---|---|---|
| Course Code | **Paper Title** | **L /T** | **P** | **E** | **CFA** | **ESE** | **C** |
| 21GEOP02G1 | Introduction to Geoscience | 4 | | 3 | 40 | 60 | 4 |
| 21GEOP02G2 | Medical Geology | 4 | | 3 | 40 | 60 | 4 |
| 21GEOP02G3 | Environmental Geosciences | 4 | | 3 | 40 | 60 | 4 |
| 21GEOP02G4 | Disaster Management | 4 | | 3 | 40 | 60 | 4 |

## ABSTRACT - CREDITS

| **Course** | **Sem. – I Credits** | | **Sem. – II Credits** | | **Sem. – III Credits** | | **Sem. – IV Credits** | |
|---|---|---|---|---|---|---|---|---|
| | **T** | **P** | **T** | **P** | **T** | **P** | **T** | **P** |
| Core Papers | 18 | 4 | 14 | 4 | 10 | 4 | 10 | 10 |
| Elective_Generic | | | 4 | | | | | |
| Elective_Disipline Centric | | | | | 4 | | | |
| Modular Course | | | | | 2 | | 2 | |
| Extension / Field Study | | | | | 2 | | | |
| **Total** | **22** | | **22** | | **22** | | **22** | |

# Semester – I

| | | | |
|---|---|---|---|
| Course Code & Title | **21GEOP0101**<br>**PHYSICAL GEOLOGY AND GEOMORPHOLOGY** | | |
| Class | M. Sc. Applied Geology and Geomatics | Semester | I |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |
| Course Objectives | **The Course aims**<br>• To learn the Origin of the Earth, Interior structure of Earth, atmosphere, Hydrosphere, Lithosphere, and various geological processes acting on Earth,<br>• To understand the natural processes which act on the earth's surface and the landforms,<br>• To build knowledge about the landforms formed due to tectonic activity,<br>• To Describe the Coastal geomorphic features and their associated landforms,<br>• To illustrate the volcanic landforms. | | |

| Unit | Content | Lectures |
|---|---|---|
| I | **Solar System; *Origin of the Earth*; Nebular Hypothesis, Planetesimal Hypothesis, Gaseous Tidal Hypothesis. Binary star Hypothesis. Major Theories and concepts, Recent studies on planetary origin. Age of the Earth;** Direct and Indirect Methods. ***Interior of the Earth*. Atmosphere, Hydrosphere, Lithosphere, and their Constituents. Geological Process;** Endogenic Process and Exogenic Process. **Isostasy, Continental Drift, Palaeomagnetism, Earth's gravity and magnetic fields. Concept of Geoid and spheroid. Indian Geomorphology.** | 9 |
| II | **Fundamental Concepts of Geomorphology; Geomorphic Processes;** Exogenetic and Endogenic processes. ***Weathering*:** Physical weathering, Chemical Weathering, Biological Weathering. **Soil Processes:** Soil Profile, Climate and Soil Formation, Soil Types. **Mass Wasting Process and inducing factors, Types of mass wasting. Karst Topography**: **Landform features.** | 9 |
| III | **Mobile belts in peninsular India, Earthquakes: Seismic waves, Origin, Classification and Causes of Earthquake, Earthquake Intensity Scale *Fluvial Geomorphology*;** Stream Erosion, Stream Transportation and Deposition, Features of Stream Erosion, ***Depositional Landforms***, **Drainage Systems,** Types of Streams and Stages of Valley Development. | 9 |
| IV | **Coastal Geomorphology: Coastal process and dynamics;** Shorelines; **Classification of Coast and shoreline**; Johnson's shoreline classification, Shepard's coast classification, Davies Classification. ***Features and landforms of Ocean basin floor*, Bathymetry - Introduction and Instruments used for coastal studies- Coral Reefs**. **Aeolian Geomorphology; Process and Landforms**. Types of Sand Dunes. | 9 |
| V | **Volcanic Geomorphology: Volcanic process; Types of volcanoes, Landforms created by volcanic eruptions Volcanic Plateaus and Plains. Active volcanoes of the world**. **Glacial Geomorphology: Process of glaciation;** Movement of Glaciers, **Glacial Erosion, Transport & Deposition dynamics; Types of Glaciers. Landforms of glacial origin** | 9 |

**References**

**Text Books:**


1. Gautam, A ., (2009) Geomorphology, First Edition: Sharada Pustak Bhawan
2. Allen Cox, (1973) Plate Tectonics, Freeman and Company.
3. Radhakrishnan. V., (1987) Physical Geology, VV.P. Publishers.
4. Savindra Singh, (2012) Geomorphology, Fifth Edition: Prayag Pustak Bhawan.
5. Thornbury, W.D., (2002) Principles of Geomorphology, John Wiley and Sons, 2nd Edition, New York.


**Reference Books:**


1. Bloom, A., (2005) Geomorphology, Pearson. New Delhi.

2. Gupta, R.P., (2003) Remote Sensing Geology, Springer - Verlag - New York, London.
3. Hamilton, E. I. (1965) Applied Geomorphology. Academic Press.
4. Holmes, A., (1965) Principles of Physical Geology. Ronald.
5. Jha, V.C., (2001) Geomorphology and Remote Sensing, ACB Publications.
6. Sharma, H. S., (1990) Indian Geomorphology. Concept Publishing Co., New Delhi.

**Web resources:**

1. *Underlined Titles are available at Swayam portal*
2. *http://shaileshchaure.com/Notes/GEOMCON.pdf*
3. *https://www.nap.edu/read/12700/chapter/3#17*
4. *https://www.usu.edu/geo/liddell/oceans/oc-ppts/ocpptxt_10.pdf*
5. http://www.geo.hunter.cuny.edu/~fbuon/GEOL_231/Lectures/Volcanic%20Landforms.pdf.
6. http://www.geo.hunter.cuny.edu/~fbuon/GEOL_231/Lectures/Coastal%20Geomorphology.pdf
7. **http://library.iigm.res.in:8080/jspui/bitstream/123456789/465/1/AnandSP_RajaramM_IAGRMemoir-10_2007_1.pdf**

**Course Outcomes**

On completion of the course, the students will be able to

- CO1: Explain the Origin, Age, and Interior of the Earth, Earthquake and Volcanoes, Isostasy, Continental Drift, and Plate Tectonics.
- CO2: Describe the Fundamental concepts of Geomorphology, Weathering, Soil processes, and Karst Topography.
- CO3: Discuss the geological structures formed by the Tectonic activities and the geological work done by a river and the various drainage systems.
- CO4: Describe the coastal process along the coast and the geological work done by the wind.
- CO5: Explain the volcanic and glacial processes acting on the surface of the earth and its resultant surface morphology.

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|---|---|
| Course Code & Title | **21GEOP0102**<br>**STRUCTURAL GEOLOGY, GEOTECTONICS, AND PALAEONTOLOGY** |
| Class | M. Sc. Applied Geology and Geomatics **Semester** I |
| Cognitive Level | K-1<br>K-2<br>K-3 |
| Course Objectives | **The Course aims**<br>• To introduce students to the concepts of Stress and Strain, deformation, types of folds.<br>• To gain knowledge of the origin, mechanism, and characteristics of various types of faults and joints<br>• To describe in detail Continental drift, plate tectonics, and Himalayan orogeny.<br>• To know the past life and Applications of fossils in age determination and correlation<br>• To study the Application of micropalaeontology in hydrocarbon exploration. |

| Unit | Content | Lectures |
|---|---|---|
| **I** | **Structural Geology:** Objectives of Structural Geology **-** Introduction to deformation mechanisms. Mechanical Properties of rocks - Theory of stress and strain. Behaviour of rocks under stress - Diagram. Strain Rate, Elastic (Hookean) Geometry and analyses of brittle-ductile and ductile shear zones. Behaviour of minerals and rocks under deformation conditions; Rheology, Viscous Behavior, Plastic (Saint-Venant) Behavior, Elastic, viscous (Maxwell) behaviour - **Controlling Factors**, finite strain: Strain ellipsoid; Flinn diagram, **Mohr's circle - types of stress ellipsoid and their geological significance - strain analyses of naturally deformed rocks.** Cleavage and Schistosity: slaty cleavage or schistocity, fracture cleavage, shear cleavage, bedding cleavage, and axial cleavage. **Stereographic Projections and Stereogram** – **Bedding - types of Stereonet** -Wulff net and Schmidt net. Primary and secondary foliation- Lineation: definition and Types of lineation. ***Folds: Geometry and Mechanism of Folding*****:** Introduction - Types of folding- Causes of folding**:** Minor folds and their uses in determining the major fold structure; Fault related fold. **Tectonic process - Non-tectonic process.** Depressions and Culminations - Domes and Saddles - Profile of a Fold –Geometric and genetic classification fold, Ramsay's fold classification based on dip isogons, cylindrical, non-cylindrical and conical folds - Canoe fold and inverted canoe fold. | 12 |
| **II** | **Fault: *Mechanism of faults*:** Introduction - Description and classification of faulting - Criteria for faulting. **Normal faults** - representation of normal faults on the block diagram's - **reverse faults and thrust faults** – Tectonic features of extensional, compressional, and strike-slip terrains and relevance to plate boundaries - Stratigraphic differences between normal and reverse faults - Nappe, klippe and tectonic window - flat, and steeps of the reverse faults - **autochthonous and allochthonous units** - imbricate and duplex structures - horst and graben - Strike-slip faults and minor structures associated with such faults - cataclastics and mylonites - **Transform Faults- Characteristics of faults and fault zones. *Joints*:** Geometry - Field studies - Principles of Failure by rupture - Relation of rupture to stress and strain - Joint formation in response to loading and stress; Fracture development and propagation; Classification of joints and | 12 |

| | | |
|---|---|---|
| | extension fractures. Geometry and mechanics of development of Foliation, Lineation and its types. **Unconformity:** Introduction - Kinds of Unconformities - Recognition of Unconformities. Significance in stratigraphy - Distinguishing Faults from Unconformities - Radiogenic dating - Tectonism and sedimentation. Diapirs and Salt Domes. **Lineament:** Mapping and Analysis - Basin Tectonics - Microstructures and Structures of Sedimentation and Intrusion- Structural analyses: - kinematic and dynamic analysis of deformation | |
| **III** | **Geotectonics:** Tectonic features of the Earth - Fabric elements and classification; S-C fabric; Petrofabric analysis, L-, L-S-, and S-tectonic fabrics. Continental drift, Contracting, and Expanding Earth hypothesis; Implications of heat flow; The nature of convection in the mantle; convection in the mantle and their evidence; Mantle Plumes. Seafloor spreading - Plate Tectonics –Elements of Tectonism - Characteristics of Plates - World Plates - Plate Boundaries - Assumptions and Problems - causes and mechanism. **Plate Tectonics and Mineral Deposits** - Geosynclines – Types – Classification and Origin – Concept of Isostasy - Orogeny & Epiorogeny – Seismic Belts of the Earth – Seismicity and Plate Movements - **Himalayan Orogeny. Concept of supercontinent their assembly and breakup – Plate tectonic setting of major mineral deposits on earth** | 12 |
| **IV** | ***Palaeontology: Brief outline of Geological time scale*** and Life through Ages –Fossils and Their Modes of Preservation – Applications of fossil in age determination and correlation. Environmental significance of fossils and trace fossils. Theories on Origin and Evolution of life – **Punctuated Equilibrium and Phyletic Gradualism models.** Species concepts – Phylogeny- Antogeny – Palingenesis – Invertebrate**; –** Paleoecology – Paleobiogeography- Palynology**; Palaeontology:** Morphology, Evolutionary Trends, Stratigraphic importance and application of ***Trilobites - Graptolites – Corals – Brachiopods – Cephalopods*** | 12 |
| **V** | **Vertebrate Palaeontology**: Classification of Vertebrates – Study of the evolution of the Horse - Elephant and Man - Extinction of Dinosaurs. **Palaeobotany:** ***Methods of preservation of fossil plants*** - Objective and limitation of fossil Plants – Classification. **Micropalaeontology:** Types of microfossils. Use of microfossils in the interpretation of seafloor tectonism. Application of micropalaeontology in hydrocarbon exploration. Definition and Applications of Micropalaeontology – Field and laboratory techniques of micropalaeontology - General Morphological Characters - Classification of Foraminifers and Ostracods - Mass extinction events and their causes | 13 |

**Text Books:**


1. Billings, M. P., (2008) Structural Geology, III edition, Prentice-Hall, Inc., New Jersey, USA.
2. Condie, K.C., (2003) Plate Tectonics & Crustal Evolution, 4th Edition, Butterworth-Heinemann, Boston.
3. Henry Woods, (2005) Palaeontology Invertebrate, The University Press.


**Reference Books:**


1. Raupsteven, D. M., and Stanley M., (2004) Principles of Palaeontology, New Delhi.
2. Davis, G.H., and Renolds, S.J., (1996) Structural Geology of Rocks and Regions, 2nd Ed., Wiley, Newyork.
3. Gokhale N W., (2009) Theory of Structural Geology, CBS Publishers & Distributors, New Delhi.
4. Hobbs, B. E., Means, W. D., & Williams, P. E., (1976) An Outline of Structural Geology, John Wiley & Sons, Inc, Australia.
5. Jain, P.C and Anantharaman, M.S., (2005) Palaeontology: Evolution and Animal Distribution, 6th Edition, Vishal Publishing Co, New Delhi.
6. Moore, R.C, Lalicker, C.G and Fisher, A.G., (1997) Invertebrate Fossils, 1st Indian Edition, CBS Publishers & Distributors, New Delhi.
7. Park, R.G, (1989) Foundation of Structural Geology, Second Edition Blackie and Sons Ltd., Glasgow, New Zealand.
8. Raup and Stanely, (2004) Principles of Palaeontology, CBS Publishers & Distributors, New Delhi.

9. Shrock and Twenhofel, (2005) Principles of Invertebrate Palaeontology, CBS Publishers & Distributors, New Delhi.
10. Park, R. G. (2004) Foundations of Structural Geology. Chapman & Hall.
11. Pollard, D. D., (2005) Fundamental of Structural Geology. Cambridge University Press.
12. Fossen, H., (2016) Structural Geology, Second Edition Cambridge University Press.

**Web resources:**

1. *Underlined Titles are available at the Swayam portal*
2. *http://geologylearn.blogspot.com/2015/08/deformation-mechanisms-and.html*
3. *http://www.yourarticlelibrary.com/geology/rocks/rock-cleavage-meaning-types-and-importance-geology/91506*
4. *https://flexiblelearning.auckland.ac.nz/rocks_minerals/rocks/schist.html*
5. *https://www.britannica.com/science/foliation-geology*
6. *http://geologylearn.blogspot.com/2015/08/folding-mechanisms-and-processes.html*
7. *http://eqseis.geosc.psu.edu/~cammon/HTML/Classes/IntroQuakes/Notes/faults.html*
8. *http://www.indiana.edu/~geol105b/images/gaia_chapter_6/unconformities.html*
9. *http://epgp.inflibnet.ac.in/epgpdata/uploads/epgp_content/S000448GO/P000596/M018266/ET/1482317287MAINTEXT.pdf*
10. *https://sciencing.com/types-fossil-preservation-5413212.html*
11. *http://osp.mans.edu.eg/abuzied/MicroPalaeontology.html.*
12. https://www.ias.ac.in/article/fulltext/reso/004/07/0042-0048
13. https://www.ias.ac.in/article/fulltext/secb/053/03/0111-0124

**Course Outcomes**

On completion of the course, the students will be able to

CO1: Predict the various forces acting on the earth and its resultant structural changes. The Geometry, Types and Mechanism of Folding

CO2: Explain the consequent movement of rocks and the consequent Geometry, types and mechanism of Faulting, other minor structures and Joints.

CO3: Assess the theory of plate tectonics and describe how the outer part of the earth is broken into large fragments (plates) that are constantly in motion relative to each other.

CO4: Describe the ancient forms of life (fossils) and Evolutionary Principles and Palaeontological Techniques.

CO5: Outline of the Vertebrate Palaeontology and Micropalaeontology.

| | |
|---|---|
| Course Code & Title | **21GEOP0103**<br>**STRATIGRAPHY AND INDIAN GEOLOGY** |

| | | | |
|---|---|---|---|
| Class | M. Sc. Applied Geology and Geomatics | Semester | I |

| | |
|---|---|
| Cognitive Level | K-1<br>K-2<br>K-3 |
| Course Objectives | **The Course aims**<br>• To introduce basic principles of stratigraphy, its classification, Geologic timescale and various types of correlation.<br>• To Learn the origin and significance of Indian Stratigraphy<br>• To Gain knowledge about the Cambrian system, Gondwana System, and Cretaceous System.<br>• To Understand the structure of the Krishna-Godavari basin, Siwalik System and Deccan traps<br>• To describe in detail the boundary and age problem |

| Unit | Content | Lectures |
|---|---|---|
| **I** | **Stratigraphy:** Principles and Classification of Stratigraphy– Litho-, Bio-, Chrono-, Magnetostratigraphy and their Applications– **Elements of** – Cyclostratigraphy, Allo-, Pedo-, Chemo- and Seismic Stratigraphy. Basic ideas of ***Sequence stratigraphy*** and Quaternary Stratigraphy. Bouma sequence – Geological Time Scale and Indian Time Scale, Paleogeography and life of each period. ***Correlation***: Physical and paleontological correlation method – Homotaxic, Contemporaneity and Syntaxis, Lateral variation and facies– code of stratigraphic nomenclature. Strato types and its requirements. | 12 |
| **II** | ***Indian Stratigraphy*****:** Stratigraphic Distribution, Geological Succession, Structure, Tectonics and **Economic Importance of the following Precambrian cratons and mobile belts of India and Proterozoic Basins:**– Southern Granulite Terrain, Dharwar Craton, Bastar Craton, Singhbhum Craton, Bundelkhand Craton, Aravalli-Delhi Orogenic Belt, Eastern Ghats Mobile Belt, Vindhyan Basin, Cuddapah Basin, Bhima basin | 12 |
| **III** | **Distribution - Classification - Structure - Correlation - Sedimentation - Fossils - Paleogeography and Economic importance** of Cambrian to Lower Carboniferous systems- Gondwana Group, Triassic of Spiti, Jurassic of Kutch, Cretaceous of Trichinopoly and the marine Cretaceous system Stratigraphy and structure of Krishna-Godavari basin, Cauvery basin, Bombay offshore basin, Kutch and Saurashtra basins and their potential for hydrocarbon exploration, Volcanic provinces of India | 12 |
| **IV** | **Distribution: Structure, Lithology, Climate, Fossils and Origin of** - Siwalik system, Pleistocene-Holocene system, Quaternary glaciations, Rise of Himalayas - Eocene, Oligocene and Lower Miocene systems. ***Deccan Traps***: Distribution - Classification - Structure - Geological Succession – Inter-Trappean and Intra-Trappean beds- Bagh Beds – Origin- Economic importance - Lameta beds - Age and Economic importance. | 12 |
| **V** | **Cenozoic Stratigraphy-**Classification, depositional characteristics, fauna and flora of the Palaeogene and Neogene systems in their type localities and equivalents in India. **Boundary and Age Problems**- K-T boundary problem, Precambrian – Cambrian boundary problem, | 13 |

Permian - Triassic boundary problem, Age of Saline Series, Age of Deccan traps, World stratigraphy**:** Brief description of the principle, stratigraphic units of the world in the type area.

**References**

**Text Books:**


1. Krishnan, M.S., (2009) Geology of India and Burma, 6th Edition, CBS Publishers & Distributors, New Delhi.
2. Wadia, (1893) Geology of India, McGraw Hill Book Co.
3. Sharma., R., (2010) Cratons and Fold Belts of India, Springer
4. Valdiya, K.S., (2016) The Making of India: Geodynamic Evolution, Springer


**Reference Books:**


1. Boggs, S., (1987) Principles of Sedimentology and Stratigraphy, Merill Publishing Co. New York.
2. Ravindra Kumar, (2010) Fundamentals of Historical Geology and Stratigraphy of India, New Age International (p) Ltd.
3. Weller. A.K., (1988) Principles of Stratigraphy. Asia Publishing House. Delhi.
4. Gignoux, M., (1960) Stratigraphical Geology, Mc Graw Hill publications.


**Web resources:**

1. *Underlined Titles are available at the Swayam portal*
1. *http://www.uh.edu/~geos6g/1330/strat.html*
2. *http://www.geographynotes.com/rocks/the-gondwana-group-of-rocks-india-geology/5783*
3. *https://www.gktoday.in/academy/article/indias-rock-formation-archean-dharwar-cudappah-vindhyan-gondwana-and-tertiary-rocks/*
4. *https://www.gns.cri.nz/Home/Learning/Science-Topics/NZ-Geology/Measuring-Geological-Time*
5. *http://www.stratigraphy.org/upload/bak/strats.htm*
6. *https://en.wikipedia.org/wiki/Quaternary_glaciation*
7. *http://northpacificresearch.com/downloads/Problems_at_the_KT_Boundary.pdf*

**Course Outcomes**

On completion of the course, the students will be able to

**CO1:** Evaluate the principles of advanced Stratigraphy and details of the Geological Time scale.

**CO2:** Identify Indian stratigraphic systems of Archean, Dharwar, Cuddapah, Kurnool, Vindhyan and Aravalli systems, The Paleozoic Group, The Tertiary Group

**CO3:** Describe the detailed insight into the Geological Time events of Gondwana, Triassic, Jurassic and Cretaceous.

**CO4:** Assess the detailed significance of the Siwalik, Pleistocene, Holocene, Himalayas, and Eocene systems.

**CO5:** Analyze the age and boundary problems of various ages.

| | |
|---|---|
| Course Code & Title | **21GEOP0104**<br>**CRYSTALLOGRAPHY, MINERALOGY AND GEMMOLOGY** |

| | | | |
|---|---|---|---|
| Class | M. Sc. Applied Geology and Geomatics | Semester | I |

Cognitive Level: K-1, K-2, K-3

Course Objectives

**The Course aims**

- To understand Crystal Symmetry and Atomic structure
- To learn the optical properties of the minerals and their characteristics features.
- To describe in detail the various mineral groups and their properties.
- To know the rock-forming silicates
- To study the various Gem varieties and their properties

| Unit | Content | Lectures |
|---|---|---|
| I | ***Crystallography; Description of Six Major Crystal Systems***, **Unit Cells and Lattice;** Parameters and Crystallographic Axes. Points in Unit Cell, Plains in Crystals. Crystal Forms and Miller Index, **Interfacial angle**. **Twin crystals and Irregularities of crystals. Derivation of 32 Class;** Concept of Point group, reciprocal lattice – Derivation of 14 Bravais lattices **Concept of Space Group** – Symmorphic and Asymmorphic Space Groups - **Mineralogical investigations methods** - X-ray diffraction- Electron Probe Micro Analysis (EPMA), Scanning Electron Microscope (SEM), and Raman Spectroscopy. **Differential Thermal Analysis (DTA).** | 12 |
| II | **Mineral Preparation for Microscopic study;** Types of Preparation, Materials for Thin Section, The Mineral Slice and Cutting. **Optical Mineralogy – Polarizing Microscope;** General Features, Parts of Microscope, Phase Microscopy and its Examination. Adjustment of Polarizing Microscope. **Plane polarized and cross-polarized light; Isotropic and Anisotropic minerals;** Behavior of minerals in cross-polarized light - **Reflection, refraction, Double refraction. Snell's law. Extension angle and its types** - Birefringence – Uniaxial minerals – **Uniaxial and Biaxial Indicatrices; Optical accessories like mica, gypsum and quartz plates** – **Determination of Optic sign**: uniaxial and biaxial minerals- Absorption of light by minerals – Scheme of pleochroism. | 12 |
| III | **Advanced Mineralogy**- Crystal chemistry- bonding- structures of silicates- Isomorphism, Polymorphism and Pseudomorphism - Atomic Substitution and Solid solution in Minerals - Non-Crystalline minerals – Luminescence of Minerals - **Descriptive Mineralogy**; Mineral Groups: Chemical, Physical, Optical Properties of minerals. Introduction to the universal stage and its application. | 12 |
| IV | Alteration products, paragenesis and modes of occurrences of the following rock-forming silicates. ***Neso silicates***: Olivine group, Garnet group-***Sorosilicate***: Epidote group – Beryl. ***Ring Silicates*****:** Tourmaline –Benitoite- ***Chain Silicates*****:** Pyroxene group- Amphibole group and Wollastonite- ***Sheet Silicates*****:** Mica group- Chlorite group- ***Tectosilicates*****:** Quartz -Feldspar group - Feldspathoid group - Zeolite and Scapolite groups. Clay and Spinel Group | 12 |
| V | **Gemmology:** Physical characteristics (including Cutting resistance, electrical, thermal and magnetic characters) and chemical composition of gemstones. **Deposits and production:** Types of deposits and mining methods. **Optical properties of Gemstones**- Classification of Gemstones - **Application of UV, X - rays and Infra-Red Rays in Gem Identification**. Synthetic gems – characteristics- Uses of gemstones. Gemstone distribution of India | 12 |

**Text Books:**

1. Ford, W.E., (2006) Dana's Textbook of Mineralogy, Fourth Edition, CBS Publishers & Distributors, New Delhi.
2. Berry Mason, L.G., (1985) Elements of Mineralogy, Reprint, W.H. Freeman &Co.
3. Kerr, P. F., (1959) Optical Mineralogy- Third Edition. McGraw-hill book company.
4. Read, P.G., (2005) Gemmology, Butterworth-Heineman

**Reference Books:**

1. Deer, W. A., Howie, R.A & Zussman (2013) An Introduction to Rock-forming Minerals, Third Edition, ELBS Ed.
2. Walhstrom, E.E., (1979) Optical Crystallography, John Wiley & Sons.
3. Perkins, D., (2010) Mineralogy, 3rd Edition, Prentice-Hall.
5. Ravell Phillips**,** W.M., and Griffen, D.T., (2004) Optical Mineralogy-The Non-Opaque Minerals, CBS Publishers & Distributors, New Delhi.
4. Mike Howard & Darcy Howard, (1998) Introduction to Crystallography and Mineral Crystal Systems, Rock hounding Arkansas.

**Web resources**:

1. *Underlined Titles are available in the Swayam portal*
2. *http://www.tulane.edu/~sanelson/eens211/#Lecture%20Notes*
3. http://jaeger.earthsci.unimelb.edu.au/msandifo/Teaching/Mineralogy2/mineralogy.pdf
4. http://epgp.inflibnet.ac.in/ahl.php?csrno=448
5. https://www.researchgate.net/publication/221923612_An_Introduction_to_Mineralogy
6. http://www.minsocam.org/msa/openaccess_publications/McNamee_Gunter_Lab_Manual.pdf

**Course Outcomes**

On completion of the course, the students will be able to

**CO1:** Discuss the Description of Six Major Crystal Systems, Unit Cells and Lattice, Derivation of 32 Class, Concept of Space Group, Mineralogical investigations methods

**CO2:** Describe the Optical Mineralogy, Mineral Preparation for Microscopic study

**CO3:** Explain the Advanced Mineralogy, Descriptive Mineralogy

**CO4:** Describe the Neso silicates, Sorosilicate's, Ring Silicates, Chain Silicates, Sheet Silicates, Tectosilicates

**CO5:** Discuss the Gemmology and Application of UV

| | | | |
|---|---|---|---|
| Course Code & Title | **21GEOP0105**<br>**REMOTE SENSING AND GPS** | | |
| Class | M. Sc. Applied Geology and Geomatics | Semester | I |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |
| Course Objectives | **The Course aims**<br>• To understand the principles of Remote sensing and interpretation key elements.<br>• To know in detail how the Electromagnetic Spectrum is related to the field of Remote sensing<br>• To introduce the satellites and their Orbits and the sensors and their characteristics<br>• To explain the types of remote sensing and the data interpretation<br>• To illustrate the principles and components of GPS and the mapping. | | |

| Unit | Content | Lectures |
|---|---|---|
| I | **Remote Sensing** – An Introduction: History and Development of Remote Sensing, Fundamentals **of Remote Sensing- Stages** in Remote Sensing Process. **Types of Remote Sensing-** Based on Platforms, energy source, Imaging media, Regions of the EM spectrum & number of Bands Advantages & Applications of Remote sensing, **Aerial Photographs**-, Basics, Types, Stereo models, Photo Mosaics and Photo scale, Drone Imageries. ***Photo Interpretation Keys & Elements***: Definition, parts, Key sets, Types of Study, **Photo Interpretation Elements** - Tone, Texture, Shadow, Size, Shape, Pattern and Association. **Geotechnical / Geomorphic Elements** - Landforms, Drainage, Erosional Pattern, Vegetative Cover | 9 |
| II | ***The Nature of Electromagnetic Radiation(EMR)***- electromagnetic spectrum, energy- frequency-wavelength relationship, Stefan-Boltzmann Law, Wien's Law, electromagnetic energy and its interactions in the atmosphere: Absorption, Scattering & Atmospheric windows and with terrain features. Planck's Radiation Law Wave Model, Types of Reflection, Spectral reflectance curve | 9 |
| III | **Satellites and Sensors- Platforms- Satellite Orbits:** Geostationary, Sun-synchronous Satellites- **Resolution:** Spatial Resolution, Spectral Resolution, Radiometric Resolution, Temporal Resolution, and Multispectral Resolution. **Scanning Mechanisms:** Across Track Scanning**,** Along with Track Scanners. **Satellite Meteorology**: Meteorological satellites – Polar-orbiting and geostationary satellites, visible and infrared radiometers, multi scanner radiometers; identification of synoptic systems, fog and sandstorms, detection of cyclones, estimation of SST, cloud top temperatures, winds and rainfall: temperature and humidity soundings. | 9 |
| IV | **Thermal Remote Sensing:** Basic concepts, Thermal scanning, Thermal radiation principle and Data Interpretation. Thermal sensors- ASTER, MODIS- **Microwave Remote Sensing**: Basic concepts, Active and Passive Microwave System and Data Interpretation.MW sensor ASTER – **Hyperspectral Remote Sensing: *Basic concepts and Data Interpretation***. **AVIRIS- LIDAR sensing** | 9 |
| V | **GPS Basics:** Introduction – Satellite, Control and User Segments – Signal Components, Errors in GPS observations, PS positioning, Differential GPS. **GPS Mapping**: Conventional Static, Kinematic GPS Semi kinematic (Stop & Go) – Rapid static Mobile mapping. | 9 |
| | **Text Books:** | |

1. Anji Reddy, M., (2012) Textbook of Remote Sensing & GIS, BS Publications, Hyderabad.
2. Curran, P., (1985) Principles of Remote Sensing, Longman, London.
3. Sabins, F.F., (2007) Remote Sensing Principles and Interpretation, Freeman, San Francisco.

**Reference Books:**

1. John, T. Smith, Jr, (1973) Manual of Colour Aerial Photography (I Edition) American
Society of Photogrammetry, ASP Falls Church, Virginia.
2. Lillesand, T.M., and Kiefer, P.W., (2007) Remote Sensing and Image Interpretation, Third Edition, John Wiley & Sons, New York..
3. Rampal, ( 1999) Handbook of Aerial Photography and Interpretation, Concept publishing.
4. Pandey, S.N., (1987) Principles and Applications of Photo geology, Wiley Eastern Limited, India.
5. Gupta, R.P., (2003) Remote Sensing Geology, Springer - Verlag - New York, London.
6. Basudeb Bhatta, (2008) Remote sensing and GIS, Oxford University Press

**Web resources**:

1. Underlined Titles are available in the Swayam portal
2. *http://www.gdmc.nl/oosterom/PoRSHyperlinked.pdf*
3. *http://www.geoservis.ftn.uns.ac.rs/downloads/ISP/1999-fundamentals-of-remote-sensing.pdf*
4. *https://webapps.itc.utwente.nl/librarywww/papers_2009/general/PrinciplesRemoteSensing.pdf*
5. https://researchweb.iiit.ac.in/~sai.deepak/lectures/Thermal%20infrared%20remote%20sensing.pdf
6. http://eoscience.esa.int/landtraining2017/files/materials/D2T3__P.pdf
7. https://www.tutorialspoint.com/satellite_communication/satellite_communication_global_positioning_system.html.
8. https://www.trimble.com/gps_tutorial/

**Course Outcomes**

On completion of the course, the students will be able to

**CO1:** Describe the basic principles of Remote Sensing and photointerpretation key elements
**CO2:** Describe the Electromagnetic spectrum and EMR interactions.
**CO3:** Categorize insight into different kinds of sensors, systems and satellite platforms
**CO4:** Discuss the types of Remote sensing
**CO5:** Predict the basic principles of GPS and GPS mapping

| | |
|---|---|
| Course Code & Title | **21GEOP0106**<br>**CRYSTALLOGRAPHY AND MINERALOGY PRACTICAL – I** |

| | | | |
|---|---|---|---|
| Class | M. Sc. Applied Geology and Geomatics | Semester | I |

| | |
|---|---|
| Cognitive Level | K-1<br>K-2<br>K-3 |
| Course Objectives | The Course aims<br>• To identify various crystal models<br>• To derive the Millerian Signs<br>• To determine the optical properties of minerals<br>• To discriminate the structural formulae for various mineral groups.<br>• To examine the megascopic properties of rock-forming minerals |

Contents

1. Study of Crystal models of all crystal systems.
2. Crystal Projections, Stereographic projections and calculation of crystal elements.
3. Equation of normal, axial ratios, interfacial angles, indices of faces.
4. Weiss zone of law, rule of three faces in the zone.
5. Derivation of Millerian signs for a co zonal quartette.
6. Determination of Optical Properties of Minerals using Petrological Microscope.
7. Determination of Relative Birefringence, order of interference colour, sign of elongation, birefringence, scheme of pleochroism and pleochroic formula.
8. Determination of Optic orientation, extinction angle, anorthite content.
9. Determination of structural formula of the following mineral groups: Garnet, Olivine, Pyroxene, Feldspar, Mica and Amphibole.
10. Megascopic Identification of Important Rock-Forming Minerals

**Course Outcomes**

On completion of the course, the students will be able to

CO1:Identify the physical properties of industrial minerals and Fe ores
CO2: Explain the physical properties of Cu and Mn ores.
CO3:Discuss the physical properties of Pb and Zn ores
CO4:Identify physical properties of Sn, As, Sb ores and radioactive ores
CO5: Analyze the Ore minerals quantitatively.

| | |
|---|---|
| **Course Code & Title** | 21GEOP0107<br>**STRUCTURAL GEOLOGY, PALAEONTOLOGY AND REMOTE SENSING - PRACTICAL - II** |

| | | | |
|---|---|---|---|
| **Class** | M. Sc. Applied Geology and Geomatics | **Semester** | I |

| | |
|---|---|
| **Cognitive Level** | **K-1**<br>**K-2**<br>**K-3** |
| **Course Objectives** | **The Course aims**<br>• To identify the megascopic features and the morphological characteristics of Fossils.<br>• To determine the geological structures through cross-sections.<br>• To identify the True dip, apparent dip, and thickness of Beds.<br>• To visually interpret the images using stereoscopes<br>• Interpret the lithology, structure, geomorphology, land use/ land cover through satellite imagery and aerial photographs. |

**Contents**

**Palaeontology**

1. Megascopic identification of Fossils.
2. Reconstruction of Broken Fossils.
3. Tracing Evolutionary trends in Trilobites
4. Tracing Evolutionary trends in Graptolites
5. Tracing Evolutionary trends in Cephalopods
6. Tracing Evolutionary trends in Brachiopods
7. Tracing Evolutionary trends in Corals
8. Morphological study of Foraminifera.
9. Morphological study of Ostracoda

**Structural Geology**

1. Three-point problems for Fold maps, Fault maps, and Unconformity maps and Preparation of cross-sections across the geological maps to bring out the structure and order of superposition of the beds.
2. Structural geology problems/Graphical determination of Dip in gradient.
3. Determination of True dip by a simple calculation.
4. Determination of Apparent dips by Graphical method.
5. Determination of Thickness of bed by calculation on level ground.
6. Geometric analyses of linear and planar features using Stereographic projection
7. Stereographic projection by using Stereonet windows software

**Remote Sensing**

1. Visual Interpretation Methods
2. Visual Interpretation Instruments – Mirror Stereoscope
3. Visual Interpretation of Panchromatic image
4. Parallax Bar
5. Lithology through an aerial photograph and satellite data
6. Structure through an aerial photograph and satellite data
7. Geomorphology through an aerial photograph and satellite data
8. Land use and Landcover aerial photograph and satellite data
9. Spatial resolution vs Features.
10. Lineament mapping and its measurements

**Course Outcomes**

On completion of the course, the students will be able to

**CO1:** Identify and Explain the Morphological features of fossils
**CO2:**Analyze the broken fossils
**CO3:** Assess the Dip and strike from the maps
**CO4:**Interpretation of Land use and land cover by using Aerial and Satellite data
**CO5:**Analyze the Lithological, Geomorphological and structural information from satellite data

## Semester – II

| Course Code & Title | **21GEOP0208**<br>**IGNEOUS AND METAMORPHIC PETROLOGY** | | |
|---|---|---|---|
| Class | M. Sc. Applied Geology and Geomatics | Semester | II |
| Cognitive Level | **K-1**<br>**K-2**<br>**K-3** | | |
| Course Objectives | **The Course aims**<br>• To learn the composition of Magma, crystallization of magma<br>• To understand the classification of Igneous rocks<br>• To gain knowledge of the petrography of various types of Igneous rocks.<br>• To know the formation and different facies of Metamorphism<br>• To describe petrography of metamorphic rocks. | | |

| Unit | Content | Lectures |
|---|---|---|
| I | **Igneous Petrology**: Composition and Constitution of Magmas – Phase rule Bowen's Reaction Principle - **Reaction principles in petrogenesis** – continuous and discontinuous series. ***Crystallization of Unicomponent Magma, Binary Magma*** (Diopside - Anorthite, Forsterite – Silica and Albite - Anorthite). ***Ternary Magma*** (Albite - Anorthite - Diopside, Forsterite - Anorthite-Silica, Diopside – Forsterite – Anorthite, diopside-forsterite-anorthite and nepheline kalsilite-silica). Outline of Quaternary System for Basalt. Crystallization of Basaltic Magma. **Partial Melting** - Magmatic evolution (differentiation, assimilation, mixing and mingling). | 12 |
| II | ***Classification of Igneous rocks*** – Chemical classification- CIPW Norm, Silica saturation and Alumina saturation**. -** Tyrrell's tabular Classification. IUGS classifications. **-** Types of Variation diagrams and their utility**– Petrography-**A detailed Petrography of Acid and Intermediate Igneous rocks and their volcanic equivalents. **-** A detailed Petrography of Basic and Ultrabasic Igneous Rocks and their volcanic equivalents. | 12 |
| III | **Petrography of Rocks** - Granites, Basalt, Anorthosites, Pegmatites, Lamprophyres, Carbonatites, and Kimberlite. **Igneous rocks at Continental margins:** The Ophiolite suite. Calc alkaline and Tholeilite group of rocks. **The Origin of Igneous rocks –** variations in igneous rock, Evidence of Differentiation, Variation within a single rock body. | 12 |
| IV | **Metamorphic Petrology:** Definition, Agents and types of Metamorphism, concept of the metamorphic zone, isograd and facies - ***Grades of Metamorphism***. Texture and Structures of Metamorphic rocks. Foliated and Non-foliated rock types. Mineralogical phase rule of close and open systems. **Mineral assemblages and metamorphic reactions**. P-T conditions of metamorphism. **Laws of Thermodynamics**- Gibbs free energy. Concept of Activity, Fugacity, Ideal and Non-Ideal solutions. Geothermobarometry**.** | 12 |
| V | ACF, AKF, AFM diagrams, Metamorphism vs Metasomatism - Metamorphic differentiation. **Petrography, nomenclature, classification and petrogenesis of the following rocks**: Slates – Phyllites – Schists – Gneiss– Granulites - Charnockites – Eclogites – Amphibolites – Khondalites – Migmatites. **Remote Sensing based mapping** - Igneous, Sedimentary and Metamorphic rocks. | 12 |

**Text Books:**


1. Turner F.J., Verhoogen, J., (2004) Igneous and Metamorphic Petrology, CBS Publishers & Distributors, New Delhi.
2. Walter Ta Huang, (2012). Petrology, First Indian Print, Surjeet Publications.


**Reference Books:**


1. Best, M. G., (2003) Igneous and Metamorphic Petrology. Wiley. New Delhi.
2. Best, M. G, (2005) Igneous Petrology. Wiley, New Delhi.

3. Bowen, N.L., (1928) Evolution of Igneous Rocks. Princeton University Press; London.
4. Hyndman, D.H., (1985) Petrology of Igneous and Metamorphic Rocks, McGraw Hill Book co.
3. Hota, R.N., (2011) Practical Approach to Petrology, CBS Publishers & Distributors, New Delhi.
5. Philipotts, (1992) An Igneous and Metamorphic Petrology, Prentice-Hall.
6. Ehlers, E.G., Blatt, H., (1999) Igneous, Sedimentary and Metamorphic Rocks, CBS Publishers and Distributors, New Delhi.
7. Winter, J. D., (2010) Principles of Igneous and Metamorphic Petrology. PHI. New Delhi.

***Web resources:***

1. *Underlined Titles are available in the Swayam portal*
2. *http://en.wikipedia.org/wiki/Igneous_petrology*
3. *http://www.tulane.edu/~sanelson/eens212/intro&textures.htm*
4. *http://ericfdiaz.wordpress.com/an-introduction-to-igneous-petrology*
5. *Krishikosh.egranth.ac.in/bitstream/1/2023720/1/BPT9862pdf.*
6. *http://www.pdfdrive.net/petrology-books html*

**Course Outcomes**

On completion of the course, the students should be able to

**CO1:** Designate the Magmatic process and formation of igneous rocks.
**CO2:** Identify the different types of Igneous Rocks
**CO3:** Explain the Rock formations and important rock descriptions.
**CO4:** Evaluate the Environment of deposition and also Metamorphic Petrology.
**CO5:** Assess the Petrography, nomenclature, classification and petrogenesis of important metamorphic rocks.

| Course Code & Title | **21GEOP0209**<br>**ECONOMIC GEOLOGY AND ORE DRESSING** | | |
|---|---|---|---|
| Class | M. Sc. Applied Geology and Geomatics | Semester | II |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |
| Course Objectives | The Course aims<br>• To Understand the process of formation of ore deposits and classification of various mineral deposits<br>• To Study the Geological setting, characteristics, and genesis of Ore deposits<br>• To Study Ore mineral textures and their paragenesis<br>• To Learn the various mining methods and prospecting methods<br>• To Acquire knowledge on the mineral dressing | | |

| Unit | Content | No. of Lectures |
|---|---|---|
| I | ***Process of formation of Ore Deposits*:** Magmatic Concentration - Sublimation - Contact Metasomatism - Hydrothermal Process - Sedimentation - Bacterial process - Submarine exhalative and volcanic process - Evaporation - Residual and Mechanical concentration - Oxidation and Supergene Enrichment - Metamorphism – Syngeneic and epigenetic deposits, forms of ore bodies, stratiform and strata-bound deposits ***Classification of mineral deposits*** - **Controls and Localization of Mineral Deposits** – Characteristics of mineral deposits spatial and temporal distribution Metallogenic Epochs its relation to crustal evolution<br>Metallogenic Provinces - Geological Thermometry and barometry for Ore minerals. | 9 |
| II | **Geological setting, characteristics, and genesis of Magmatic and pegmatitic deposits:** Chromite, Titanium, Diamond, Cu-Ni sulphide, PGE, REE, muscovite. **Hydrothermal deposits:** Porphyry Cu-Mo, Greisen Sn-W, Sulphide deposits, Orogenic gold. **Sedimentary deposits**: Fe, Mn, Phosphorite, Placer deposits, Supergene deposits: Cu, Al, Ni and Fe. **Metamorphic and metamorphosed deposits:** Mn, Graphite **Geological setting, characteristics, and genesis of ferrous, base and noble metals. Base Metals:** Iron, Copper, Nickel, Zinc, Lead, Aluminium, Tin, Tungsten, Molybdenum, Tantalum, Cobalt, Chromium, Cadmium, Titanium | 9 |
| III | **Geological setting, characteristics, and genesis of:** Antimony, Beryllium, Bismuth, Gallium, Germanium, Hafnium, Niobium, Rhenium, Thallium, Vanadium, Zirconium. Minerals used in refractory, fertilizer, ceramic, cement, glass, paint industries; minerals used as abrasive, filler; building stones - Ore grade and Reserve, assessment of grade, reserve estimation. | 9 |
| IV | **Mineral Economics:** Significance of Minerals in National Economy - Demands and Supplies - Substitutes - Market Economy - Essential, Critical and Strategic Minerals - ***Mineral Conservation Policy***- India's Status in Mineral Production. **Ore Mineral Textures-** Single Grain, Aggregates, Growth fabric, Colloidal, Sedimentary, Paramorphic replacement, Exsolution- Simple and Complex, Replacement, Relict, Decomposition, Oxidation (Weathering), Cementation, Curvature of linear features, Schlieren, Brecciation or Cataclasis, recrystallization, Reequilibrium, Dynamic Metamorphic effect, Thermal Metamorphic | 9 |

| | | |
|---|---|---|
| | effects, Skarns, Framboids or Framboidal**. Paragenesis: Shape, Relict, Colloform Banding, Growth zoning, Cross-Cutting relationship, Twinning, Exsolution, Replacement, Fluorescence.** | |
| V | **Mineral Dressing** - Definition and Scope of Mineral dressing (ore dressing) Physical and Chemical Properties of minerals made use of in Mineral dressing. **Comminution:** Principles, theories of Comminution, ore grindability. Crushers: Primary and Secondary Crushers. **Grinding Mills (Tumbling Mills):-** types of Mills: Rod, Ball and Autogenous mills. Industrial Screening: Screens and their types**.** | 9 |

**Text Books:**


1. Bateman, A., (2013) Economic Mineral Deposits, John Wiley.
2. Prasad, U., (2000) Economic Geology- Economic Mineral Deposits, Second Edition, CBS Publishers & Distributors, New Delhi.
3. Evans, A.M., (1993) Ore Geology and Industrial Minerals, An Introduction., Blackwell Science.
4. Robb, L., (2005), Introduction to Ore-Forming Processes, Blackwell Science, Springer-Verlag.


**Reference Books:**


1. Moon, C., Whateley, K.G.M., and Evans, M.A., (2005) Introduction to Mineral Exploration, John Wiley & Sons.
2. Edwards, R., and Atkinson, K., (1986) Ore Deposit Geology, Chapman & Hall, London.
3. Gokhale & Rao, (2010) Ore Deposits of India, Thomson press.
4. Levorsen A.I., (1985) Geology of Petroleum, Second Edition, CBS Publishers and Distributors, New Delhi.
5. Sinha, R.K., and Sharma, N.L., (1988) Mineral Economics, Oxford-IBH, New Delhi.
6. Ineson. P.R., (1989) Introduction to Practical Ore Microscopy, Taylor & Francis.


**Web resources:**

1. *Underlined Titles are available in the Swayam portal*
2. *https://www.britannica.com/science/mineral-deposit/Formation-of-mineral-deposits*
3. *http://www.preservearticles.com/2012010519974/the-processes-of-formation-of-mineral-deposits-are-grouped-into-three-main-types.html*
4. *https://www.geologyforinvestors.com/classification-of-mineral-deposits/*
5. *https://iasmania.com/mineral-resources-india-iron-coal-aluminium-copper-lead-zinc/*
6. *http://www.aadnc-aandc.gc.ca/eng/1100100028056/1100100028058*
7. *https://everydayoil.wordpress.com/2012/11/16/different-types-of-drilling-and-its-breif-description/*
8. *http://www.cienciaviva.pt/img/upload/Introduction%20to%20mining.pdf.*
9. *https://www.americangeosciences.org/critical-issues/faq/what-are-main-mining-methods*
10. *http://emfi.mines.edu/emfi2011/Coal%20Mining%20Methods%20-%20EMFI%20Summary.pdf*

**Course Outcomes**

On completion of the course, the students will be able to

**CO1:** Describe the process of Ore formation and understand the Syngeneic and epigenetic deposits

**CO2:** Discuss the geological formation of Metallic mineral groups.

**CO3:** Assess the Ore Mineral properties

**CO4:** Formulate the Scientific questions of the Underground mining methods.

**CO5:** Discuss the Mineral dressing techniques

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|---|---|---|---|
| Course Code & Title | **21GEOP0210**<br>**ENVIRONMENTAL GEOLOGY AND NATURAL DISASTER MANAGEMENT** | | |
| Class | M. Sc. Applied Geology and Geomatics | Semester | II |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |
| Course Objectives | The Course aims<br>• To Know the Importance of Environmental geology and various types of resources.<br>• To Study about the Energy, Land and Air resources and their related problems<br>• To Understand the concepts of disasters, their classification, causes and impacts.<br>• To Acquire knowledge about the approaches to Disaster risk reduction | | |

| Unit | Content | Lectures |
|---|---|---|
| I | **Environmental Geology:** Planet Earth, environment and its types, scope and importance of Environmental Geology, public awareness, **Natural Resources;**–types of resources (based on origin, based on continual utility). **Natural Resources and Associated Problems**: Water resources,—Properties of water; Hydrological cycle; water resource and management degradation and contamination of surface water and groundwater quality due to industrialization and urbanization —Control measures to reduce the contamination / Conservation of surface and subsurface water bodies | 9 |
| II | **Energy Resources,** Energy resources, uses, degradation, alternatives and management; Ecology and biodiversity. Impact of the use of energy and land on the environment. Exploitation and conservation of mineral and other natural resources **Land resources:** Man-land relationship, **Biosphere as an Ecosystem** -System, the biosphere, biosphere as a system, biosphere, as an ecosystem, sub-systems of biosphere, modifiers of biosphere, components of biosphere – Atmosphere components–**Atmospheric Disturbances: Cyclones and Anticyclones) Causes, Effects and Control Measures of** Air Pollution. | 9 |
| III | ***Introduction to Disaster*:** Concepts and Definitions. Disaster, Hazard, Risk, Vulnerability, Resilience. **Disaster: Classification, Causes and Impacts:** Natural Disaster: Beneath the Earth Surface: ***Earthquake*** -Types and Characteristics of Seismic waves. Distribution, magnitude and intensity of earthquakes Mitigation measures of Earthquake. **Tsunami:** Nature, characteristics, causes and origin of Tsunami; Arrival, adverse effects and management of Tsunami disaster. | 9 |
| IV | ***Natural Disaster*:** On the Surface: ***Volcanic Eruptions-*** Types, effects and mitigation measures of Volcanoes. Landslides- Types, Influencing factors, effects and its management strategies. Avalanche. **Meteorological /Hydrological Disasters;** Flood- Types, causes, effects and its control measures. Droughts- its types and mitigation measures. Windstorms, Hailstorms, Tornadoes. | 9 |
| V | **Approaches to Disaster Risk Reduction:** Disaster Management Cycle, Phases of Disaster Cycle. Culture of Safety, Prevention, mitigation and Preparedness. Structural measures, Components of Disaster Relief. Four phases of Disaster Management. Disaster | 9 |

management in India – NDMA, NIDM, SDMA. Role of Technology in Disaster management

**Text Books:**


1. Jonathan Turk and Graham R. Thompson, Environmental Geoscience: Saunders College Division, 2000.
2. Savindra Singh, (2015) Environmental Geography, Pravalika Publications, Allahabad.
3. Keller, E.A., (2010) Environmental Geology: CBS Publisher, New Delhi
4. Valdiya, K.S., (2005) Geology Environment and Society. Universities Press,
5. Bryant, E., (2008) Natural Hazard. Camb. Univ. Press.


**Reference Books**:


1. Chouhan, T.S.& Joshi, K.N., (1996) Applied Remote Sensing and Photo Interpretation, VigyanPrakashan,
2. Savindra Singh, (2020) Oceanography, Pravalika Publications, Allahabad,


**Web Resources:**

1. *Underlined Titles are available in the Swayam portal*
2. *http://www.svu.edu.eg/links/ictp/e_learning/links/courses/dr_abbas/course3/1.pdf*
3. *https://en.wikipedia.org/wiki/GIS_in_environmental_contamination*
4. *http://www.geo.unibe.ch/unibe/portal/fak_naturwis/e_geowiss/a_igeo/content/e42577/e42580/e454184/e454188/RWIforbeginnersA5-ERZ2_ger.pdf*
5. *http://www-naweb.iaea.org/napc/ih/documents/global_cycle/vol%20IV/IV_Ch4.pdf*
6. *https://www.conserve-energy-future.com/causes-and-effects-of-environmental-degradation.php*
7. *http://www.civileblog.com/types-of-soil/*
8. *http://environment.uwe.ac.uk/geocal/SoilMech/classification/default.htm*
9. *http://cbse.nic.in/natural%20hazards%20&%20disaster%20management.pdf*
10. *http://www.fao.org/3/a-i0304e.pdf*
11. *https://think-asia.org/bitstream/handle/11540/5035/disaster-management-handbook.pdf?sequence=1*
12. *http://www.untagsmd.ac.id/files/Perpustakaan_Digital_1/DISASTER%20MANAGEMENT%20Disaster%20Management%20Handbook.pdf*

**Course Outcomes**

On completion of the course, the students willbe able to

CO1: Assess the basics of Environmental Geology and Natural Disaster Management
CO2: Explain the Natural Resources and their related problems.
CO3: Analyze the risk and mitigation of hazards.
CO4: Assess the cause, effects and mitigation measures of disasters.
CO5: Discuss the Natural Disaster Management through Geospatial Technology

| Course Code & Title | **21GEOP0211**<br>**DIGITAL IMAGE PROCESSING AND GEOCOMPUTING** | | |
|---|---|---|---|
| Class | M. Sc. Applied Geology and Geomatics | Semester | II |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |
| Course Objectives | The Course aims<br>• To understand the basic principles of Image Processing<br>• To learn the various image processing techniques<br>• To gain knowledge on Image Transformation.<br>• To know types of Image classification techniques.<br>• To describe the computer and Android applications in the field of geology | | |

| Unit | Content | Lectures |
|---|---|---|
| I | **Principles of Image Processing**: Digital Image formats - **Image Processing systems:** Hardware Component, Software Consideration and color composites, Image Display. **Image Restoration**: **Geometric Correction Methods**: Sources of Errors, Systematic and Nonsystematic Correction Processes. **Radiometric Correction**: Sources of errors, correction processes. **Atmospheric Correction Methods. Miscellaneous Pre-processing. Ortho Rectifications Methods.** | 12 |
| II | **Image Enhancement: Contrast Enhancement**; Linear Contrast stretch, Non-Linear Contrast enhancement. Histogram Equalization, Gaussian Stretch, Density Slicing. **Spatial Filtering;** Spatial convolution filtering, Low-frequency filtering in the spatial domain, High-frequency filtering in the spatial domain. **Edge enhancement in the Spatial Domain;** Linear edge enhancement, Band rationing, Color Ratio Composite Images. | 12 |
| III | **Image Transformation:** Image Arithmetic operations; Image addition, Image subtraction, Image multiplication, Indices/Ratioing. PC transformation. Fourier transformation**. Image Fusion:** Multiplicative Fusion, PCA transform fusion, HIS transform fusion. **Image Classification: The Classification Stage** | 12 |
| IV | **Supervised classification**; Minimum distance to Means Classifiers, Parallelepiped Classifiers, Gaussian Maximum Likelihood Classifier, **The Training Stage. Unsupervised classification**; Cluster building, Cluster Labeling, Reclassification Processing and Feature Extraction. Subpixel classification, **Classification Accuracy Assessment;** Overall Classification Map Accuracy Assessment, Site-Specific Classification Map Accuracy assessment. Classification Error Matrix | 12 |
| V | Normalized Density Vegetation Index, Normalized Density Water Index, Pan sharpening. Drone data analysis. **Digital Online Data Sources;** Bhuvan, USGS, GLCF, and Google Earth. **Computer Applications in Geology;** Aquachem, Rockworks, Petro plot, Stereonet, Igpet, IPI2WIN, Surfer, Petrograph, Tri plot, SPSS, Statistical, Origin.-**Mobile Android Geological Softwares;** Field Move Clino, Smart Geology - Mineral Guide, Petrologic, Geological time scale, Strike and dip, Rocklogger, ArcGIS, Geo Area. | 12 |

**Text Books:**


1. Curran, P., (1985) Principles of Remote Sensing, Longman, London.
2. Nilblack, W., (1986) An Introduction to Digital Image Processing, III Edition, Prentice-Hall International.
3. Davis, B.E., (2001) GIS A visual approach, Second edition, Onword Press/ Thomson Learning

**Reference Books:**


1. Hord M.P., (1982) Digital Image Processing of Remotely Sensed Data, Academic Press.
2. Jenson, (2004) Introduction to Digital image processing, 3 Edition, Prentice Hall.
3. Lillesand, T.M., and Kiefer, P.W., (2003) Remote Sensing and Image Interpretation, John Wiley & Sons, New York.
4. Paul J. Gibson and Clara H. Power (2000) Introductory Remote Sensing, Digital Image Processing and Applications, Routledge.
5. Pratt, S.K., (1990) Digital Image Processing, Wiley - Inter-Science, New York.
   Gupta, R.P., (2003) Remote Sensing Geology, Springer - Verlag - New York, London.
6. Basudeb Bhatta, (2008) Remote sensing and GIS, Oxford University Press.


**Web resources:**

1. *Underlined Titles are available in the Swayam portal*
2. *http://148.206.53.84/tesiuami/S_pdfs/Remote%20Sensing%20Digital%20Image%20Analysis.pdf*
3. *http://www.wamis.org/agm/pubs/agm8/Paper-5.pdf*
4. *http://www.fao.org/3/a-i0304e.pdf*
5. *https://think-asia.org/bitstream/handle/11540/5035/disaster-management-handbook.pdf?sequence=1*
6. *http://www.untagsmd.ac.id/files/Perpustakaan_Digital_1/DISASTER%20MANAGEMENT%20Disaster%20Management%20Handbook.pdf*
7. *https://think-asia.org/bitstream/handle/11540/5035/disaster-management-handbook.pdf?sequence=1*
8. *http://www.untagsmd.ac.id/files/Perpustakaan_Digital_1/DISASTER%20MANAGEMENT%20Disaster%20Management%20Handbook.pdf*

**Course Outcomes**

On completion of the course, the students will be able to

**CO1:**Describe the basic principles of DIP
**CO2:** Illustrate the Image Enhancement techniques and their applications
**CO3:**Describe Image transformation techniques
**CO4:**Describe Image classification and assess the-accuracy
**CO5:**Describe the computer and Android applications in Geology

| | | | |
|---|---|---|---|
| Course Code & Title | **21GEOP0212**<br>**IGNEOUS AND METAMORPHIC PETROLOGY AND ECONOMIC GEOLOGY – PRACTICAL - III** | | |
| Class | M. Sc. Applied Geology and Geomatics | Semester | II |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |
| Course Objectives | The Course aims<br>• To Differentiate the megascopic properties of igneous, sedimentary and metamorphic rocks<br>• To Discriminate the petrographic properties of rocks microscopically<br>• To study the optical properties of ore minerals<br>• 'To Identify the economic minerals in hand specimen<br>• To Learn the ore reserve Estimation | | |

**Contents**

1. Megascopic Identification of Igneous and Metamorphic rocks.
2. Microscopic Identification of Rock Fabrics, Mineral assemblages of Igneous, and Metamorphic rocks.
3. Calculation of C.I.P.W. Norm.
4. Variation diagrams: Binary- Harker, Niggli, Ternary variation diagrams.
5. ACF, AKF and AFM diagrams.
6. REE distribution patterns and Petrogenetic significance of rocks.
7. Identification of economic minerals in hand specimen.
8. Study of optical properties of opaque minerals in reflected light and their identification in polished thin sections.
9. Study ore textures and interpretation of paragenesis.
10. Identification of following important economic minerals in hand specimen
    A. Native Elements
    B. Oxides
    C. Oxide- Hydroxide
    D. Hydroxide
    E. Sulphides
    F. Sulphates
    G. Carbonates
    H. Chlorite halogen
    I. Silicates
    J. Phosphates
    K. Halites
    L. Oxide - spinel group

**Ore Reserve Estimation**

1. Theory of sampling
2. Included area and valance weight method
3. Triangular grouping method
4. Area of Influencing method

**Course Outcomes**

On completion of the course, the students will be able to

**CO1:**Identify the Igneous, Sedimentary and Metamorphic rock
**CO2:**Evaluate the microscopic properties of Igneous, Sedimentary and Metamorphic rock
**CO3:** Prepare the Harker, Niggli and Ternary variation diagrams.
**CO4:** Prepare the ACF, AKF and AFM diagrams.
**CO5:** Identify the physical properties of important economic minerals.

| | | | |
|---|---|---|---|
| Course Code & Title | **21GEOP0213**<br>**DIGITAL IMAGE PROCESSING - PRACTICAL - IV** | | |
| Class | M. Sc. Applied Geology and Geomatics | Semester | II |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |
| Course Objectives | The Course aims<br>• To-Do geometric corrections of raw images<br>• To Compute various image processing techniques<br>• To Apply the classification techniques<br>• To Generate DEM, contours, slope maps<br>• To Understand the basic principles of geological software's | | |

**Contents**

Exploring the Digital Image Processing Software Interface and Working with True and False Color Composite using remotely sensed data sets.

1. Data download from Bhuvan, USGS, GLCF, and Google Earth, (ArcGIS Living Atlas - https://livingatlas.arcgis.com/en/browse/#d=2)
2. Portal, and Blend, Flicker, Swipe and Geolinking.
3. Overlay of Vector Layer over Image.
4. Reading Raw Image, Reproject Raster and Geometric Correction. Mosaicing of Images
5. Spatial and Spectral Subset.
6. Image Enhancement/ Stretch, Apply Spatial Filter, Mosaic.
7. Pan sharpening.
8. Density Slicing
9. NDVI and NDWI Calculation https://apl.esri.com/jg/VegetationChange/index.html ).
10. Principal Component Analysis (PCA).
11. Band Rationing
12. Image Fusion
13. Change Detection, Anomaly Detection.
14. Spectral Analogues Tool for Vegetation Delineation.
15. Relative Water Depth Analysis.
16. Unsupervised Classification.
17. Supervised Classification, Accuracy Assessment, Generation of Class Statistics.
18. Object-based Classification
19. Lidar data analysis
20. Drone images processing (Digital surface model creation, orthorectification)
21. Generation of Digital terrain model from contours and break lines
22. Generation of Contours from DEM
23. Generation of Slope and Aspect
24. Generation of Line of Sight
25. AOI based Clip/subset of imageries
26. Create 3D fly-through
27. Atmospheric Correction
28. Exploring the basic principles of geological software.
    a. Rockworks
    b. Igepet
    c. Surfer
    d. Aquachem
    e. Petroplot
29. Mobile Applications

a) Field Move Clino
b) Smart Geology -Mineral Guide
c) Petrologic
d) Geological time scale
e) Strike and dip
f) Rocklogger
g) Geo Area

**Course Outcomes**

On completion of the course, the students will be able to

**CO1:**Geometrically correct the data

**CO2:**To Carry out the image processing techniques

**CO3:**To generate DEM, Line of Sight map, contour maps

**CO4:** Work with various geological software's.

**CO5:**To apply mobile technology in geological mapping

## Semester – III

| | |
|---|---|
| Course Code & Title | **21GEOP0314**<br>**SEDIMENTARY PETROLOGY AND MARINE GEOLOGY** |

| | | | |
|---|---|---|---|
| Class | M. Sc. Applied Geology and Geomatics | Semester | III |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |

Course Objectives

**The Course aims**

- To learn the Physical properties, classification and composition of sedimentary rocks
- To study the petrographical properties of clastic and non-clastic sedimentary rocks
- To understand the environment of deposition through grain size analysis and XRF methods
- To learn the scope and importance of marine geology, classification of the coast and the important marine mineral deposits.
- To acquire knowledge about the microfossils, properties of the sea, and various marine samplers.

| Unit | Content | Lectures |
|---|---|---|
| I | ***Sedimentary Petrology*:** Physical properties of sedimentary particles and minerals - Mineral Stability and their Significance - Porosity and Permeability. **Classification and Composition of Sedimentary rocks**- Textures, ***Structures*** and their Environmental Significance. Provenance of sediments - ***Lithification and diagenesis***. **Environment of Deposition:** Non-marine, Transitional and Marine Environments and products. | 12 |
| II | **Formation and evolution of sedimentary basins**. Diagenesis of siliciclastic and carbonate rocks. **Sedimentation and tectonics**: tectonic control of sedimentation, geosynclines and their lithological association, plate tectonics in relation type and evolution of basins. **Petrography**- Nomenclature, Classification, Depositional Environment and Genesis of Clastic Sedimentary Rocks: Sandstones: Shales: Breccias: Conglomerates. **Non-clastic sedimentary rocks**: Limestones, Dolomites, Flint, Chert, and Evaporites. | 12 |
| III | **Environment of Deposition:** Non-marine, Transitional and Marine environments and products**. Outline on Grain size analysis**: Heavy mineral analysis, Clay mineral analysis and palaeoenvironmental studies. **Grain size determination:** sample preparation, direct measurements, dry and wet sieving. Grain size analysis and graphical representation. Provenance of sedimentary rocks. | 12 |
| IV | **Marine Geology: *Introduction and scope of marine geology:*** Morphologic and tectonic domains of the ocean floor. Structure, composition and mechanism of the formation of oceanic crust. **Classification of coast:** erosion and accretion. Waves, Currents and Tides. Coastal protection structures. **Classification of marine mineral deposits:** Origin and depositional system of marine resources. **Beach placers**: Shelf deposits, Deep Ocean phosphatic, Polymetallic nodules, Sulphate deposits, Hydrocarbon deposits. | 12 |
| V | Oceanic sediments: Factors controlling the deposition and distribution of oceanic sediments; geochronology of oceanic sediments, Concept of sea-level changes. Diagenetic changes inoxic and anoxic environments. Tectonic evolution of the ocean basins. Mineral resources. M**icrofossils**: Marine stratigraphy, correlation and chronology. Seismic stratigraphy and sequence stratigraphy as applied to marine geology. Physical and chemical properties of seawater. | 12 |

Marine pollution, pathways, resilence time, pollutants in the marine environment. Methods of measuring properties of the sea.

**Text Books:**


1. Tucker, M.E., (2001) Sedimentary Petrology an Introduction to the Origin of Sedimentary Rocks, Third edition, Blackwell publishing.
2. Sengupta S.M., (2011) Introduction to Sedimentology, Second edition, CBS Publishers and Distributors, New Delhi.
3. Gary Nichols, (2009). Sedimentology and Stratigraphy, Second Edition, Wiley - Blackwell.
4. Lal D.S., (2013). Climatology and Oceanography, Sharda Pustak Bhavan Publishers and Distributors.
5. Savindra Singh, (2014). Oceanography, Pravalika Publications.
6. U.S Army Corps of Engineers, (1995). Coastal Geology, University Press of the Pacific Honolulu, Hawaii


**Reference Books:**


1. Collision, J.D., Thompson, D.B., (1989). Sedimentary Structures. 2nd Ed. Unwin Hyman, London.
2. Tucker, M.E., (2001). Sedimentary Petrology an Introduction to the Origin of Sedimentary Rocks. Third edition, John Willey & Sons, New York.
3. Pettijohn, F.J., (1975) Sedimentary Rocks, 3rd Edition, Harper & Row, New York.
4. Reineck, H.E., Singh I.B., (1980) Depositional Sedimentary Environments, Springer Verlag.
5. Ernest, G. Ehlers., Harvey Blatt, (1999) Igneous, Sedimentary and Metamorphic Rocks, CBS Publishers and Distributors, New Delhi.


**Web Resources:**

1. *Underlined Titles are available in the Swayam portal*
2. www.usouthal.edu/geology/haywick/GY402/402-pp1.pdf.
3. https://www.lib.utexas.edu/geo/folkready/entirefolkpdf.pdf.
4. http://ocean.stanford.edu/courses/bomc/chem/lecture_14.pdf
5. https://ucmp.berkeley.edu/fosrec/Lipps1.html

**Course Outcomes**

On completion of the course, the students will be able to

**CO1:** Describe the process and formation of Sedimentary rocks.
**CO2:** Categorize the Classification of Sedimentary Rocks
**CO3:** Describe the concept of Marine geology.
**CO4:** Analyze the marine environments using marine geological instruments.
**CO5:** Identify the suitable remote sensing applications in ocean sciences

| | | | |
|---|---|---|---|
| Course Code & Title | **21GEOP0316**<br>**GEOPHYSICS AND GEOCHEMISTRY** | | |
| Class | M. Sc. Applied Geology and Geomatics | Semester | III |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |
| Course Objectives | The Course aims<br>• To know the gravity and radiometric method of exploration<br>• To learn the magnetic and electromagnetic methods of exploration<br>• To describe the Electric method of exploration, its interpretation and analysis techniques.<br>• To gain knowledge of the seismic method of exploration<br>• To illustrate the principles of Exploration geochemistry | | |

| Unit | Content | Lectures |
|---|---|---|
| I | ***Physical Properties of the Earth***: Objectives of Geophysics – Classification of Geophysical methods - Gravitational - Electrical - Magnetic - Thermal and Chemical - **Gravity Methods**: Introduction - Gravitational field of the Earth - Densities of rocks and minerals - **Instruments**: Pendulum - Torsion Balance - Gravity meters. Field procedures - **Reduction of gravity data**: Instrument drift - Latitude correction - Free air correction - Bouguer correction - Terrain correction and Tidal correction. Gravity anomaly maps and Interpretation methods in gravity prospecting. Advantages and Limitations of gravity method of prospecting ***Radioactive Methods***: Introduction - Ground Radiometric survey - Radioactive decay and Types: Beta Decay – Positron Decay – Electron Capture Decay – Branched Decay – Branched Decay – Alpha Decay - Radioactivity of rocks and minerals –Instruments: Geiger-muller counters - Scintillation counters - Gamma-ray spectrometers. Field procedures - Interpretation of radiometric data - Applications and Limitations. | 9 |
| II | **Magnetic Methods**: Principle– Magnetic Susceptibility - Earth's Magnetism - Magnetism of rocks and minerals: Induced and remnant magnetism. Magnetic materials and Magnetic domains: The Neel temperature and Curie temperature – Magnetic properties of materials: Diamagnetism – Para magnetism – Ferromagnetism – Anti-ferromagnetism – Ferrimagnetism Instruments: Schmidt type Magnetometers: Vertical force magnetometer - Horizontal force magnetometer - Torsion magnetometer - Field procedures - Reduction of data: Temperature correction - Correction for diurnal variations - Normal corrections - Preparation of magnetic anomaly maps and profiles - Interpretations - Applications and limitations. – **Electromagnetic Methods:** General principles- Eddy currents - Instruments- Field procedures - Anomalies – Interpretation of EM data - Applications and limitations - **Telluric and Magneto Telluric Field methods: Introduction – Surveying with TC and MT– Equipment – Depth equation.** | 9 |
| III | **Electrical Methods:** Principles **and types - Resistivity methods:** Principles - Instruments: D.C Potentiometer - Electric mill voltmeter. Equipotential and in equipotential method – Typical resistivity values of Important rocks - Electrode arrangements: Wenner arrangement - Schlumberger arrangement – Pole – Dipole method – Di pole – Di pole method **Field procedures**: Lateral exploration or profiling- Vertical Exploration or Depth sounding **- Interpretation - Application of resistivity methods. Self-Potential method: Principle –** | 9 |

| | | |
|---|---|---|
| | **Background potentials – Mineralization potential – Sato and Mooney's hypothesis – Field equipment -** Non-polarizable electrodes - The potentiometer - Electric millivoltmeter. **Field procedure** - Interpretation - Applications. **Induced Polarization Methods:** Principle - Polarization types: Membrane or electrolytic polarization – Electrode polarization - Time-domain IP and Frequency Domain IP – Instruments Field procedures - Interpretation - Applications. | |
| IV | **Seismic Methods:** Principle -Seismology and seismic prospecting - Elastic properties of rocks – Factors influencing Seismic wave velocities - Refraction and Reflection of seismic waves - Instruments: Geophones - Amplifiers and filters - Gain control systems - Time markings Magnetic recorders - Operational methods: Fan shooting, Arc shooting and Profile shooting - Reduction of data – Travel time curves for single homogenous and heterogenetic layers - Interpretation - Applications and limitations - **Well logging methods:** Introduction and types of well logging – Permeability and lithology log – Gamma-ray log – Spontaneous potential log – Caliber log – Porosity and density log – Sonic log – Neutron log – electrical logs. | 9 |
| V | **Ore Guides**: Regional and local parameters for exploration - Regional and detailed exploration -Geochemical guides – Pathfinder elements, especially in diamond exploration – Groundwater as a guide – Geobotanical and biochemical guides. ***Exploration Geochemistry*****:** Relative abundance of elements in whole Earth: Geochemical Anomaly and Province - Geochemical cycle - Primary and Secondary Dispersion of elements - Controls of dispersion - Mobility of elements – Oxidation Application of Utility of pathfinder elements and minerals. **Geochemical Surveys**: Definition – Types - Sampling Methodology – Application to mineral deposits – Outline of analytical methods used in Exploration Geochemistry - XRF, SEM, TEM, EDAX, AAS, EPMA, ICP- MS. | 9 |

**Text Books:**


1. Lowrie, W., (2007) Fundamentals of Geophysics. 2nd ed. Cambridge University Press, New Delhi,
2. Ramachandra Rao, M.B., (1993) Outlines of Geophysical Prospecting. EBD, Dhanbad.
3. Telford, W.M., Geldart, L.P.& Sheriff, R.E., (1990) Applied Geophysics. 2nd ed. Cambridge University Press, New Delhi.


**Reference Books:**


1. Arogyaswamy, R.N.P., (1980) Courses in Mining Geology. Oxford& IBH, New Delhi.
2. Banerjee, P.K. & Ghosh, S., (1997) Elements of Prospecting for Non-Fuel Mineral Deposits. Allied Publishers, Chennai.
3. Dobrin, M.B. &Savit, C.H., (1988) Introduction to Geophysical Prospecting. 4th ed. McGraw Hill. New Delhi.
4. Hartman, H.L., (1992) SME Mining Engineering Handbook. SMME Inc.Colorado.
5. Kearey, P., Brooks, M &Hill.I., (2002) An Introduction to Geophysical Exploration, 3rd ed. Blackwell Science.
6. Moon, C.J., Whateley, M.K.G. &Evans, A.M., (2006) Introduction to Mineral Exploration. Wiley Blackwell, New Delhi.
7. Mussett, A.E. & Khan, M.A., (2000) Looking into the Earth: An Introduction to Geological Geophysics. Cambridge University Press, New Delhi.
8. Parasnis, D.S, (1975) Principles of Applied Geophysics. Chapman & Hall. New York.
9. Kearey, P., Brooks, M., and Hill, A., (2002) An Introduction to Geophysical Exploration, Third Edition, Wiley Blackwell.
10. Li, M., Zhao, Y., (2014) Geophysical Exploration Technology, Elsevier Science Limited.
11. Randive, K.R., (2013) Elements of Geochemistry, Geochemical Exploration and Medical Geology, Research Publishing.

**Web resources:**

1. *Underlined Titles are available in the Swayam portal*
2. *https://www.school-for-champions.com/astronomy/earth.htm#.WxddcO6FO70*
3. *https://geoinfo.nmt.edu/geoscience/projects/astronauts/gravity_method.html*
4. *http://www.geol-amu.org/notes/b8-4-4.htm*
5. *https://www.michigan.gov/documents/deq/GIMDL-USGSINF672R6_302983_7.pdf*
6. *http://www.geol-amu.org/notes/b8-3-6.html*
7. *https://csegrecorder.com/articles/view/magnetic-and-gravity-methods-in-mineral-exploration*
8. *http://rallen.berkeley.edu/teaching/F04_GEO594_IntroAppGeophys/Lectures/L05.pdf*
9. *http://crack.seismo.unr.edu/ftp/pub/louie/class/492/data/2011/gph492_all_files_2011/AppliedGeophysics_Telford/AppliedGPH_MagneticMethods.pdf*
10. *https://sites.ualberta.ca/~unsworth/UA-classes/223/notes223/223D1-2009.pdf*
11. *http://www.engr.uconn.edu/~lanbo/G228378Lect0510EM1.pdf*
12. *https://www.kau.edu.sa/Files/0003035/Subjects/EM(1).pdf*
13. *http://shodhganga.inflibnet.ac.in/bitstream/10603/65005/8/08_chapter%201.pdf*
14. *http://www.tomoquest.com/attachments/File/EEG_Electrical_Surveying_SP.pdf*
15. *http://en.geophysik.at/index.php/methods/seismic-methods*
16. *http://www.geosearches.com/seismic.php*
17. *http://www.subsurfacesurveys.com/pdf/Methods.pdf*
18. *http://www.mdru.ubc.ca/home/resources/seg/seg_talks/Ray_Lett_Notes.pd*
19. *http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.489.6536&rep=rep1&type=pdf*

**Course Outcomes**

On completion of the course, the students will be able to

**CO1:** Explain the basic principles, Field procedure and application of Gravity methods and radioactive methods for Geological studies.

**CO2:** Analyze the basic principles, Field procedure and application of Magnetic methods and Electromagnetic methods for Geological studies.

**CO3:** Evaluate the basic principles, Field procedure and application of Electrical Methods and Radioactive methods for Geological studies.

**CO4:** Assess the basic principles, Field procedure and application of Refraction methods and Reflection methods for Geological studies.

**CO5:** Describe the basic principles of Exploration Geochemistry

| | | | |
|---|---|---|---|
| Course Code & Title | **21GGMPO317**<br>**GEOPHYSICAL, GEOCHEMISTRY AND SEDIMENTOLOGY - PRACTICAL V** | | |
| Class | M. Sc. Applied Geology and Geomatics | Semester | II |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |
| Course Objectives | **The Course aims**<br>• To Analyze and interpret the resistivity data using the Wenner method and Schlumberger method<br>• To Interpret the structures using Gravity and seismic data<br>• To Process, analyze and interpret the geochemical data<br>• To Identify the Megascopic and microscopic properties of Sedimentary rocks<br>• To Know the grain size analysis techniques. | | |

**Contents**

**Geophysics**

1. Resistivity survey and the interpretation for lithology and water resources - Wenner method
2. Resistivity survey and the interpretation for lithology and water resources - Schlumberger method
3. Geological and structural interpretation using Gravity data
4. Geological and structural interpretation using seismic data.
5. Find out the half-life period of the elements by using Radiometric data.

**Geochemistry**

1. Geochemical Sample preparation (A solution, B solution)
2. Geochemical anomaly map preparation and interpretation
3. Statistical analysis of geochemical data.

**Sedimentology**

1. Megascopic and microscopic and description of the sedimentary rocks
2. Microscopic examination of important sedimentary rocks Sieve Analysis/ Trask's method, Folk and Ward method
3. Techniques and procedures used in the study of sediment and sedimentary rocks. Collection, Analysis and Interpretation of data on size, sorting, roundness and sphericity

**Course Outcomes**

On completion of the course, the students should be able to

**CO1:** Predict the subsurface lithologies through electrical methods
**CO2:** Use of Gravity and Seismic data for structural interpretation
**CO3:** Analyze the half-life period of the Elements by using radiometric data
**CO4:** Interpret the megascopic and microscopic properties of sedimentary rocks
**CO5:** Interpret sedimentation process

| | |
|---|---|
| Course Code & Title | **18GGMPO318**<br>**GEOGRAPHIC INFORMATION SYSTEM AND GPS- PRACTICAL-VI** |
| Class | M. Sc Geology and Geomatics Semester III |
| Cognitive Level | K-1<br>K-2<br>K-3 |
| Course Objectives | **The Course aims**<br>• To learn to handle the fundamental tools of ArcGIS software<br>• To Gain detailed knowledge in map registration, GDB creation and Digitization<br>• To Compute the various Conversion and overlay techniques<br>• To-Do the Mosaicking, DEM generation, Classification processes |

**Contents**

1. Introduction to Arc GIS Features and Tools
2. Map Registration
    a. Toposheet Registration b. Registration using GCP's
    GDB Creation
    3. Feature Data Creation
    a. Point generation and Add field b. Line feature generation and Add field
    c. Polygon feature generation and Add field
4. Digitization and working with Advanced Editing tools
    a. Cut polygon b. Shape editing c. Edit vertices
5. Geometric and field calculation
6. CSV to feature generation
7. Conversion Exercise
    a. Feature to line b. Feature to polygon c. kml to layer d. Layer to kml
8. Overlay analysis
    a. Union b. Split c. Merge d. Join
9. Map layout
10. Map Generalization
11. Importing Field Photo to ArcGIS
12. Query Analysis
13. LAS Dataset & LIDAR Dataset
14. Road Network Analysis
15. Subtitle - Group of features
16. Spatial Join
17. Mosaic
18. Model Builder
19. NDVI in GIS
20. NDWI in GIS
21. DEM in GIS
22. Image Classification
23. Line of Site Analysis
24. Pan Sharpening
25. Watershed Generation from SRTM & Contour.
26. Location capturing Using GPS,
27. Accuracy assessment in GPS

**Course Outcomes**

On completion of the course, the students will be able to

**CO1:**Able to handle ArcGIS tools

**CO2:**Compute processes like Map registration, GDB creation, Digitization and overlay analysis

**CO3:**Carry out Mosaicking, DEM generation, NDVI, NDWI

**CO4:**Generate Contour maps and classified images through image classification

**CO5:**Assess the location accuracy using GPS

# Semester – IV

| | | | |
|---|---|---|---|
| Course Code & Title | **21GEOP419**<br>**PETROLEUM GEOLOGY, COAL GEOLOGY AND GEOTHERMAL RESOURCES** | | |
| Class | M. Sc. Applied Geology and Geomatics | Semester | IV |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |
| Course Objectives | **The Course aims**<br>• To Describe the origin and mode of formation of hydrocarbon<br>• To Learn the geological conditions favouring the formation of hydrocarbon<br>• To Know the mode of occurrence of petroleum and the concept of atomic fuel<br>• To Understand the origin, properties, classification, and distribution of coal<br>• To Gain knowledge on the various geothermal resources | | |

| Unit | Content | Lectures |
|---|---|---|
| I | **Petroleum Geology**: Properties of petroleum: **Origin and Theories:** Organic and Inorganic Processes; **Environment of Oil Formation:** Sedimentary Basins - Continental and Offshore; **Migration of Petroleum:** Porosity, Permeability mechanism, pattern and barriers. Physical and chemical characteristics of crude oil | 9 |
| II | ***Mode of Occurrence of Petroleum: Surface and Subsurface Occurrence*** Entrapment of oil: types and mechanism, Origin of oil, source rock and maturation. Reservoir rocks, fluids and cap rocks Petroleum Provinces **Atomic Fuel:** Concept of atomic energy. Mode of occurrence and association of atomic minerals in nature. Methods of exploration for atomic minerals. Productive geological horizons of atomic minerals in India. **Global Distribution of Petroleum Reserves- *Petroliferous Basins of India***. ***Well Logging,*** Mudlogging method and usage in oil companies. Wireline logs, different types of wireline logs Identification of major minerals like oil and gas (Hydrocarbons), Coal. | 9 |
| III | **Coal Geology**: Physical Properties, Chemical Composition; Classification of Coal: Rank and Grade; Origin of Coal. **Lithologic characters of Coal:** Bed Structure, Coal Texture; Maceral Concept: Vitrain, Clarain, Durain and Fusain. Coke, **Coal for Liquefaction- Coal Gasification**- Beneficiation of Low-Grade Coal and Conservation. Coalbed methane – a new energy resource. Elementary idea about generation of methane in coal beds, coal as a reservoir and coalbed methane exploration. | 9 |
| IV | **Occurrence of Coal: Geological and Geographical Distribution of Coal in India;** Detailed study of important Coal Fields in India; Neyveli Lignite Deposits; An Outline of Estimation of Coal Reserves. Identification of various lithology. Drilling method. **Coal and Environment.** | 9 |
| V | **Geothermal Resources** – Geothermal Energy- Various Types, Availability, Size, Distribution-Recovery; Applications and Economics of Geothermal Energy. **Mineralogy of the Nuclear Metals**; Distribution of U and Th in rocks; **Geochemical Guides-** Radiometric Prospecting Methods and Assaying; Bore Hole Logging, Field and Airborne Surveys | 9 |
| | **Text Books:**<br>1. Levorsen, A.I., (1985) Geology of Petroleum, Second Edition, CBS Publishers and Distributors, Delhi.<br>2. Larry Thomas, (2012) Coal geology, Wiley India Pvt. Ltd. | |

3. Dickson, M.H., and Fanelli, M., (2013) Geothermal energy utilization and technology, 1st Edition, Routledge- CRC press.

**Reference Books:**

1. Brown, A. R., (1986) Interpretation of Three-Dimensional Seismic Data, American Association of Petroleum Geologists, USA.
2. Aswathanarayana, U., (1985) Principles of Nuclear Geology. NBT. Delhi.
3. Paine, D.P., (1986) Aerial photography and image interpretation for resource management, Wiley and Sons, New York.
4. Rao, D.P., (1999) Remote Sensing for Earth Resources, Second Edition, Association of Exploration Geophysicist, Hyderabad.
5. Chandra, D., and Singh, R M., (2000) Textbook of coal geology (Indian context) Tara Book Agency, Varanasi.

**Web Resources:**

1. Underlined Titles are available in the Swayam portal
2. http://petroleum.nic.in/sites/default/files/basins_0.pdf
3. https://www.ndrdgh.gov.in/NDR/?page_id=603
4. https://en.wikipedia.org/wiki/Petroleum
5. http://www.petroleum.co.uk/refining
6. http://www.eolss.net/sample-chapters/c01/e6-15-08-03.pdf
7. https://gis.gov.in/cs/groups/public/documents/document/b3zp/mtyx/~edisp/dcport/gsigovi161863.pdf
8. https://www.pmfias.com/coal-in-india-gondwana-coal-tertiary
9. https://geology.com/rocks/coal.shtml

**Course Outcomes**

On completion of the course, the students will be able to

**CO1:** Explain the Formation, properties, Migration and accumulation of Petroleum.
**CO2:** Identify the Occurrences of Petroleum.
**CO3:** Explain the Characteristics of Coal.
**CO4:** Identify the Occurrences of Coal.
**CO5:** Predict the Geothermal Resources and uses.

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|---|---|
| Course Code & Title | **21GEOP0420**<br>**MINING GEOLOGY AND ENGINEERING GEOLOGY** |

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|---|---|---|---|
| Class | M. Sc. Applied Geology and Geomatics | Semester | IV |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |
| Course Objectives | The Course aims<br>• To Understand the process of formation of ore deposits and classification of various mineral deposits<br>• To Study the Geological setting, characteristics, and genesis of Ore deposits<br>• To Study Ore mineral textures and their paragenesis<br>• To Learn the various mining methods and prospecting methods<br>• To Acquire knowledge on the mineral dressing | | |

| Unit | Content | Lectures |
|---|---|---|
| I | **Mining Geology:** Introduction to Mining - Prospecting and Sampling - Trenching – Pitting – Exploratory Drilling and Calculation of Grades - Methods of Investigation of Ore Bodies. **Drilling Methods and Types of Drills** - **Classification of Mining methods**: Surface Mining - Alluvial Mining - Opencast mining or quarrying - Parts of Opencast mine: Bench Parameters - Mine Haulage. | 12 |
| II | **Underground Mining: Basic concepts and terms**: Shaft - adit - winze - raise - stope - mine support and ventilation **Open stope**: gophering mining method - Breast stope - Open underhand stoping - Open overhand stoping - Underground glory hole - Pillar and chamber method - Sub-level stoping. **Supported stopes**: Overhand stoping method with supports - Timbered stopes - Square set method - Filled stopes - Shrinkage stopes - Mitchell slicing system- **Caving methods** - **Outline of underground coal mining methods** | 12 |
| III | **Cycles of Mining Operation** - **Mine Explosives (Moved from 4th unit)** Mining machineries - Organization and structure of a mine - **Role of a geologist in mining industry** - Mining legislations - Preparation of mine plans - mining scheme - ***Environmental Impact Assessment*** and Management Plans - Mine Accidents - Miner's Diseases. | 12 |
| IV | **Engineering properties of rocks**: Rock measurements: Laboratory measures, Field-scale measure. Factors affecting rock properties – Index properties of rocks - Strength of rocks, compressive strength, tensile strength. Poissen's ratio and their measurement Rocks as materials for construction – Rocks as sites for construction - Specific Gravity, Porosity, Absorption - Soil profile, soil particles, soil structure, plasticity & swelling - Decorative stones & Building Stones. | 12 |
| V | **Dams: Objective of the dams, Types of Dams: Gravity dams, Buttress dams, Arch dams, Embankment dams, Geotechnical considerations, Selection of dam sites, Geological characters for dam sites, B**rief account on Major Indian Dams. **Reservoirs: Types of Reservoirs, Important terms related to Reservoirs, Geological investigations, - Tunnels:** Types of tunnels, Geological Investigations and Considerations, - Road network & related problems & preventive measures, Ghats road alignment. | 12 |
| | **Text Books**<br>1. Arogyaswami, R. N. P., (1980) Course in Mining Geology, Oxford and IBH Publishing house. | |

2. Parbin Singh, (2013) Engineering and General Geology, S. K. Kataria & Sons, New Delhi.

**Reference Books**

1. Hartman, H.L., (1992) SME Mining Engineering Handbook. SMME Inc.Colorado.
2. Bell, F.G.,(2005) Fundamentals of Engineering Geology. B.S Publications, Hyderabad
3. Krynine, P.D and Judd, W.R., (1956) Principles of Engineering Geology & Gotctonics. CBS Publsihers & Distributors, New Delhi
4. Legget, R.F and Hathway A.W., (1988) Geology and Engineering, 3rd Ed.McGraw Hill. New York.
5. Blyth, F.G.H. and De Freitas, M.H., (1984) A Geology for Engineers, 7th ed. Elsevier, New Delhi.
6. Singh, R.D., (1998) Coal Mining, New Age Publishers, Delhi.
7. Thomas, R.T., (1986) Introduction to Mining methods, McGraw Hill, New York.
8. Peters, W.C., (1978) Exploration and Mining Geology, Wiley, Newyork.

**Web Resources**

1. Underlined Titles are available in the Swayam portal
2. *https://iasmania.com/mineral-resources-india-iron-coal-aluminium-copper-lead-zinc/*
3. *http://www.aadnc-aandc.gc.ca/eng/1100100028056/1100100028058*
4. *https://everydayoil.wordpress.com/2012/11/16/different-types-of-drilling-and-its-breif-description/*
5. *http://www.cienciaviva.pt/img/upload/Introduction%20to%20mining.pdf.*
6. *https://www.americangeosciences.org/critical-issues/faq/what-are-main-mining-methods*
7. *http://emfi.mines.edu/emfi2011/Coal%20Mining%20Methods%20-%20EMFI%20Summary.pdf*

**Course Outcomes**

On completion of the course, the students will be able to

**CO1:** Assess the Sampling and surface mining methods.
**CO2:** Formulate the Scientific questions the Underground mining methods.
**CO3:** Analyze the role of Geologist in the mining sector
**CO4:** Discuss the Engineering Properties of rocks
**CO5:** Study of Geological consideration of the construction of dams, reservoirs and tunnels

| | | | |
|---|---|---|---|
| Course Code & Title | **21GEOP0421**<br>**METEOROLOGY AND CLIMATOLOGY** | | |
| Class | M. Sc. Applied Geology and Geomatics | Semester | IV |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |
| Course Objectives | The Course aims<br>• To Understand the atmospheric composition and its layer details<br>• To Study circulations characteristics of atmosphere and basics of wind characteristics<br>• To assess the cyclones and their factors<br>• To Learn the precipitation and its characteristics<br>• To Acquire knowledge on climatology basics | | |

| Unit | Content | Lectures |
|---|---|---|
| I | **Atmosphere**: Composition and structure of the atmosphere, Layered structure of the atmosphere, Insolation and distribution of Insolation. Heat Budget, heating and cooling of temperature, Temperature distribution, Air pressure – Pressure gradient and pressure variations, Atmospheric pressure patterns and Pressure belts. | 12 |
| II | Circulations in the Atmosphere – Thermal circulation on a rotating Earth. Circulation patterns. Wind: Fundamental forces affecting wind, Surface wind systems, Atmospheric circulation patterns and wind Belts. | 12 |
| III | Cyclones and Anticyclones. Local winds – Land Breeze and Sea Breeze, Mountain Breeze and Valley Breeze. Clouds and Precipitation: Formation and classification of clouds, Precipitation – Ice crystal theory and Collision-Coalescence theory. | 12 |
| IV | Forms of precipitation, types of precipitation, Distribution of precipitation, Intensity of precipitation, Artificial precipitation. Monsoon – Concepts of the origin of monsoon, Asian monsoon and Indian monsoon, climatic significance of monsoon, Economic importance of monsoon. | 12 |
| V | Climatology – Earth's radiation balance; latitudinal and seasonal variation of insolation, temperature, pressure, wind belts, humidity, cloud formation and precipitation, water balance. Air masses, monsoon, Jet streams, tropical cyclones, and ENSO. Classification of climates – Koppen's and Thornthwaite's scheme of classification. Climate change. | 12 |

Text Books:


1. Ackerman, S.A., and Knox, J.A., (2007) Meteorology – Understanding the Atmosphere, Thomson Brooks/Cole.
2. Ahrens, C.D., and Henson, R., (2016) Meteorology Today: An Introduction to Weather, Climate, and the Environment, Eleventh Edition Cengage Learning.


Reference Books:


1. Barry, R.G., and Chorley, R.J., (2003) Atmosphere, Weather and Climate, Taylor & Francis Group.
2. Kelkar, R.R., (2007) Satellite Meteorology, BS Publications.
3. Lal, D.S., (2003) Climatology, Sharda Pusthak Bhavan, Allahabad.
4. Lutgens, F. K., and Tarbuck, E.J., (2010) The atmosphere: An Introduction to meteorology 11th edition, Pearson.
5. Moran, J.M., Morgan, M.D., and Pauley, P.M., (1997) Meteorology: The Atmosphere and the Science of Weather, Prentice-Hall, New York.

6. Murthy, P., (2004) Environmental Meteorology, I K International, New Delhi.
7. Siddhartha, K. (2002), Atmosphere, Weather and Climate, Kisalaya Publications Pvt. Ltd.

Web Resources:

1. *https://www.topfreebooks.org/meteorology/*
2. *https://www.nap.edu/search/?rpp=20&ft=1&term=METEOROLOGY*
3. https://www.geos.ed.ac.uk/~dstevens/teaching/MetAE_labbook_2013-14_FINAL.pdf
4. https://imdpune.gov.in/training/training%20notes/Climatology-IMTC.pdf
5. https://digitalcommons.usu.edu/modern_climatology/15/

**Course Outcomes**

On completion of the course, the students will be able to

**CO1:** Assess the Sampling and surface mining methods.
**CO2:** Formulate the Scientific questions the Underground mining methods.
**CO3:** Analyze the role of Geologist in the mining sector
**CO4:** Discuss the Engineering Properties of rocks
**CO5:** Study of Geological consideration of the construction of dams, reservoirs and tunnels

| | | | |
|---|---|---|---|
| Course Code & Title | **21GEOP0422 HYDROGEOLOGY** | | |
| Class | M. Sc. Applied Geology and Geomatics | Semester | III |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |
| Course Objectives | The Course aims<br>• To Describe the hydrological properties of rocks<br>• To Illustrate the physical parameters of water quality standards<br>• To Understand the concept of groundwater basins<br>• To Know the engineering properties of rocks<br>• To Learn the geological considerations for constructing dams, reservoirs, tunnels | | |

| Unit | Content | Lectures |
|---|---|---|
| I | **Hydrological Properties of Rocks:** Porosity, Permeability, Specific Yield and Specific Retention, **Darcy's Law** – Permeability Determination – Laboratory methods – Constant head method – Falling head method – Non-discharge method – Field Methods – By using tracers. | 12 |
| II | **Groundwater Exploration** - Surface Methods – Geological methods – Lithological control – Structural control – Stratigraphic control – Geobotanical Indicators – **Geophysical method of exploration** – Electrical resistivity survey – Seismic survey – Sub-surface methods – Drilling – Well logging – Sampling - Geophysical logging. | 12 |
| III | **Sources of elevated concentration of salts** – Calcium and Magnesium, Sodium, Potassium, Iron, Silica, Acids, Nitrates. Minor and Trace elements. **Chemical Analysis of Water** – Estimation of PH, Ec, TDS, Carbonate, bicarbonate, chloride, sulphate, calcium, magnesium, sodium and potassium. **Water Quality** – Standards of water for different uses – Drinking purposes – Irrigation purposes – Industrial purposes (WHO, BIS and ICAR) - Water Quality Parameters for Drinking, Agriculture, and Industrial Uses. | 12 |
| IV | **Graphical Representation and Interpretation of Water Quality Data:** WILCOX, USSL, GIBBS plot, Piper, Doneen and Durov diagrams, Water Pollution – Introduction – Types of Pollution - Controlling methods.<br>**Seawater Intrusion** – Ghyben-Herzbergrelation – Freshwater – saltwater relation in Oceanic Island – Control of seawater Intrusion – Groundwater recharge. | 12 |
| V | **Pumping Tests**: Dupuit's equilibrium formula for unconfined and confined aquifers – Thiem's equilibrium formula for unconfined and confined aquifers.<br>**Natural and artificial recharge** – Quality of recharging water – Recharge rate – Methods of artificial recharge.<br>Water Purification – Settings – Coagulation – Fluorination – Defluorination – Disinfection – Deuteration – Groundwater basins of Tamilnadu. | 12 |

**Text Books:**


1. David Keith Todd, Larry W. Mays, (2013) Groundwater Hydrology, Wiley publications.
2. Raghunath, H.M., (2003) Groundwater, New Age international publications.


**Reference Books:**


1. Ramakrishnan. S. (1998) Groundwater, CBS Publishers & Distributors.
2. Fetter, C. W, (2007) Applied Hydrology, CBS Publications.
3. Herman Bouwer, (2014) Groundwater Hydrology, McGraw hill education

private limited.

**Web sources:**

1. file:///C:/Users/Geology/Downloads/Hydrogeology--TDM.pdf
2. http://water.lecture.ub.ac.id/files/2012/03/Book_HydrogeologyFieldManual-2ndEdition.pdf
3. http://www.hawaiidoh.org/references/Domenico%201990.pdf

**Course Outcomes**

On completion of the course, the students will be able to

**CO1:** Predict the origin and occurrence of groundwater
**CO2:** Assess the groundwater exploration phenomena
**CO3:** Describe the characteristics of groundwater quality and analytical methods
**CO4:** Assess the interpretation of water quality parameters using graphical methods.
**CO5:** Discuss the recharge methods, pump test principles and water purifications methods.

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|---|---|---|---|
| Course Code & Title | **21GEOP0423**<br>**HYDROGEOLOGY - PRACTICAL VII** | | |
| Class | M. Sc. Applied Geology and Geomatics | Semester | II |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |
| Course Objectives | The Course aims<br>• To Analyze and interpret the resistivity data using the Wenner method and Schlumberger method<br>• To Interpret the hydrological properties of rocks<br>• To Process, analyze and rainfall data<br>• To explore the water quality<br>• To Know the software applications in hydrogeology | | |

**Contents**

1. Resistivity survey and the interpretation for lithology and water resources
   (i) Schlumberger method
   (ii) Wenner method
2. Problems on hydrological properties of rocks
   (i) Porosity
   (ii) Specific yield
   (iii) Specific retention.
3. Methods of rainfall assessment-
   (i) Arithmetic mean method
   (ii) Thiesson polygon method
   (iii) Isohyetal method
4. Geochemical anomaly map preparation and interpretation
5. Water quality analysis
   (i) Physical parameters
      (a) Estimation of pH
      (b) Estimation of EC
      (c) Estimation of TDS
      (d) Estimation of TH
   (ii) Chemical parameters
      (a) major cations
      (b) major anions
6. Graphical interpretation of water quality data.
   (i) Collins bar diagram
   (ii) Stiff diagram
7. Pumping test data interpretation.
8. Isohyetal map generation through surfer software
9. Rockworks software and its application

**Course Outcomes**

On completion of the course, the students will be able to

**CO1:** Predict the subsurface groundwater conditions through electrical methods
**CO2:** Use of hydrogeological properties of rocks in Groundwater exploration i
**CO3:** Analyze the rainfall data
**CO4:** Interpret the hydrogeochemical properties of surface and sub-surface

| | | | |
|---|---|---|---|
| Course Code & Title | **21GEOP0424 DISSERTATION** | | |
| Class | M. Sc. Applied Geology and Geomatics | Semester | IV |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |
| Course Objectives | The students are allowed to work in various domains of geology and will undergo the practice to collect, process, analyze and interpret the data to bring out new results. | | |

**DISCIPLINE CENTRIC COURSES**

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|---|---|---|---|
| Course Code & Title | **21GEOP03D1**<br>**EXPERIMENTAL PETROLOGY (ELECTIVE_DISCIPLINE CENTRIC)** | | |
| Class | M. Sc. Applied Geology and Geomatics | Semester | III |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |
| Course Objectives | The Course aims<br>• To understand the principles of Experimental petrology<br>• To learn the process involved in thermodynamics.<br>• To evaluate thermodynamic data using Raoult's Law and Henny's law<br>• To calibrate the geothermometers and Geobarometers from the experimental thermodynamic data<br>• To know the oxidation reactions | | |

| Unit | Content | Lectures |
|---|---|---|
| I | **Experimental Petrology:** High Temperature – Pressure Techniques, Hydrothermal apparatus and Piston Cylinder **apparatus**, Experiments on Solid – Solid Dehydration and De-carbonation Reaction. Introduction to Equilibrium crystallization and Fractional crystallization - | 12 |
| II | **Thermodynamics:** Gibb's Energy and equilibrium constant, mole fraction, activity coefficients. Regular and sub regular solutions. Standard states, fugacity and activity - Experimental and thermodynamic appraisal of metamorphic reactions. | 12 |
| III | **Raoult's Law, Henry's Law**, Heat Capacity, Evaluation and tabulation of thermodynamic data. Isobaric thermal expansion and pressures. | 12 |
| IV | **Calibrations of Geothermometers and geobarometers** from thermodynamic and experimental data. Reduced activity of water from dehydration reactions<br>**Mantle rock types and processes - Basalt lab - Pyroxene - thermobarometry - Serpentine stability** | 12 |
| V | Introduction to Multi-anvil High P-T equipment **- Recycling of mantle - Melting & Crystallization Processes -** Log $O_2$ from oxidation reactions. | 12 |

**Text Books:**

1. Chatterjee. N.D.(1991) Applied Mineralogical Thermodynamics. Springer Verlag
2. Koch, G.S and Link, R.F. (1970) Statistical Analysis of Geological Data. John Wiley.

**Reference Books:**

1. Powell, R. (1978) Equilibrium Thermodynamics in Petrology, an Introduction, Harper & Row.
2. Wood, B.J. and Frasser, D.G (1976) Elementary Thermodynamics for Geologists. Oxford Univ. Press.

**Course Outcomes**

On completion of the course, the students will be able to

**CO1:** Explain the principles of Experimental petrology
**CO2:** Describe the concepts of thermodynamics
**CO3:** Evaluate the Thermodynamic data using Raoult's Law and Henny's Law
**CO4:** Calibrate Geothermometers and Geobarometers
**CO5:** Elaborate Oxidation reaction

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|---|---|---|---|
| Course Code & Title | **21GEOP03D2**<br>**ADVANCED ORE PETROLOGY**<br>**(ELECTIVE_DISCIPLINE CENTRIC)** | | |
| Class | M. Sc. Applied Geology and Geomatics | Semester | III |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |
| Course Objectives | The Course aims<br>• To Understand the modern concepts of ore genesis<br>• To Study in detail the ore isotopes<br>• To Acquire knowledge of the ore deposits<br>• To Learn the plate tectonic and the related ore genesis<br>• To Describe the advanced studies in ore genesis | | |

| Unit | Content | Lectures |
|---|---|---|
| I | **Modern Concepts of Ore Genesis**: Detailed study of all principal ore mineral groups - their textures and structures - Chemistry of ore minerals and host rocks - Paragenesis - paragenetic sequences and zoning in metallic ore deposits - Methods in geothermometry - geobarometry in ore-geology. | 12 |
| II | **Stable and Radiogenic Isotopes of Ores and the Host Rocks**: Specialized models of ore deposits related to mafic and intermediate to felsic intrusions - Vein-deposits and ore deposits related to sub areal and submarine volcanism | 12 |
| III | **Detailed Study of Ore Deposits:** Chemical precipitates - syngenetic clastic beds and by weathering - Significance of stratiform and strata - bound ore deposits of sedimentary affiliation and those of metamorphic affiliation | 12 |
| IV | **Plate Tectonics and Ore Genesis**: Ore deposits of oceanic crust - ocean floor and those related to plate subduction - Geological modelling for mineral exploration | 12 |
| V | **Advance Study of Ore:** Ore mineral textures and their application in paragenesis - Application of ore microscopy in mineral technology - Geochemical modelling of ore deposits – Fluid inclusion studies in ore Geology – Mineral Exploration and Fluid inclusion - Fluid inclusion in copper and gold deposits – Case studies | 12 |

**Text Books:**


1. Wolf, K.H., (1981) Hand Book of Strata bound and Stratiform Ore Deposits. Elsevier.


**Reference Books:**


1. Klemm, D.D. and Schneider, H.J., (1977) Time- and Strata Bound Ore Deposits. Springer Verlag.
2. Ramdohr, R, (1969) The Ore Minerals and Their Intergrowths. Pergamon Press.
3. Arogyaswamy, R. N. P., (1980) Courses in Mining Geology. Oxford & IBH, New Delhi.
4. Bateman, A. (2013) Economic Mineral Deposits, John Wiley.
3. Shepard et al. 1985 A Practical Guide to Fluid Inclusion Studies Blackie.


**Course Outcomes**

On completion of the course, the students should be able to

**CO1:** Explain the Modern Concepts of Ore Genesis
**CO2:** Discuss Stable and Radiogenic Isotopes of Ores and the Host Rocks
**CO3:** Identify the Ore Deposits
**CO4:** Describe the Plate Tectonics and Ore Genesis
**CO5:** Explain the Advance Study of Ore

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|---|---|---|---|
| Course Code & Title | **21GEOP03D3<br>GEOGRAPHIC INFORMATION SYSTEM<br>(ELECTIVE_DISCIPLINE CENTRIC)** | | |
| Class | M. Sc. Applied Geology and Geomatics | Semester | III |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |
| Course Objectives | The Course aims<br>• To Provide the basic principles and components of GIS<br>• To Learn the different types of Spatial and non-spatial data<br>• To know the basic concepts of data quality and data problems<br>• To integrate and Analyze the data.<br>• To Gain knowledge of the advanced processing techniques in GIS. | | |

| Unit | Content | Lectures |
|---|---|---|
| I | **GIS Overview:** Introduction to GIS and GIS Infrastructure. GIS hardware components and GIS roles. **Geographic data and database**-Data and information definitions Geographic data: spatial data, types of GIS database and discrete and continuous data GIS data characteristics Spatial Data Relationships, Proximity Relationships Time and GIS data, The Database and Relational Database in GIS. | 12 |
| II | **Raster and vector data:** Raster and Vector data and Models - **Raster data:** Raster Coding, Resolution, Gridding and Linear features - Raster Precision and Accuracy - **Vector Data.** Raster and Vector Structures - Raster and Vector Advantages and Disadvantages - **Topology,** Appling Topology - Topology Tables - Multiple Connectivity - Topology and Relational Queries - Topology contribution. **Rasterization and Vectorization** | 12 |
| III | **Spatial Data Management**: Introduction - **Data quality:** Error, Accuracy, Precision - Generalization and derived data - Scale and Precision, scale differences, scale incompatibility - Area and coverage, Incomplete Coverage, Smallest Scale Rule - Data Problems, Continuous Data Interpretation, Complete and Consistent Data - **Acquiring and Distribution of data:** Data Accessibility, Data Cost, Data Standards, Meta Data - Distributed GIS: Advantages and Disadvantages – Web GIS, Mobile GIS - Open GIS**-Types Of Mapping In GIS -Interactive GIS Mapping. (Web source)** | 12 |
| IV | **Inventory operations and basic Analyses**: Viewing GIS, Database reading - Database Queries and Summaries - Relational Database Queries, Boolean Queries and Graphical Selection Queries - Measurement and Types, Distance applications, Reports - **Theme Modification**: Subsets and Tiles - Spatial deletes, dissolve and merge - Recoding and reclassification - **Basic Analyses(spelling):** Introduction - Overlay, its types and Principles - - Database Merging and Applying Theme - Buffers and applications, Spatial analyses - Statistical Reporting and Graphing. | 12 |
| V | **Advanced Analyses:** Proximity analyses, Nearest features, Spider diagrams, Distance selection, Aggregation - Spatial operations: Centroids, Thiessen polygons - Tracking GIS - **Terrain analyses:** Elevation analyses, Terrain profiles - 3D views, Slope and Aspect, Shaded Relief views and View analyses - Overlays and Additional features, Dropping, Perspective views and Z data views - GIS output: types, Maps, Legends and Supporting elements - **Future GIS-** The Future GIS and the Future of GIS. | 12 |
| | **Text Books:**<br>1. Burrough, P.A., (1986) Principles of Geographical Information Systems for Land Resources Assessment, Clarandone Press, Oxford. | |

2. Bernhardsen, T., (2007) Geographic Information System – An introduction, Third edition, Wiley.
3. Davis, B.E., (2001), GIS Visual Approach, Second Edition, Cengage Learning.

**Reference Books:**

1. Kang - Tsung Chang, (2002) Introduction to Geographic Information System, Mc Graw Hill, Boston.
2. Campbell, J., (1984) Introductory Cartography, Printers Hall Englewood Cliffs, N.J,
3. Dent B.D., (1985) Principles of Thematic Map Design, Addition - Wesley, Reading, Mass.
4. Freeman, H and Pieroni, G.G., (1980) Map Data Processing, Academic Press, New York.
5. Gurugnanam, B., (2009) Geographic Information System, New India Publishing Agency.

**Web Resources:**

1. https://www.saylor.org/site/textbooks/Essentials%20of%20Geographic%20Information%20Systems.pdf
2. https://webapps.itc.utwente.nl/librarywww/papers_2009/general/PrinciplesGIS.pdf
3. http://www.geografie.webzdarma.cz/GIS-skriptum.pdf
4. https://eos.com/blog/gis-mapping/

**Course Outcomes**

On completion of the course, the students will be able to

***CO1:*** Discuss the GIS, functions and components, Geographic data and database
***CO2:*** Explain the Raster and vector data, Topology and conversion of Data
***CO3:*** Discuss the Data quality, Acquiring and Distribution of data and interactive mapping of GIS
***CO4:*** Analyze the Inventory operations, Theme Modification and basic Analysis.
***CO5:*** Discuss the Advanced analysis, Terrain analysis, and the Future GIS

**MODULAR COURSES**

| | | | |
|---|---|---|---|
| Course Code & Title | **21GEOP03M1**<br>**MEDICAL GEOLOGY (MODULAR COURSE)** | | |
| Class | M. Sc. Applied Geology and Geomatics | Semester | III |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |
| Course Objectives | The Course aims<br>• To know the basic principles and concepts of medical geology<br>• To learn in detail the Geological impacts of trace elements in nutrition<br>• To Gain knowledge of the medicinal value of various minerals by understanding their physical and chemical properties. | | |

| Unit | Content | Lectures |
|---|---|---|
| I | **Introduction to Medical Geology:** Medical Geology: Natural Distribution and Abundance of Elements, Functions of major and minor elements in the human body, the functional value of Trace elements, Geological Impacts on Nutrition**;** Physical, chemical properties, Origin and Distribution, Uses and medicinal value of **Magnesite, Gypsum**, **Calcite**, **Fossiliferous Limestone, Red Ocher, Asbestos, Sulphur, Cinnabar** | 13 |
| II | Fluoride in Natural Waters, soils, sediments, plants. Fluorides and health: Bioavailability of fluoride, Dental fluorosis, Skeletal fluorosis, Dental fluorosis in India, source, nature, cause and extent; Physical, chemical properties, Origin and Distribution, Uses and medicinal value of **Orpiment**, **Realgar, Ferrogenous Shale, Chalcanthite, Rock Salt, Borex, Malachite and Azurite, Salt Petre and Mica**, **Hematite, Magnetite and Siderite** Animals and Medical Geology; The Impact of Micronutrient Deficiencies in Agricultural Soils and Crops on the Nutritional Health of Humans; Techniques and Tools GIS in Human Health Studies. | 13 |

**Text Books:**


1. Park, K. (2013) Textbook of Preventive and social medicine, M/s Banaras Bhanot publishers Jabalpur.
2. Dissanayake, C. B., Chandrajith, R. (2009) Introduction to Medical Geology Springer-Verlag
3. Year: 2009
4. Park. K., (2015) Essential of Community Health Nursing, Seventh Edition, M/S Banarsidas Bhanot Publishers.
5. Sornamariammal (2016) Bogar Ezayiraththil Siddha Maruththuva Kanimangal. Published by World Siddha Trust.


**Reference Books:**


1. David Werner (1993) Where there is no doctor, Reprinted, Macmillan.
2. Singh, R.Y., (2007) Geography of settlement, Reprinted, Rawat publications.
3. Purohit, N.J., (2014) Earth Science, Geology, Environmental and the Universe, 1st Edition, Swastik Publications, New Delhi, India
4. Skinner C.H and Berfer R.A., (2000) Geology and Health, Oxford University Press.
5. Selninus, E. D., (2000) Essentials of Medical Geology, Elsevier.
6. Dissanayake C.B., and Chandrajith, R., (2009) Introduction to Medical Geology, Springer, London.


**Web Resources:**

1. *https://www.saylor.org/site/textbooks/Essentials%20of%20Geographic%20Information%20Systems.pdf*

2. *https://webapps.itc.utwente.nl/librarywww/papers_2009/general/PrinciplesGIS.pdf*
3. *http://www.geografie.webzdarma.cz/GIS-skriptum.pdf*

**Course Outcomes**

On completion of the course, the students will be able to

***CO1:*** Explain the Importance of Geology in Medicine and the characteristics and role of Magnesite, Gypsum, Calcite, Fossiliferous Limestone, Red Ocher, Asbestos, Sulphur, Cinnabar in Medicine.

***CO2:*** Use the knowledge of and application of this material in Medical Science Orpiment, Realgar, Ferrogenous Shale, Chalcanthite, Rock Salt, Borex, Azurite, Salt Petre and Mica, Hematite, Magnetite and Siderite.

| Course Code & Title | **21GEOP03M1**<br>**GEOSTATISTICS (MODULAR COURSE)** | | |
|---|---|---|---|
| Class | M. Sc. Applied Geology and Geomatics | Semester | IV |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |
| Course Objectives | The Course aims<br>• To introduce the advanced and applied aspects of Mathematical Geology.<br>• To understand the Concepts of Geostatic and concepts of data distribution in space<br>• To learn the concepts of correlation, exploratory spatial data analysis and interpolation | | |

| Unit | Content | Lectures |
|---|---|---|
| I | **Concepts of probability:** Radom variation – Sampling estimates and standard errors- Simple tests based on normal, chi-square and F Distributions. The mean and mode – Standard deviation. **Geostatistics:** Meaning, Definition, and History of Geostatistics, **Spatial data**- Definition and Characteristics Types: Point pattern, continuous surfaces, Area with counts and aggregate rates, Terms in Spatial Analysis - **Definitions of** i. Spatial dependence, Stationary and Isotropy, Anisotropy, Region of stationary, Spatial correlation, Autocorrelation, Corelogram. **Exploratory spatial data analysis:** ESDA/EDA - Meaning of Exploratory spatial data analysis (ESDA) and Exploratory data analysis (EDA). **Concepts of data distribution in space** - Data – i. Sampling, ii. Heterogeneity, iii. Dependency, Univariate description. Frequency tables, Histogram, Cumulative frequency table, Normal probability plots. Summary / Descriptive statistics, Bivariate description - Scatter plot, correlation, covariance, correlation coefficient, linear regression. | 13 |
| II | **Structural analysis**: Meaning/definitions -. i. Spatial correlation, ii. Autocorrelation, and iii. Spatial Autocorrelation, Spatial autocorrelation. Concept and "Moran's I" statistic, Correlogram - a. Concept, b. types: **Omnidirectional and directional**, Concepts of i. Autocovariance ii. Semivariances. iii. Semi variogram iv. Variogram: a. Components- Nugget variance, Sill, & Range. Variogram models. **Making predictions: Global interpolation** - **Local Interpolation** – **Practical Exposure on Exploratory spatial data analysis: Bivariate description. Spatial interpolation** | 12 |

**Text Books:**


1. Sancheti. D. C. and Kapoor, V. K. (1992) Statistics Theory, Methods and Application. Sultan Chand & Sons publishers


**Reference Books:**


1. Isaaks, E. H., and Srivastava, R.M., (1989) An Introduction to Applied Geostatistics, Oxford University Press,
2. Davis, J. C., (2002) Statistics and data analysis in geology, third edition, John Wiley & Sons, Singapore.
3. Using ArcGIS Geostatistical Analyst. (2001) GIS by ESRI.
4. Kitanidis P.K., (1997) Introduction to Geostatistics, Applications in Hydrogeology, Cambridge University Press.
5. Sharma, D. D., (2009), Geostatistics with applications in Earth sciences Jointly published with Capital Publishing Company.
6. Simon W., (2000) Houlding Geostatistics: Modeling and Spatial Analysis, Springer: Har/CdrEdition (8 June 2000), CD-ROM: 161 pages, 2000.
7. Cressie, N.A.C. (1993) Statistics for Spatial Data, New York: John Wiley & Sons, Inc.

8. Duetsch, C.V. and Journel, A.G. (1992) GSLIB: Geostatistical Software Library and User's Guide, New York: Oxford University Press,
9. Hohn, M.E. (1988) Geostatistics and Petroleum Geology, New York: Van Nostrand Reinhold,

**Web Resources**:

1. *http://people.ku.edu/~gbohling/cpe940/Variograms.pdf*
2. *http://maps.unomaha.edu/Peterson/gisII/ESRImanuals/Ch3_Principles.pdf*
3. *http://geofaculty.uwyo.edu/yzhang/files/Geosta1.pdf*

**Course Outcomes**

On completion of the course, the students should be able to

**CO1:**Describe the principles of Geo statics

**CO2:**Apply Geostatistics in geological data interpretation

| Course Code & Title | **21GEOP03M2**<br>**ADVANCED HYDROGEOLOGY (MODULAR COURSE)** | | |
|---|---|---|---|
| Class | M. Sc. Applied Geology and Geomatics | Semester | IV |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |
| Course Objectives | The Course aims<br>• To Introduce basic phenomena of hydrogeology and its advances.<br>• To Understand the concepts of the hydrologic cycle<br>• To Interpret the role of geologic structures in identifying the potential zones of groundwater<br>• To Describe the Characteristics of groundwater in arid, semi-arid coastal as well as alluvial regions<br>• To Know the chemical characteristics of groundwater | | |

| Unit | Content | Lectures |
|---|---|---|
| I | ***Hydrologic cycle***. Hydrographic analyses, Water balance studies - Groundwater in the hydrological cycle, Distribution of water in the Earth's crust - **Springs (including thermal):** origin and movement of water. Geologic structures favouring groundwater occurrence - Methods of identification of groundwater reservoir properties - Fluctuation of groundwater level. Water budget equation –Modern Techniques for Hydrogeological study | 13 |
| II | **Groundwater in arid and semi-arid, coastal and alluvial regions** - Groundwater in hard rocks and limestone terrain with reference to Indian situation - **Chemical characteristics of groundwater** in relation to various uses- domestic, industrial and irrigation purposes - Water pollution and treatment. Environmental impact of groundwater extraction - Wells and their construction and design. Seawater intrusion into coastal aquifers – Case studies | 13 |

**Text Books:**


1. David Keith Todd, Larry W. Mays, (2013) Groundwater Hydrology, Wiley & sons.
2. Gurugnanam B. Essentials of Hydrogeology, First Edition, Publisher: NIPA
3. Agarwal V.C., (2012) Groundwater Hydrology, Published by Asoke K. Ghosh, PHI Learning Private Limited,
4. Fetter C.W., Applied Hydrogeology, Second Edition, published by Satish Kumar Jain and produced by V.K. Jain for CBS Publishers & Distributer Pvt. Ltd.,
5. Herman Bouwer, Groundwater Hydrology, 2014 Edition, Published by McGraw Hill Education (India) Private Limited


**Web Resources:**

1. *http://opac.vimaru.edu.vn/edata/EBookManual_of_applied_Field_Hydrogeology.pdfhttps://water.usgs.gov/ogw/pubs/TWRI3-B2/TWRI3-B2-with-links.pdf*
2. *http://unesdoc.unesco.org/images/0013/001344/134432e.pdf*
3. *http://www.basichydrogeology.com/HydrogeologyLectureNotes-v2.3-LR.pdf*

**Course Outcomes**

On completion of the course, the students should be able to

**CO1**: Describe the Concepts of Hydrogeology

**CO2:** Elaborate the characteristics of Groundwater

| Course Code & Title | **21GEOP03M2**<br>**MICROPALAEONTOLOGY (MODULAR COURSE)** | | |
|---|---|---|---|
| Class | M. Sc. Applied Geology and Geomatics | Semester | III |
| Cognitive Level | K-1<br>K-2<br>K-3 | | |
| Course Objectives | The Course aims<br>• To Learn the sampling methods as well as the processing techniques<br>• To Interpret and rebuild the paleoenvironments using microfossils<br>• To Understand the role of microfossils in hydrocarbon exploration | | |

| Unit | Content | Lectures |
|---|---|---|
| I | **Surface and subsurface sampling method Processing of samples** - Morphology - classification - Evolution of foraminifera - Stratigraphy of foraminifera with special reference to India - Biometrics of larger Foraminifera - Paleo Environmental interpretation using microfossils - Ostracoda - Nanofossils-Radiolaria-Conodonts- **Bryozoa - Role of microPalaeontology in hydrocarbon exploration.** | 13 |
| II | Deep-sea records with reference to the Indian Ocean - Stable isotopic study in foraminifera and interpretation of paleotemperature and paleoenvironment reconstruction. Significance of microfossils in biochronostratigraphy, event stratigraphy and sequence stratigraphy. Application of microfossils in paleo-bathymetric and paleo-temperature estimation, Seafloor tectonism and environmental studies. | 13 |

**Text Books:**


1. Anantharaman, M.S. (2005) Palaeontology: Evolution and Animal Distribution, 6th edition, Vishal Publishing Co, New Delhi.
2. Bignot, G. (1985) Elements of Micropalaeontology. Graham and Trotman.


**Reference Books:**


1. Haq, B.V. and Boersma, A., (1998) Introduction to Marine Micropalaeontology. Elsevier.
2. Haynes, J.R. (1981) Foraminifera. John Wiley.


**Course Outcomes**

On completion of the course, the students will be able to

**CO1:** Describe the concept of MicroPalaeontology
**CO2:** Categorize the various branches of MicroPalaeontology
**CO3:** Identify the importance of MicroPalaeontology on the environment.
**CO4:** Analyze qualitative data systematically by selecting appropriate ecological analysis.
**CO5:** Analyze the environmental and ecological significance of foraminifera and Ostracoda